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The cushion–star *Parvulastra exigua* in South Africa: one species or more?

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Abstract

The cushion–star *Parvulastra exigua* (Lamarck, 1816) is a widely distributed member of the temperate intertidal fauna in the southern hemisphere. In South Africa, it occurs in sympatry with the endemic *Parvulastra dyscrita* (Clark, 1923), the two species being differentiated predominantly by gonopore placement. Several recent studies have suggested that there may be additional cryptic species within the *P. exigua* complex in South Africa, based variously on color morphology, genetic evidence and the differential placement of the gonopores. This paper attempts to resolve whether one or more species are represented within *P. exigua*. A total of 346 *P. exigua* and 8 *P. dyscrita* were collected from sites on the west and south–west coasts of South Africa; morphological, anatomical and genetic analyses were performed to determine whether cryptic species and/or *P. exigua* specimens with aboral gonopores were present. Results show that neither cryptic species nor *P. exigua* specimens with aboral gonopores occur at these sites. This study thus refutes previous claims of the existence of aboral gonopores in South African *P. exigua*, and suggests that a single species is represented. The distinction between *P. exigua* and *P. dyscrita* is also confirmed, and features separating these two species are clarified and documented.

Keywords

Cryptic species, gonopore, *Parvulastra dyscrita*, *Parvulastra exigua*, *Patiriella*, starfish

Introduction

The dwarf cushion–star *Parvulastra exigua* (Lamarck, 1816) is a prominent and widespread member of the temperate intertidal fauna in the southern hemisphere (Hart et al. 2006), occurring along the entire southern coastline of Africa from Namibia to Mozambique, in southeastern Australia and on several oceanic islands (Clark and Downey 1992). In South Africa, *P. exigua* occurs in sympatry with another endemic cushion–star, *Parvulastra dyscrita* (Clark, 1923), which has a larger adult size, occurs in lower densities and is found predominantly subtidally along the south and east coast, between False Bay and East London (Branch et al. 2010). *Parvulastra dyscrita* has a complex and intertwined taxonomic history with *P. exigua* (Table 1), which in part was driven by their morphological and ecological similarities. However, *P. exigua* and *P. dyscrita* have now been confirmed as two separate species in an unpublished thesis by Dunbar (2006), based on molecular and morphological (external gonopore position) evidence.

While the larger *P. dyscrita* has a fairly consistent mottled coloration (Fig. 1), *P. exigua* demonstrates a high degree of color variation, with two major color morphs in South Africa demonstrating an allopatric distribution (Fig. 1; Branch et al. 2010). The distribution patterns of these color morphs were studied in detail by Dunbar (2006), who noted a strong spatial divergence separated by a narrow zone of color morph sympatry around Cape Point. On the west coast, *P. exigua* were of a uniform khaki green color (similar to Australian populations), while more brightly colored, variegated individuals dominated along the east and south coasts. Dunbar (2006) also found the color morphs to demonstrate some degree of ecological divergence. The mottled morph is found predominantly in the high tidal zone within protected, bare rock, algae–encrusted and under boulder habitats with few algal tufts, while the green and intermediate color morphs were found in the mid tidal zone, with the green color morph inhabiting under boulder and bare rock habitats and tidal pools with little/no algae canopy and coralline algae. Similarly, the intermediate color morph also predominantly inhabited bare rock tidal pools, with little coralline algae, but also avoided those with algal tufts and an algal canopy.

Contrary to her expectations, Dunbar (2006) found no evidence of genetic separation between the two major color morphs, with perhaps temperature and/or predation maintaining the observed color polymorphism. In addition, a highly divergent haplotype was identified in twelve Kommetjie specimens, indicating the presence of a reproductively isolated cryptic species within a very narrow geographic range (Dunbar 2006). These individuals were documented as members of the intermediate color morph and exhibited a unique reddish–orange coloration (Dunbar 2006). Apart from this relatively subjective difference in color morph, Dunbar (2006) noted that this cryptic species appears morphologically similar to *P. exigua*, especially with regards to the presence of oral gonopores, but was found to be more closely related to the outgroup taxa *Parvulastra parvivipara* (Keough and Dartnall 1978) and *Parvulastra vivipara* (Dartnall 1969). Dunbar (2006) went on to suggest that this Kommetjie lineage should be classed as a new species, but to the authors' knowledge, no such species description was ever prepared.

Table 1. The taxonomic history of *Parvulastra exigua* and *Parvulastra dyscrita*.

Step in taxonomic history	Performed by
P. exigua first described as *Asterias exigua.*	Lamarck (1816)
Asterina exigua Lamarck found to be conspecific with *Asterina kraussii* Gray and *Asteriscus pentagonus* Müller & Troschel.	Perrier (1875)
Oral gonopore placement of *Asterina exigua* first noted. Oral gonopore placement of *Asterina exigua* confirmed.	Whitelegge (1889) Mortensen (1921)
Asterina exigua moved into the new genus *Patiriella* (often ignored by later authors).	Verrill (1913)
A new species with aboral gonopores, *Asterina dyscrita* described; suggestion made that it may only be a variety of *Asterina exigua.*	Clark (1923)
Asterina dyscrita placed into synonymy with *A. exigua.*	Mortensen (1933)
Asterina (*Patiriella*) *exigua* reviewed; it was proposed that there was a second species within *exigua* with aboral gonopores.	Dartnall (1971)
It was suggested that the species with aboral gonopores was *Asterina dyscrita* and moved to the genus *Patiriella* due to morphological similarity with *Patiriella exigua*.	Clark (1974)
Patiriella exigua and *Patiriella dyscrita* moved to the new genus *Parvulastra* which is distinguished from *Patiriella* based on ray width, ray plate alignment and is supported by previous molecular studies conducted by Waters et al. (2004).	O' Loughlin and Waters (2004)
Parvulastra exigua and *Parvulastra dyscrita* were confirmed to be two separate species based on morphological (external gonopore position) and molecular evidence (mtDNA COI). Another species that only occurs in Kommetjie was recognized within *P. exigua*, but no species description was recorded.	Dunbar (2006)

The major differentiating features between *P. exigua* and *P. dyscrita* are the position of the gonopore and reproductive mode. *Parvulastra exigua* is an ovipositor that spawns predominantly from August to October (Lawson–Kerr and Anderson 1978; Byrne 1992). The sticky egg masses are laid via oral gonopores (Lawson–Kerr and Anderson 1978) on the undersides of boulders and give rise to distinct lecithotrophic benthic larvae (Byrne and Anderson 1994). By contrast *P. dyscrita* releases eggs into the water column via aboral gonopores, where they hatch into planktonic larvae.

However, in 2006, Hart et al. externally examined various preserved specimens of *P. exigua* from museum collections from South Africa, southern Australia and several islands (St. Helena, Amsterdam, St. Paul and Kerguelen) for evidence that some *P. exigua* populations might include cryptic species with a different mode of reproduction. Overall, 33% (21% in South Africa) of the *P. exigua* specimens examined (excluding individuals in which gonopore position was uncertain) were reported to have aboral gonopores, with such individuals occurring predominantly in South Africa and the St. Paul, Amsterdam and St. Helena islands. Hart et al. (2006) also analyzed mitochondrial DNA sequence data from the study by Waters and Roy (2004), leading them to tentatively suggest that a cryptic species of *P. exigua* (or more) exist in South Africa, probably with aboral gonopores. Moreover, Dartnall and Byrne (unpublished observation cited in Colgan et al. 2005) proposed the presence of a cryptic species with aboral gonopores in South Africa and a few oceanic islands.

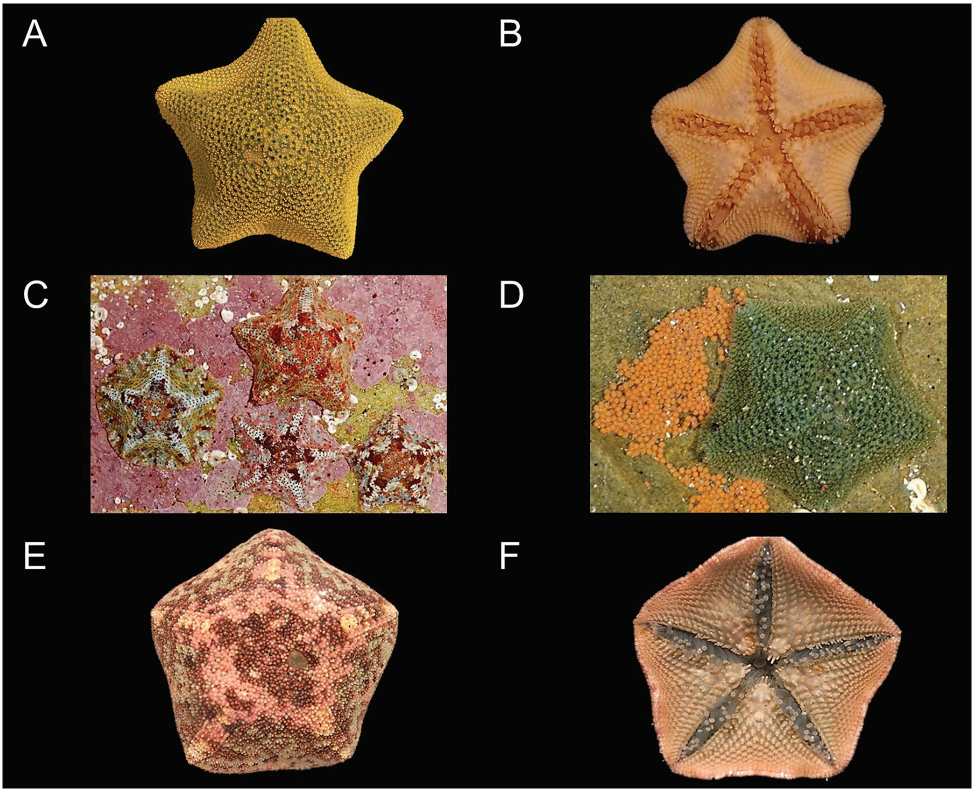

Figure 1. Abactinal (**A**) and actinal (**B**) view of *Parvulastra exigua*, with equivalent views of *Parvulastra dyscrita* (**E, F**), with the *P. exigua* mottled color morph found on the east coast of South Africa (**C**) and an adult *P. exigua* laying sticky eggs via oral gonopores onto the underside of a rock (**D**). All photos by C.L. Griffiths; individuals not to scale, with approximate sizes given in Table 5.

The studies of both Dunbar (2006) and Hart et al. (2006) point to the possibility (and presence) of cryptic species within *P. exigua*, yet with the absence of specimens from both studies and the lack of resolution on gonad structure, this remains unresolved. Therefore, the aim of this study was to resample *P. exigua* populations on either side of the morphological overlap to confirm whether genetically distinct specimens and/or *P. exigua* specimens with aboral gonopores are in fact present. To do this, mtDNA COI gene as well as geometric morphometric approaches were utilised.

Methods

Specimen collection

Where possible, 90 starfish were collected during low spring tide from intertidal rocky shores at each of four main collecting sites (Fig. 2; compiled using QGIS v.2.6.1): Kalk

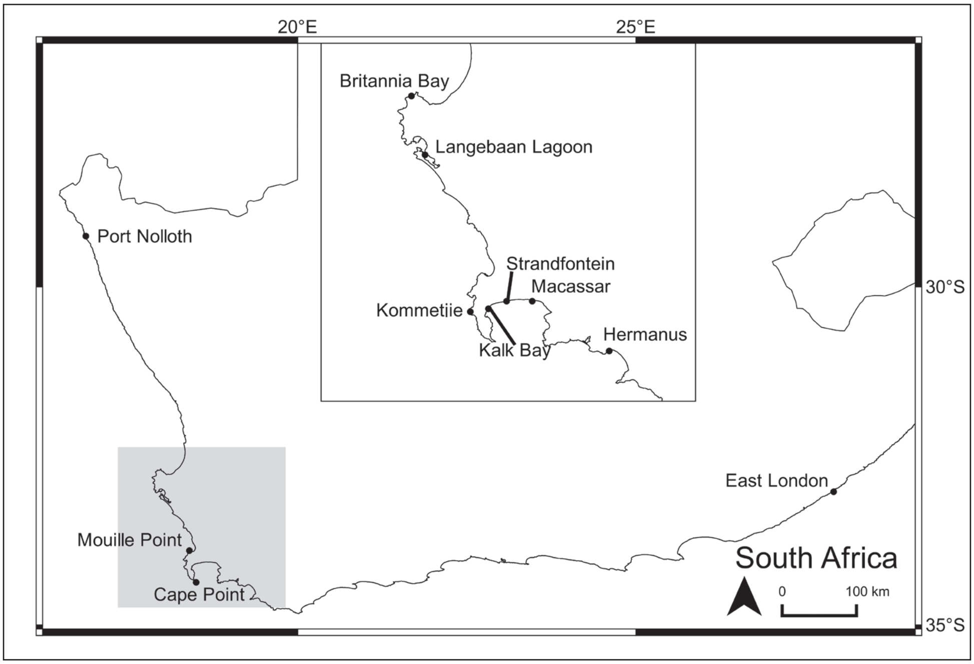

Figure 2. Map of South Africa demonstrating sampling localities and other locations mentioned in the text.

Table 2. Number of starfish collected per sampling location. Brackets indicate the number of *Parvulastra dyscrita* collected.

Coast	Location	High	Medium	Low	Sand	Total
West	Britannia Bay (B)	33	31	2	–	66
	Langebaan Lagoon (L)	–	–	–	9	9
	Kommetjie (Ko)	33	30	33	–	96
South–west	Kalk Bay (Ka)	30	30	34(6)	–	94
	Strandfontein (S)	–	–	2 (1)	–	2
	Macassar (M)	–	–	(1)	–	1
	Hermanus (H)	33	32	30	–	95
					Total	363

Bay and Hermanus (south–west coast), and Kommetjie and Britannia Bay (west coast) which lie within two bioregions. At each site, 30 specimens were collected from three vertical intertidal zones; the high–, mid– and low shores. An exception was Britannia Bay, where few starfish could be found in the lowest zone. Twelve additional specimens were added to the analysis from other sites around the coast to either enhance the *Parvulastra dyscrita* sample size, or to include *Parvulastra exigua* of unusual appearance or from unusual habitats, such as intertidal sandbanks (Table 2).

Morphology and anatomy

The oral and aboral surface of each specimen was photographed after collection to document the color pattern of each starfish. After preservation in 70% ethanol, several qualitative and quantitative characteristics, based predominantly on previous taxonomic descriptions from both known species, were recorded, using a dissecting microscope and digital caliper respectively (Table 3). In addition, marginal plate spines and tube feet were examined, but these characteristics were excluded from further analyses, as no differences between specimens were noted. The abactinal and actinal surface coloration of each individual specimen was also eliminated while only R/r values were considered, due to the high variability observed and possibility of skewing the analyses respectively. Specimens were not retained after examination.

Statistical analyses

Overall, 354 specimens were included in the multivariate analyses, which were performed on unstandardised and untransformed characteristic data using PRIMER v.6.1.5 (Plymouth Routines in Multivariate Ecological Research; Clarke and Gorley 2006). A non–metric multidimensional scaling (MDS) ordination, based on a resemblance matrix generated from Bray–Curtis similarities, was used to visually assess specimen similarity. Additionally, this ordination was utilized to identify outlying individuals which were included in the genetic analyses. Six groups were defined (Fig. 3; Table 4), each comprising seven individuals that could possibly represent cryptic species within *P. exigua*. A seventh group, consisting of seven *P. dyscrita*, was included for comparison.

The one–way ANOSIM (analysis of similarity) routine was performed to determine whether possible specimen groupings are associated with any of the documented characteristics, with the significance of the statistical tests assigned at the 5% level. Thereafter, SIMPER (similarity percentage analysis) was used to determine the characteristics that contribute to at least 90% of the difference between divergent cluster groups.

Genetics

DNA extraction, PCR and sequencing

Overall, 49 specimens were selected for genetic analyses (Fig. 3; Table 4); 44 were successfully sequenced. Approximately 25 mg of the specimen arm was removed for analysis. DNA was extracted using the NucleoSpin Tissue Kit (Machery–Nagel), following the manufacturer's instructions.

Table 3. Starfish characteristics examined per specimen and used in multivariate analyses.

Characteristic		Technique
Quantitative	R/r	Expression of body proportion. R = greater radius measured along the ambulacral groove. r = smaller, interambulacral radius. Both measured along three non–deformed arms per specimen and averaged.
	Peristomial membrane diameter	Used as an expression of body size. Measured twice per specimen and averaged.
	Madreporite diameter	Measured twice per specimen and averaged.
	Papulae diameter	Five diameters measured per specimen and averaged.
	Oral plate spines	Number of oral plate spines.
	Oral plate erect spinulation	Number of erect spines per oral plate.
	Oral marginal plate spinulation	Number of oral marginal spines.
Qualitative	Color morph	Green or mottled.
	Abactinal surface spinulation	Described as having either fine, short columnar or coarse, granuliform globose spinelets.
	Abactinal surface texture	Either clusters of spinelets, or evenly granular surface texture.
	Adradial actinal spinulation	Absent or present. Where present, noted whether these spines occurred in more, or less than, three arms.
	Furrow/Ambulacral spinulation	Classified according to relative number of plates with one spine, as well as the presence or abundance of three spines per plate.
	Actinal intermediate plate spinulation	Classified according to the relative number of plates with one or two spines, starting position of the plates with two spines and the presence of plates with three spines.
	External visible gonopore position	Having either oral gonopores or none (aboral gonopores are difficult to observe).
	Gonopore position by dissection	Dissected to determine gonad placement and definitively document gonopore position.

Table 4. Specimen groups selected for genetic analyses. Each group comprises seven individuals identified on an MDS.

Group	Description
1. Mottled	Individuals from south–west coast with variegated coloration.
2. Green	Individuals from west coast with green coloration.
3. Orange	Individuals from west coast with orange coloration.
4. Two oral plate spines	Individuals with two oral plate spines, as opposed to the four observed in most specimens collected.
5. Langebaan	Individuals from a sandflat habitat with deep aboral 'dents' and peculiar abactinal surface spinulation. Some also appear non–pentagonal.
6. Peculiar	Individuals with atypical coloration, shape, size etc.
7. *Parvulastra dyscrita*	Outgroup included for comparison.

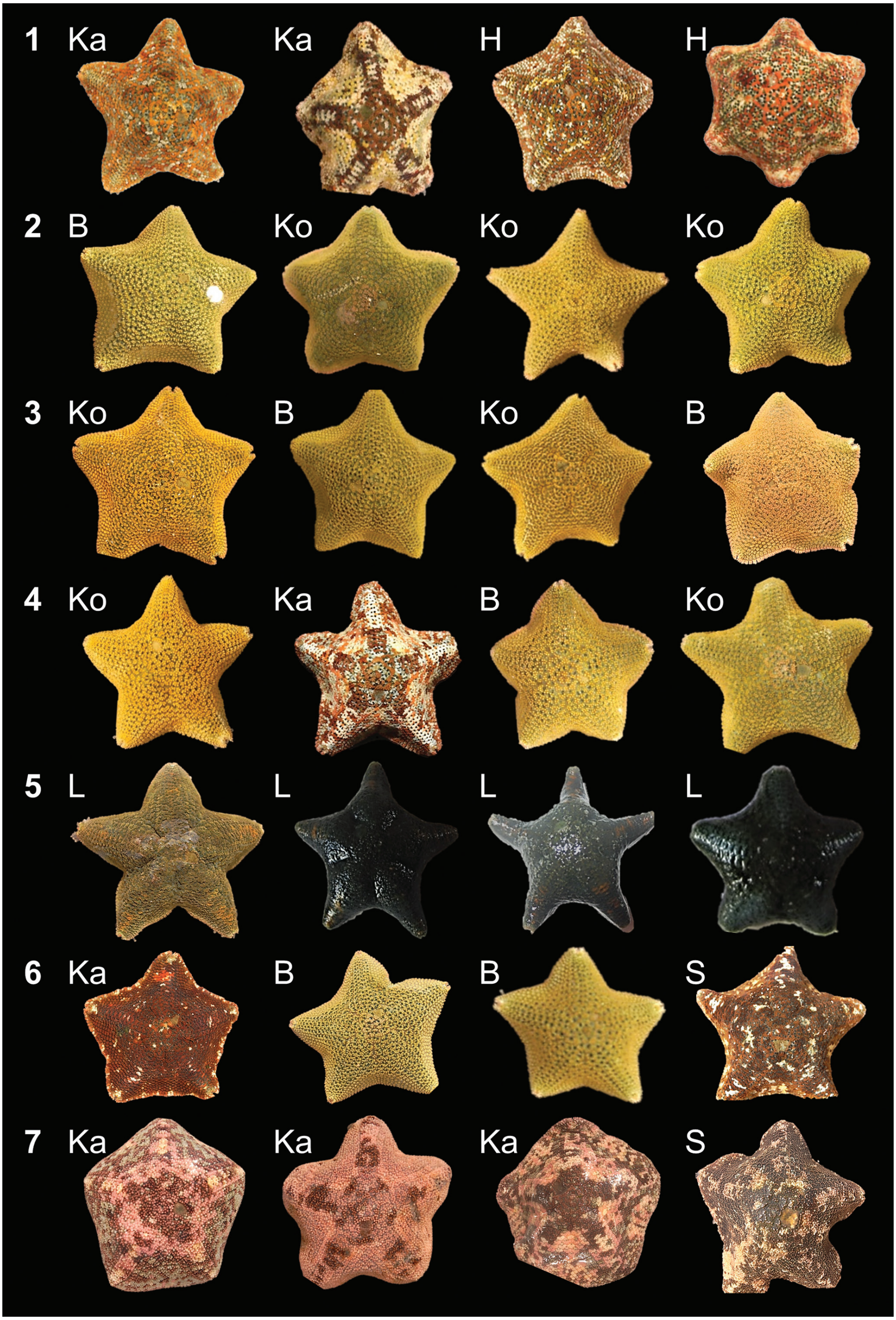

Figure 3. Shape and color pattern of four specimens from each of the seven groups of seven specimens as defined in Table 4, and used in the genetic analyses. Letters indicate location of specimen collection as seen in Table 2. Photos by R.P. Payne; individuals not to scale, with approximate sizes given in Table 5.

A partial section of the mtDNA cytochrome oxidase I gene was amplified by PCR, using a combination of primers; the invertebrate primers LC01490 and HCO2198 (Folmer et al. 1994), as well as *P. exigua* specific primers: Pexig_F1 (5'–CTTTCC-CACGAATGAACAAYATGAGC–3') and Pexig_R1 (5'–CCGAGGGCTCATAG-GAGAGGAGTGTC–3') (Mertens 2012). All amplifications were performed in 25 µL reactions, with the PCR protocol as follows: an initial denaturing step of 3 min at 94 °C, followed by 35–38 cycles of 94 °C for 30 s, an annealing temperature of 45 °C for 45 s, and 45 s at 72 °C, with a final extension of 10 min at 72 °C. The number of cycles (35–38) was dependent on the primers and DNA dilution used, which differed according to specimen. PCR products were visualized on a 1% agarose gel stained with ethidium bromide, and sequences were generated on an ABI–3100 automated sequencer, at the Stellenbosch University Central Analytical Facility.

Sequence analyses

Geneious v.6.1.6 was used to build an unrooted neighbor–joining tree with bootstrap support from consensus sequences that had a final length of 345 bp. Sequences were also analyzed using TCS v.1.21. (Clement et al. 2000) in order to generate a parsimony haplotype network. For the latter analysis, a 95% plausible connection limit was used. The parsimony haplotype network was visualized using Haploview (Barrett et al. 2005).

Results

Of the 354 specimens included in the analysis, eight were identified as *Parvulastra dyscrita* and the remainder as *Parvulastra exigua*. The two species are morphologically distinct (Fig. 1); Table 5 lists the main morphological differences between them. The collection location, as well as several characteristics including size, abactinal surface coloration, surface spinulation, surface texture and the presence or absence of adradial actinal spines can aid in the identification of specimens in the field.

All collected *P. dyscrita* specimens had muted shades of pink, white, brown and turquoise on the abactinal surface, with a bluish–yellow color orally (Fig. 1). The gonopore position was not externally visible in any of these specimens, but once dissected it was clear that all had aboral gonopores

Representative individuals of *P. exigua* collected from the various study sites are depicted in Fig. 3, displaying a wide range of both shape and color. Specimens collected from Kommetjie and Britannia Bay (west coast sampling sites) exhibited a variety of uniform abactinal surface coloration, ranging from pale green, olive green, to orange, brown and blue, while those from Hermanus and Kalk Bay (south–west coast sampling sites) were all mottled morphs, of darker coloration. No green morphs were sampled from the south–west coast collection sites and neither were intermediate forms. Indi-

Table 5. Characteristics that distinguish *P. exigua* from *P. dyscrita*, based on published literature and measurements taken during the present study.

Characteristic		*P. exigua*	*P. dyscrita*	Source
Quantitative	Size; R/r	Small, up to 20 mm; 1.07–1.83	Larger, up to 40 mm; 1.16–1.45	Branch et al. (2010)
	Peristomial membrane diameter (mm)	1.26–6.10	4.70–7.15	–
	Madreporite diameter (mm)	0.19–2.92	2.27–4.62	–
	Papulae diameter (mm)	Large; 0.07–0.28	Small, numerous; 0.13–0.26	Clark (1923); O' Loughlin and Waters (2004)
	Oral plate spines	Two, four or variable.	Four or more, often variable.	–
	Oral plate erect spinulation	Two tall oral spines per plate, often consisting of two spines in the place of one.	Two tall oral spines per plate, often consisting of 'bunches' of spines in the place of one.	Clark (1923); O' Loughlin and Waters (2004)
	Oral marginal plate spinulation	Three–five spines per plate, or a combination.	Five–seven spines per plate, or a combination.	Clark (1923); O' Loughlin and Waters (2004)
Qualitative	Abactinal surface coloration	Dull khaki–green, orange, blue, brown and orange–shouldered on the west coast of South Africa. Variegated (often geometrical) patterns on the south and east coast, including most color combinations.	Mottled shades of pale pink, white, purple and maroon.	Clark (1923); Clark and Courtman–Stock (1976); Branch et al. (2010)
	Actinal surface coloration	Variable; not consistently blue–green.	Not consistently blue–green; bluish yellow.	Dartnall (1971); Clark (1974)
	Abactinal surface spinulation	Fine, short columnar.	Coarse, granuliform globose.	Clark (1923); O' Loughlin and Waters (2004); Branch et al. (2010)
	Abactinal surface texture	Clusters of spines.	Evenly granular.	Branch et al. (2010)
	Adradial actinal spinulation	Absent.	Often present.	O' Loughlin and Waters (2004)
	Furrow/ Ambulacral spinulation	Two (often three) slender, short spines.	Two (often three) slender, short spines.	Clark 1923; Dartnall (1971); O' Loughlin and Waters (2004)
	Actinal intermediate plate spinulation	Each plate with only one or two spines, with the latter occurring more frequently distally.	Many plates with two spines each, some with three.	Clark (1923); Dartnall (1971); O' Loughlin and Waters (2004)
	Subambulacral spines	Tall, thick, pointed spine on each adambulacral plate.	Large, blunt, truncate spine on each adambulacral plate.	Clark (1923); Dartnall (1971); O' Loughlin and Waters (2004)

	External visible gonopore position	Oral or none. Often difficult to detect.	None. Difficult to detect.	–
	Gonopore position	Oral–two in each interradius, separated from oral plates by approximately three actinal plates.	Aboral.	Dartnall (1971); Clark and Courtman–Stock (1976) O' Loughlin and Waters (2004)

viduals collected from Langebaan Lagoon were dark green, with some exhibiting an orange shoulder. Actinal coloration was highly variable between and among sampling sites and the oral gonopore position could be seen in some preserved specimens, while no gonopores could be seen in others. Specimens collected from Langebaan Lagoon all demonstrated large aboral 'grooves' that could be confused for gonopores. However, when dissected, all *P. exigua* specimens displayed oral gonopores.

Inter–species differences

As can be identified in Fig. 4, two clear clusters, with an average dissimilarity of 35.96%, are evident in the MDS plot, representing *P. dyscrita* and *P. exigua*. This confirms that these represent distinct species, with gonopore position (ANOSIM, R = 0.981, p = 0.001), abactinal surface texture (ANOSIM, R = 0.981, p = 0.001), abactinal surface spinulation (ANOSIM, R = 0.757, p = 0.001) and oral plate spines (ANOSIM, R = 0.682, p = 0.001) playing a predominant role in this configuration. SIMPER results suggest that spinulation plays a major role in the delineation of these species, with erect oral plate, actinal intermediate plate, oral marginal plate and furrow/ambulacral spinulation contributing to 57.55% of the difference between the two species. An unrooted neighbor joining tree (data not shown) supports this distinction, with a clear separation of the sequences into two clades with 100% bootstrap support. This finding is supported by the haplotype network (Fig. 5), which failed to connect the two clades with more than 95% probability.

Intra–species variation

Within the *P. exigua* cluster (Fig. 4), the specimens differed significantly, with oral plate spines (two to four spines per oral plate or variable, ANOSIM, R = 0.677, p = 0.001) and abactinal surface spinulation (short columnar spines to similar spines but with slightly different shape, ANOSIM, R = 0.527, p = 0.001) playing a predominant role in this configuration. Overall there seems to be little morphological separation between *P. exigua* specimens. The phylogenetic tree (data not shown) and the haplotype network (Fig. 5A) show little genetic variation between *P. exigua* sampled at different locations, tidal heights or color morph. Two main haplotypes dominate

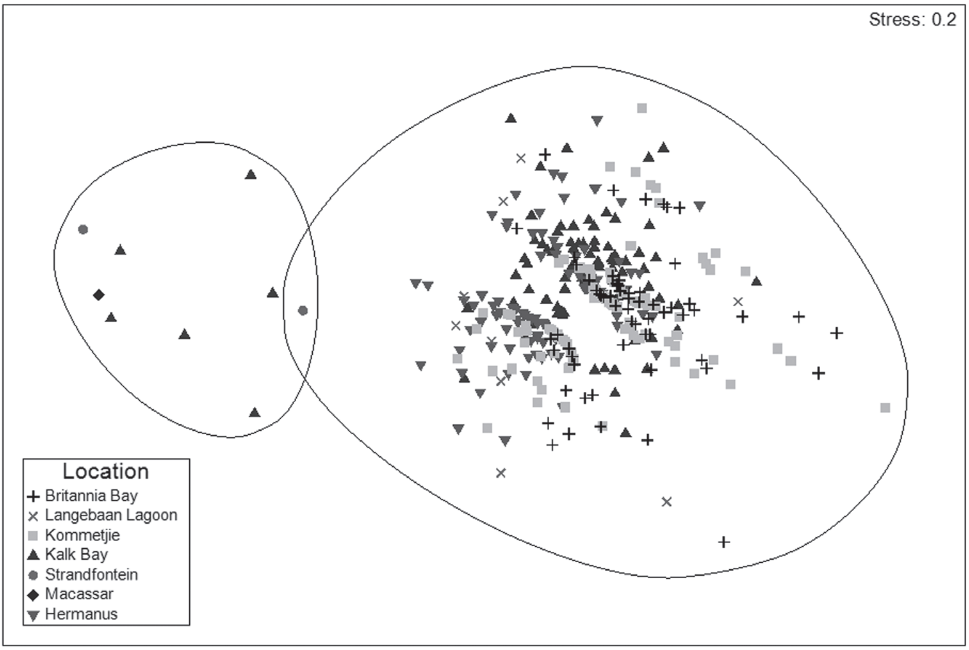

Figure 4. Non–metric MDS ordination of all specimens analyzed. Two clear clusters displayed which represent the species *Parvulastra dyscrita* on the left, and the species *Parvulastra exigua* on the right. Circles indicate 75% similarity. The specimen causing a cluster overlap is of the species *P. exigua*, but has many of the morphological characteristics associated with *P. dyscrita* due to its large size and possibly collection location.

the haplotype network for *P. exigua* (Fig. 5A), both of which are well distributed across the sampling locations, with three unique haplotypes found along the west coast. The connections between the haplotypes indicate that they are genetically very similar (at the maximum five mutational steps distance). Overall, this evidence suggests that all *P. exigua* specimens collected in this study represent a single, morphologically variable species.

Discussion

The validity and identification of *Parvulastra dyscrita*

Parvulastra dyscrita and *P. exigua* show a clear separation, based on morphology, anatomy and genetics, unambiguously confirming them to be two distinct species. The differences in characteristics of the two species supports those defined in earlier taxonomic work (Table 5) with gonopore position, abactinal surface texture and abactinal surface spinulation playing a major role. SIMPER results confirm that spinulation is a main delineator between these species.

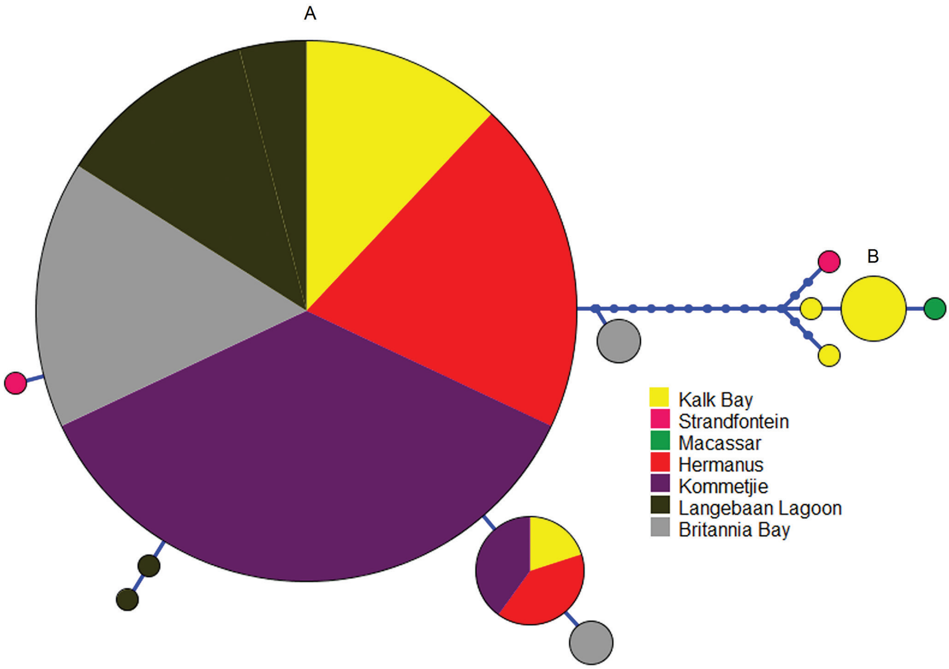

Figure 5. Parsimony haplotype network for (**A**) 37 *Parvulastra exigua* and (**B**) 7 *Parvulastra dyscrita* specimens. Circle size relates to the frequency of each haplotype, with color indicating origin of the individuals. Smallest circles represent one individual and one haplotype. Extinct or not sampled haplotypes are marked by a blue dot and each line represents one mutational step.

The clear separation of these two species confirms Dunbar's (2006) results, but that study also highlights the ease with which specimens can be misidentified. This is understandable, especially in the case of large *P. exigua*, that can sometimes look morphologically very similar to *P. dyscrita* (personal observation), an example being the specimen in Fig. 4 that causes the 75% similarity circles to overlap. Based on the position of the gonopore, and several other characteristics, this specimen is definitely *P. exigua*, but is one of the largest specimens collected overall, had spinulation characteristics similar to those of *P. dyscrita* and was collected from the front of Strandfontein rockpool, which could be considered a subtidal location. All these characteristics facilitate misidentication in the field and caution that more detailed examination of spinulation and gonopore position are needed to confirm identification of ambiguous specimens.

Species resolution in *P. exigua*

All *P. exigua* specimens collected exhibited oral gonopores, with only slight morphological differences in oral plate spines and abactinal surface spinulation, but no separation great enough to indicate the presence of a cryptic species. This was confirmed by molecular analyses; the haplotype network shows little genetic variation within *P. exigua* sampled at different localities, tidal height or specimen group. Mertens (2012) conducted genetic analyses on a further 177 *P. exigua* specimens collected ~800 km of the west coast of South Africa (from Kommetjie to Port Nolloth) and did not find evidence of any cryptic species. However, it is important to note that no intermediate reddish–orange color morphs were collected in the present study and only a few Kommetjie specimens were analyzed genetically. All of this evidence suggests that if an undescribed *Parvulastra* species exists, it occurs in very low numbers, or in a very narrow geographic range, as suggested by Dunbar (2006). This warrants further investigation, and perhaps an extensive future sampling survey at Kommetjie. In addition, the slight intraspecific variation and observed colour polymorphism in *P. exigua* may be maintained by temperature and/or predation, as suggested by Dunbar (2006), and warrants more study. Future work should also include further comparisons (both morphological and molecular) of *P. exigua* and *P. dyscrita* specimens across the entirety of their currently known distributions, as well as the potential hybridization between South African *Parvulastra* species, which has not been investigated.

Gonopore position

After no *P. exigua* specimens from our original samples were found to have aboral gonopores, a further 200 *P. exigua* individuals were collected from Mouille Point, a location where a museum specimen with supposed aboral gonopores had been collected previously and examined by Hart et al. (2006). These specimens were also found to all have oral gonopores. In addition, Dunbar (2006) also found an examined subset of her *P. exigua* specimens to only have visible oral gonopores. On enquiry, it was determined that Hart et al. (2006) only examined museum specimens externally (Michael Hart and Maria Byrne, pers. comm.) and it is suggested that they mistook abactinal dimples (or the lack of visible oral gonopores) for aboral gonopores. This proposal is supported by the fact that *P. dyscrita*, a species with aboral gonopores, has no easily identifiable external gonopore position, making it hard to confirm gonopore position without dissection. A similar situation was faced with regards to the few *P. exigua* specimens examined in this study, as these displayed no oral gonopores and had to be dissected in order to reveal that the gonads were indeed orally directed. Finally, Langebaan Lagoon *P. exigua* specimens have deep abactinal grooves, and as some lack visible oral gonopores unless dissected, they could easily be mistaken as having aboral gonopores. It is also important to note that Waters and Roy (2004) did not include *P. dyscrita* in their molecular analysis and so some of the samples included in their analysis that depicts cryptic diversity in South Africa, could include *P. dyscrita* misidentified as *P. exigua* (Michael Hart, pers. comm.). Thus, this study suggests that *P. exigua* specimens in South Africa with aboral gonopores do not exist.

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Taxonomy and distribution of some katydids (Orthoptera Tettigoniidae) from tropical Africa

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Abstract

Results of the study of specimens collected in tropical Africa and preserved in different European collections and museums are reported and extensively illustrated. The following three new species are described: *Horatosphaga aethiopica* **sp. n.**, *Dapanera occulta* **sp. n.** and *Cestromoecha laeglae* **sp. n.** In addition, new diagnostic characters or distributional data for *Ruspolia differens* (Serville, 1838), *Thyridorhoptrum senegalense* Krauss, 1877, *Horatosphaga leggei* (Kirby, 1909), *Horatosphaga linearis* (Rehn, 1910), *Preussia lobatipes* Karsch, 1890 and *Dapanera eidmanni* Ebner, 1943 are reported. Finally, *Symmetropleura plana* (Walker, 1869) is proposed to be transferred to the genus *Symmetrokarschia* Massa, 2015, *Conocephalus carbonarius* (Redtenbacher, 1891) to the genus *Thyridorhoptrum* Rehn & Hebard, 1915; the genus *Gonatoxia* Karsch, 1889 is proposed to be synonymized with *Dapanera* Karsch, 1889.

Keywords

Distribution, taxonomy, tropical Africa, new species, synonymies

Introduction

The present paper is the result of the study carried out on material collected in tropical Africa by different collectors and preserved in various museums; it follows other three papers on the same subject (Massa 2013, 2014, 2015). Tropical Africa is a very rich area of Orthoptera, order of insects that in these regions have reached a very high degree of morphological diversity. Concerning katydids, many studies have been carried out since 1800 in this wide geographic area, but this group of Ensifera still hides many unknown taxa. Here taxonomy and distribution of some selected species are discussed and new taxa are described.

Material and methods

Series of tropical African specimens kindly obtained from Philippe Moretto were studied and identified; further specimens were examined in the below cited museums or loaned from them.

Abbreviations used in this paper

BMCP	Bruno Massa Collection, University of Palermo;
ISAM	Iziko South African Museum, Cape Town;
MfN	Museum für Naturkunde, Berlin;
MNCN	Museo Nacional de Ciencias Naturales, Madrid;
MRT	Museo Regionale di Storia Naturale, Terrasini (Palermo);
MSNG	Museo Civico di Storia Naturale 'G.Doria', Genoa;
MZR	Museo di Zoologia Università La Sapienza, Rome.

Some specimens were photographed with a Nikon Coolpix 4500 digital camera, mounted on a Wild M5 Stereomicroscope or Leika MZ75, and photos were integrated using the freeware CombineZP (Hadley 2008). Mounted specimens were measured with a digital calliper (precision 0.01 mm); the following measures were taken (all measurements in mm): Body length: dorsal length from the head to the apex of the abdomen, ovipositor excluded in females; Pronotum length: length of the pronotum along dorsal median line; Pronotum height: maximum height of the pronotum; Hind femur: length of hind femur; Tegmina: length of tegmina; Ovipositor: maximum length.

Results

Fam. Tettigoniidae Krauss, 1902
Subfam. Conocephalinae Burmeister, 1838
Tribe Copiphorini Karny, 1912

Ruspolia differens (Serville, 1838)

Material examined. Seychelles, Silhouette Is. 27.VI-3.VII.1988, F.A. Repetti (1♂) (MSNG).

Distribution. Angola, Ghana, Ivory Coast, Central African Republic, Zaire, Rwanda, Kenya, Uganda, Tanzania, Rhodesia, Zanzibar, Mauritius, Madagascar (Bailey 1975, Bailey and McCrae 1978).

Remarks. *Ruspolia differens* is a very widespread species throughout tropical Africa, including also some islands of the Indian Ocean. Its presence in the Seychelles archipelago is possibly explained as a passive importation.

Tribe Conocephalini Burmeister, 1838

Genus *Thyridorhoptrum* Rehn & Hebard, 1915

Rehn and Hebard (1915) described the genus *Thyridorhoptrum* with these characters: pronotum more abbreviate than in the American genus *Orchelimum* Krauss, 1877, very narrow lateral lobes of pronotum, an extremely large male stridulatory field of tegmina, with a large speculum (at least two-thirds that of the whole stridulatory field; the Latin name *Thyridorhoptrum* means window tambourine), bidentate male cerci, and broad fluting of the lateral surfaces of the ovipositor, abruptly terminating shortly proximad of the apex. They included only the species *T. senegalense* (Krauss, 1877). Later, Pitkin (1977), on the basis of much material coming from West, central, East and South regions of Africa, revised the genus, and described another species, *T. baileyi*, highlighting that both species of the genus may have two different forms, one with large mirror and another with small mirror, that could belong to different taxa. Finally, a third undescribed species has been recorded by Naskrecki (1999) from Ghana. Among material collected by Philippe Moretto in the Ivory Coast there is a species matching with the description of *Xiphidium carbonarium* Redtenbacher (1891), currently listed as *Conocephalus* (*Conocephalus*) *carbonarius* by Eades et al. (2015); it is here proposed to ascribe it to the genus *Thyridorhoptrum*.

Thyridorhoptrum senegalense Krauss, 1877

Material examined. Ivory Coast, Tuba, Biémasso 7-11.VII.2014 (UV), P. Moretto (1♀); Ivory Coast, Tuba, Biémasso forest 7-11.VII.2014, P. Moretto (1♀); Ivory Coast, Man, Mt. Tonkoui (1200 m) 24-27.XI.2014 (UV), P. Moretto (1♀); Burkina Faso, Borolo, Ft. Sorobouli 1-4.VII.2013 (UV), P. Moretto (1♀) (BMCP).

Remarks. The specimens above listed have 1 spine on outer genicular lobe of fore femora and on inner and outer genicular lobes of hind femora.

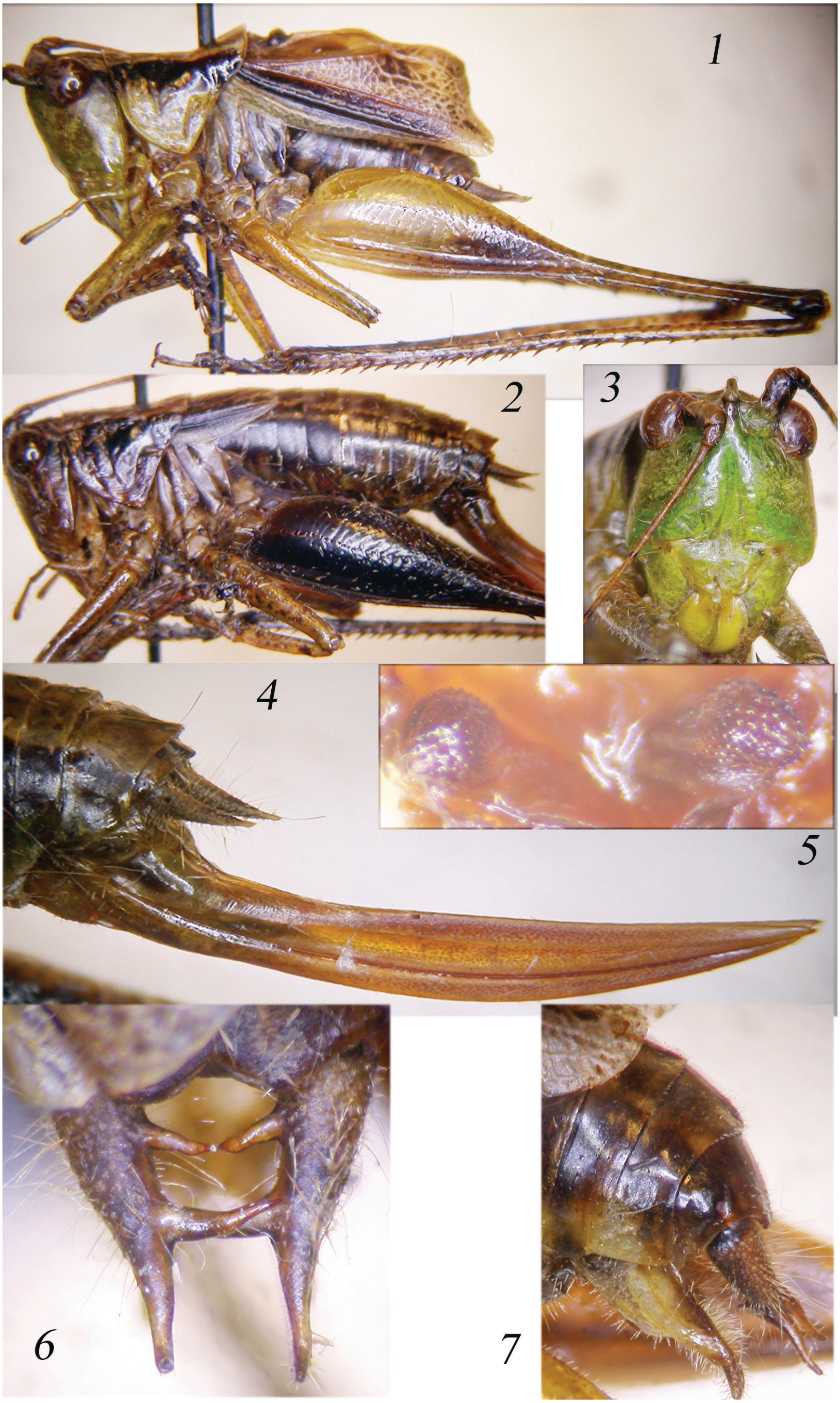
Thyridorhoptrum carbonarium (Redtenbacher, 1891), comb. n.

Figs 1–12

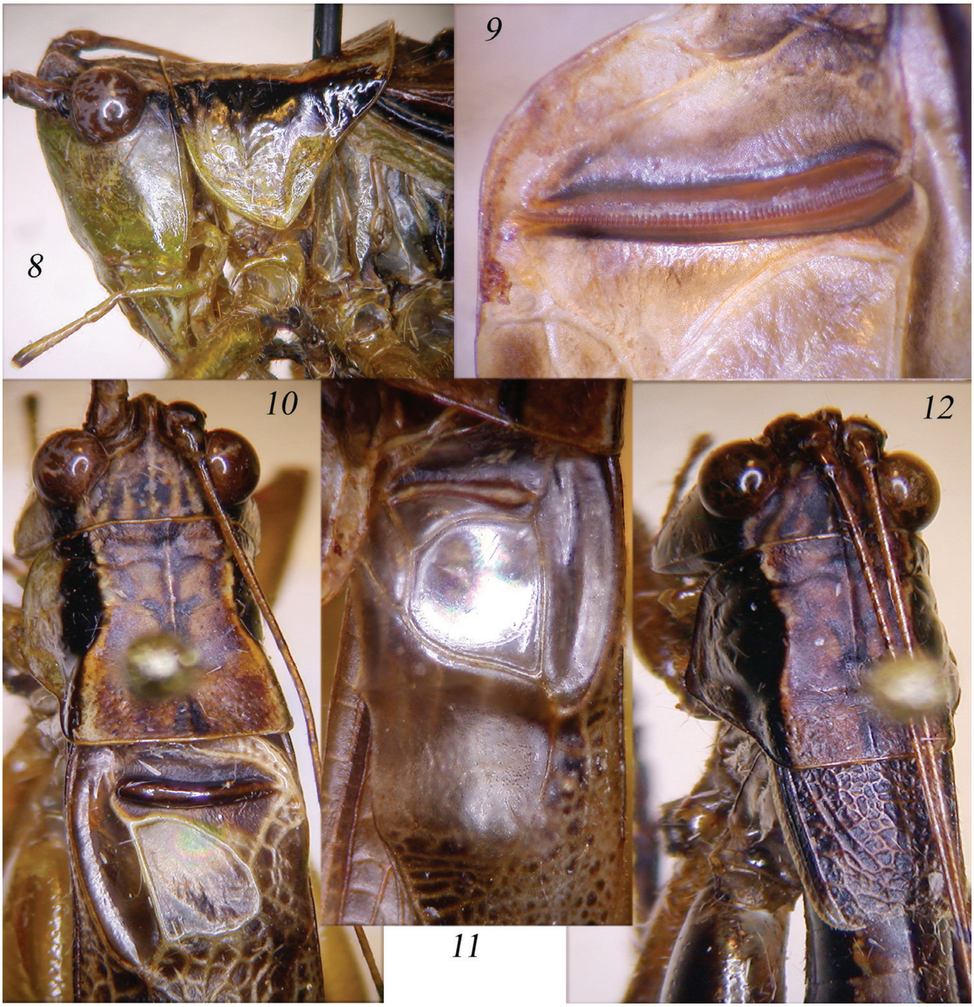
Material examined. Ivory Coast, Man, Mt. Tonkoui (1200 m) 7°26'58.46"N, 7°39'01.14"W 1–2.VII.2014 (UV), P. Moretto (1♂, 1♀); Ivory Coast, Man, Mt. Tonkoui (1200 m) 28.VI-1.VII.2014 (UV), P. Moretto (5♂, 4♀); Ivory Coast, Man, Mt. Tonkoui (1200 m) 24–27.XI.2014 (UV), P. Moretto (2♂, 3♀); Ivory Coast, Korhogo Village (347 m) 9°25'07.02"N, 5°36'59.41"W 13–15.VII.2014 (UV), P. Moretto (1♂) (BMCP).

Previous records. Redtenbacher (1891) described this species from Accra (Ghana). Chopard (1954) reported it as *Conocephalus* from Guinea, Ragge (1967) listed it again as *Conocephalus* from Democratic Republic of Congo, and Naskrecki (2008, 2009) from Ghana.

Redescription. When Redtenbacher (1891) described this species, he highlighted that two spines are present on the prosternum. Thus, it cannot be ascribed to the subgenus *Conocephalus* Thunberg, 1815, that lacks these spines. However, characters of male and female are more matching those of the genus *Thyridorhoptrum* than those of *Anisoptera* Latreille, 1829, to which the species has been ascribed by Kirby (1906). The characters are: Fastigium of vertex very narrow and raised between antennae (Fig. 3). Antennae twice longer than body. Eyes round (Figs 8, 10, 12). Fore coxae armed with a long spine, fore and mid femora unarmed, hind femora with 3 spines on outer lower margin. 1 small spine on the outer genicular lobe of fore femora and on inner and outer hind femora. Fore and mid tibiae with 4-5 spines on lower margins + 1 spur on each side, dorsal margins unarmed. Tympanic auricles closed. Hind tibiae with 8-10 spines on both lower margins + 2 spurs on each side; upper margins with many spines + 1 spur on each side. Sternum armed with two spines. Tegmina as long as abdomen or little shorter, clearly inflated, hind wings nearly rudimentary, as long as tegmina but very narrow. The stridulatory area of the left tegmen is accentuated by a swelling of the rib, which gives an undulating appearance when viewed along the lateral plane of the wing (Figs 1, 10). Stridulatory file of left tegmen as in Fig. 9; row of teeth not much curved, differentiated into very dense teeth at the dorsal and proximal ends and large and spaced teeth in the central section. The mirror of right tegmen is slightly rounded (Fig. 11). Cerci finely pointed, with two inner spines, the first shorter than the second,



Figures 1–7. *Thyridorhoptrum carbonarium* comb. n. Lateral view of male (**1**) and of female (**2**); face of the male (**3**); ovipositor (**4**); titillators (**5**); dorsal (**6**) and lateral view of cerci (**7**).



Figures 8–12. *Thyridorhoptrum carbonarium* comb. n. Lateral view of the head and pronotum of male (**8**); stridulatory file (**9**); dorsal view of head, pronotum and stridulatory area of left tegmen of male (**10**); mirror of right tegmen (**11**); dorsal view of head, pronotum and tegmina of female (**12**).

both are smooth (Fig. 6). Sub-genital plate concave with small styli (Fig. 7). Titillators, previously undescribed, are small and round, with a very wrinkled surface (Fig. 5). Female pronotum not raised, with metazona matt and roughly punctate (Fig. 12), micropterous, with very short tegmina, narrow hind wings, just exceeding tegmina (Figs 2, 12). Ovipositor gently up-curved (Fig. 4), sub-genital plate triangular with straight margin. Cerci conical.

Colour. Brown with green parts, with a clear darkish stripe on head and pronotum, continuing on fore wings. Frons green, hind legs with darkish markings in the distal parts of femora and basal parts of tibiae, in some specimens darkish outer face of hind femora (Figs 1, 2).

Table 1. Measurements of *Thyridorhoptrum carbonarium* comb. n. compared with the two forms (large- and small-mirror) of *T. senegalense* and *T. baileyi* (after Pitkin 1977). For all species the min-max range is reported, for *T. carbonarium* in parenthesis the mean value is also reported.

Species	Total length	Pronotum length	Length of hind femora	Length of tegmina	Length of ovipositor
T. senegalense large mirror	27.6–40.0 (♂) 34.0–45.9 (♀)	4.2–5.8 (♂) 4.0–5.6 (♀)	14.5–19.5 (♂) 15.6–22.3 (♀)	21.0–31.0 (♂) 25.1–35.9 (♀)	9.9–12.1
T. senegalense small mirror	28.0–31.9 (♂) 34.1–41.8 (♀)	4.7–5.5 (♂) 4.6–5.7 (♀)	15.8–17.9 (♂) 18.1–22.1 (♀)	19.4–25.2 (♂) 25.6–33.0 (♀)	11.2–14.1
T. baileyi large mirror	29.2–43.2 (♂) 33.6–41.9 (♀)	4.1–6.0 (♂) 4.0–5.0 (♀)	13.7–19.4 (♂) 16.1–19.9 (♀)	24.1–34.6 (♂) 26.6–33.6 (♀)	8.8–10.7
T. baileyi small mirror	20.4–34.9 (♂) 30.5–37.3 (♀)	4.2–5.4 (♂) 4.8–5.6 (♀)	13.6–19.6 (♂) 18.1–21.6 (♀)	14.1–27.0 (♂) 21.1–27.4 (♀)	12.0–13.9
T. carbonarium comb. n.	13.5–15.0 (14.0) (♂) 16.0–18.5 (17.3) (♀)	3.7–4.4 (4.1) (♂) 4.1–4.5 (4.3) (♀)	14.0–15.8 (15.2) (♂) 16.2–18.2 (17.5) (♀)	7.4–8.5 (8.0) (♂) 3.2–3.6 (3.4) (♀)	8.7–9.7 (9.2)

Measurements. See Table 1. *Thyridorhoptrum carbonarium* is a small species with very short wings (mainly in the females) and short ovipositor.

Diagnosis. No brachypterous species of *Thyridorhoptrum* are known. Both *T. senegalense* and *T. baileyi* are long-winged. The mirror of male right tegmen of *T. carbonarium* is similar to that of the small mirror form of *T. senegalense*, while in *T. baileyi* is more triangular. The stridulatory files are differently shaped in the other two species (see Pitkin 1977). The first inner spine of cerci in *T. senegalense* and *T. baileyi* has a serrated apex, while it is smooth in *T. carbonarium*. The ovipositor of *T. carbonarium* is gently up-curved, while in the other two species it is quite strongly up-curved.

Habitat. According to Chopard (1954), this species was collected in Guinea in forest habitats. Mt. Tonkoui is a forested mountain of Ivory Coast, with an average elevation of ca. 1,000 m a.s.l. It is covered by a tropical Moist Forest with evergreen broad-leaved species. Nevertheless, *T. carbonarium* is not strictly linked to forest habitats, because it has also been collected at light in the village of Korhogo (347 m). It seems that the main geographical feature is an average annual rainfall of ca. 1,200 mm, with the rainiest months being May to October, when adults of *T. carbonarium* are active.

Subfam. Phaneropterinae Burmeister, 1838[1]
Tribe Acrometopini Brunner von Wattenwyl, 1878

Genus *Horatosphaga* Schaum, 1853

According to Ragge (1960) the genus *Horatosphaga* is characterized as follows: basal part of MA of fore wings developed into longitudinal concavity with reduced venation, Cu_{1a} area basally enlarged, cross veins (mainly in costal and anterior medial areas) arranged

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[1] Recently Heller et al. (2014) proposed to consider Phaneropterinae at the family level, but Braun (2015) and Song et al. (2015) have shown that they have to be considered a sub-family of Tettigoniidae.

in closely parallel fashion, forming web-like pattern, R_s or its branches ending at tip of wings. Fastigium of frons almost reaches to top of antennal scrobes, tympanic auricles of fore tibiae often inflated. Females differ by fastigium of vertex sloping steeply to frons, pronotum sometimes with lateral carinae, tympana of fore tibiae not inflated, fore wings unmodified and hind wings rudimentary.

Twenty-nine species are currently listed within the genus *Horatosphaga*, of which three have been described by Hemp (2002, 2006, 2007), after the revision of Ragge (1960). In addition, Hemp et al. (2010) have described the genus *Altihoratosphaga*, including four species, three previously included in the genus *Horatosphaga*, *A. montivaga* (Sjöstedt, 1910), *A. nomima* (Karsch, 1896) and *A. nou* (Hemp, 2006), and another, *A. anangensis* Hemp, 2010, newly described in Hemp et al. (2010).

Characters of *Altihoratosphaga* are round tegmina with reduced venation and scattered black spots (except for *A. nomima*), vestigial alae, shape of pronotum verrucose in most species, and emarginate tenth abdominal tergite (only found similarly in the fully winged *Horatosphaga concava* Ragge, 1960). Females may be recognized by their slender, long, and slightly upcurved ovipositor. Both sexes in species of *Altihoratosphaga* are rather plump and dark green in colour, with rounded broad wings lacking web-like venation, whereas typical *Horatosphaga* are more slender, especially the males, and are mostly light green in colour, with more elongated wings, and with web-like venation in the male forewings. *Horatosphaga* is a very heterogeneous genus, with variable characters among species (e.g.: length of wings, sexual dimorphism, ovipositor shape, etc.), and following Ragge (1960), several species within this genus remain to be described. Here a new Ethiopian species is described, showing the characters of the genus.

Horatosphaga leggei (Kirby, 1909)

Figs 13, 15, 25

Material examined. Democratic Republic of Congo, Goma 3.I.1967, T. De Stefani (1♂); same data 11–12.XII.1967 (2♂); same data 21.XII.1967 (2♂); same data 25.XII.1967 (1♂); same data 29.XII.1967 (1♂); same data 31.XII.1967 (1♂); Democratic Republic of Congo, Bukavu 7.VIII.1967, T. De Stefani (1♂); same data 6.III.1969 (1♂); Democratic Republic of Congo, Mt. Kanzi (2000 m) 22.III.1970, T. De Stefani (1♂) (MRT).

Remarks. The right tegmina of specimens listed (both males and females) (Fig. 13) have venation as depicted by Ragge (1960), who also wrote that the female has the pronotum with well-developed lateral carinae in metazona. However, the female pronotum also has a verrucose surface of disc, not cited by Ragge (1960) (Fig. 15). *H. leggei* has a stridulatory file composed of 92-95 regularly placed teeth (Fig. 25).

Distribution. According to Ragge (1960) *H. leggei* is the most common species of the genus from East Africa to the Democratic Republic of Congo.

Horatosphaga linearis **(Rehn, 1910)**

Figs 14, 16

Material examined. Democratic Republic of Congo, Bukavu 28.III.1969, T. De Stefani (1♀); 10 Km N-NW Bukavu 3.VIII.1970, T. De Stefani (1♀) (MRT).

Remarks. The female of this species is well characterized by the venation of the right tegmen (Fig. 14) and slender ovipositor (Ragge 1960); the female pronotum has a verrucose surface of disc (Fig. 16), previously not cited (cf. Ragge 1960), but less so than in *H. leggei*.

Horatosphaga aethiopica **sp. n.**

http://zoobank.org/C13E52EB-70F7-4D4F-AA03-BD41E1D416DA

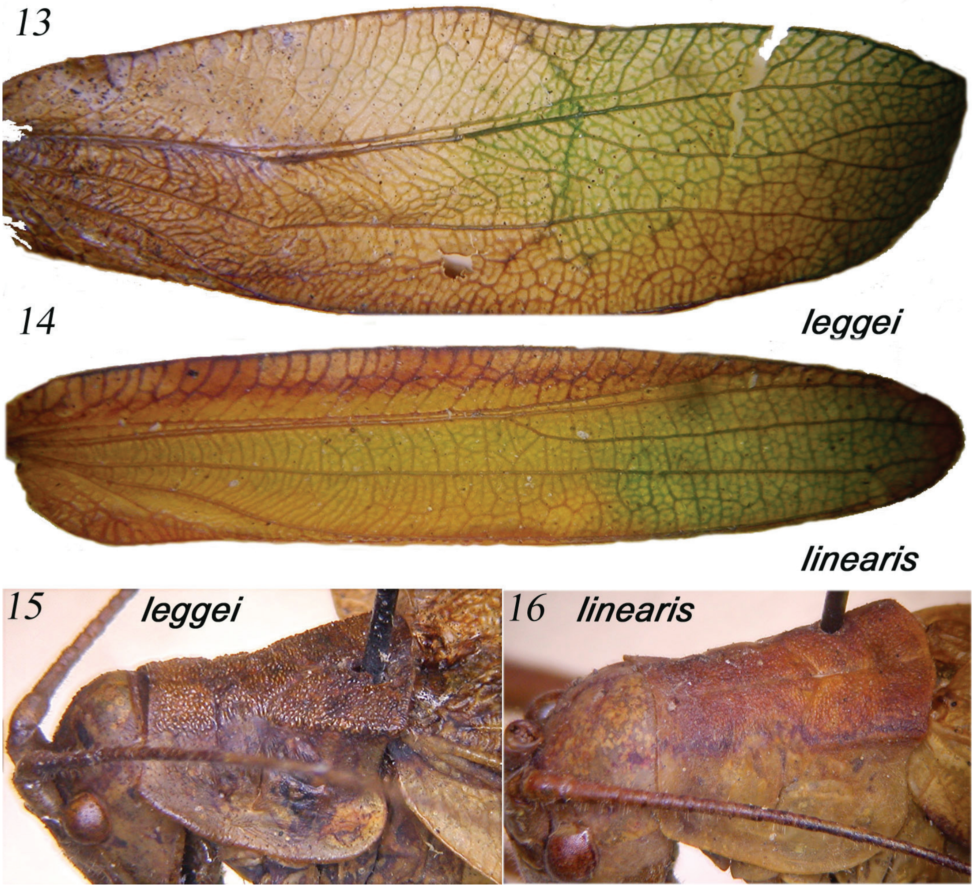
Figs 17–24

Material examined and depository. Ethiopia, Omo river, El Dire 5°06'21.45"N, 36°51'08.77"E (950 m) 21.V.1939 (Expedition E. Zavattari) (♂ holotype, ♀ allotype, ♂ paratype); Ethiopia, Omo river, El Dire (950 m) 19.V.1939 (Expedition E. Zavattari) (♀ paratype); Ethiopia, Omo river, Calam 4°41'20.08"N, 35°39'58.46"E (370 m) 14.VIII.1939 (Expedition E. Zavattari) (♀ paratype)) (MZR).

Colour. Yellowish (alive specimens may show different colour) (Figs 17, 22).

Description. Male. Head and antennae: fastigium of vertex very narrow, furrowed above, separated from the tuberculated fastigium of frons. Eyes rounded, well projecting. Legs long. Fore coxae unarmed. Fore tibiae furrowed on upper margin, distinctly widening above tympanum, which is closed on inner and on outer sides, tympanic auricles inflated. Fore femora unarmed, fore tibiae with 11 spines plus 1 spur on inner and outer ventral margins, 1 spur on inner and outer dorsal margins, mid femora unarmed, mid tibiae with 14 spines on inner and outer ventral margins, plus 1 spur on each side and 1 spur on both sides of dorsal margins, hind femora unarmed, hind tibiae with many spines on ventral and dorsal margins and 3 spurs on each side. Thorax: pronotum little narrowing anteriorly, little raised posteriorly, anterior margin straight, posterior margin rounded, humeral sinus absent, lobes of pronotum rounded and low. Tegmina shorter than abdomen, with pointed apices, their web-like venation very simple, cross-veins of area MA are arranged in a parallel fashion, a bit arcuate in inner part (Fig. 21). Hind wings rudimentary and linked to metanotum. Stridulatory region of left tegmen short and inflated, stridulatory file composed of 20-25 widely spaced teeth, of different size (Fig. 24). Abdomen: tenth tergite greatly enlarged and completely concealing supra-anal plate, in lateral view similar to a raptor beak (Figs 18-20); sub-genital plate long, up-curved and deeply divided into two lobes reaching margin of the tenth tergite and curved a bit backwards at end (Fig. 19); styli absent. Cerci short, in-curved, with a small apical spine (Fig. 20).

Female. As the male, but tegmina reduced to two small overlapping scales, not exceeding first abdominal tergite, but showing a residual web-like venation (Fig. 22).

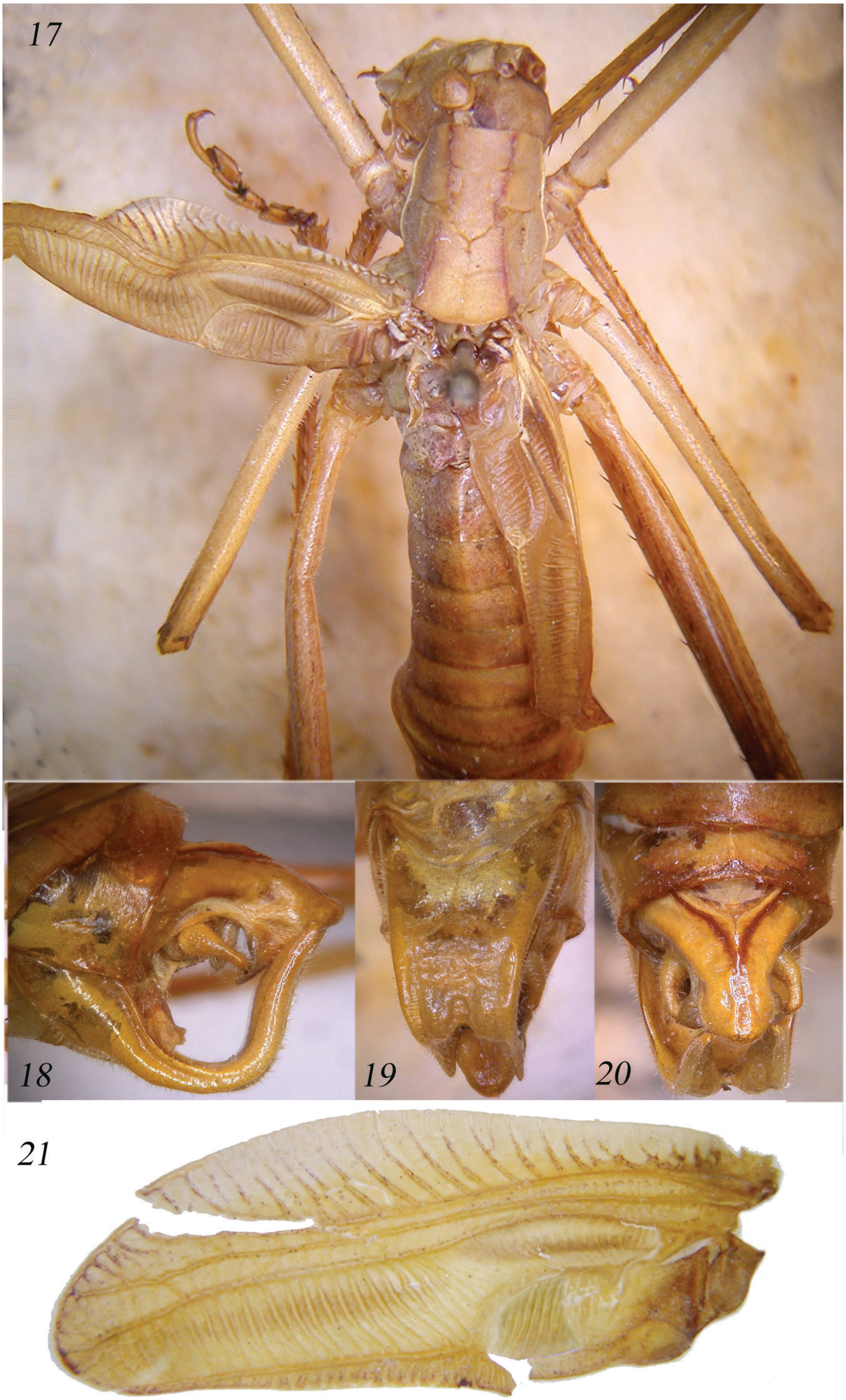


Figures 13–16. Right tegmen of females of *Horatosphaga leggei* (**13**) and *H. linearis* (**14**); lateral view of female pronotum of *Horatosphaga leggei* (**15**) and *H. linearis* (**16**).

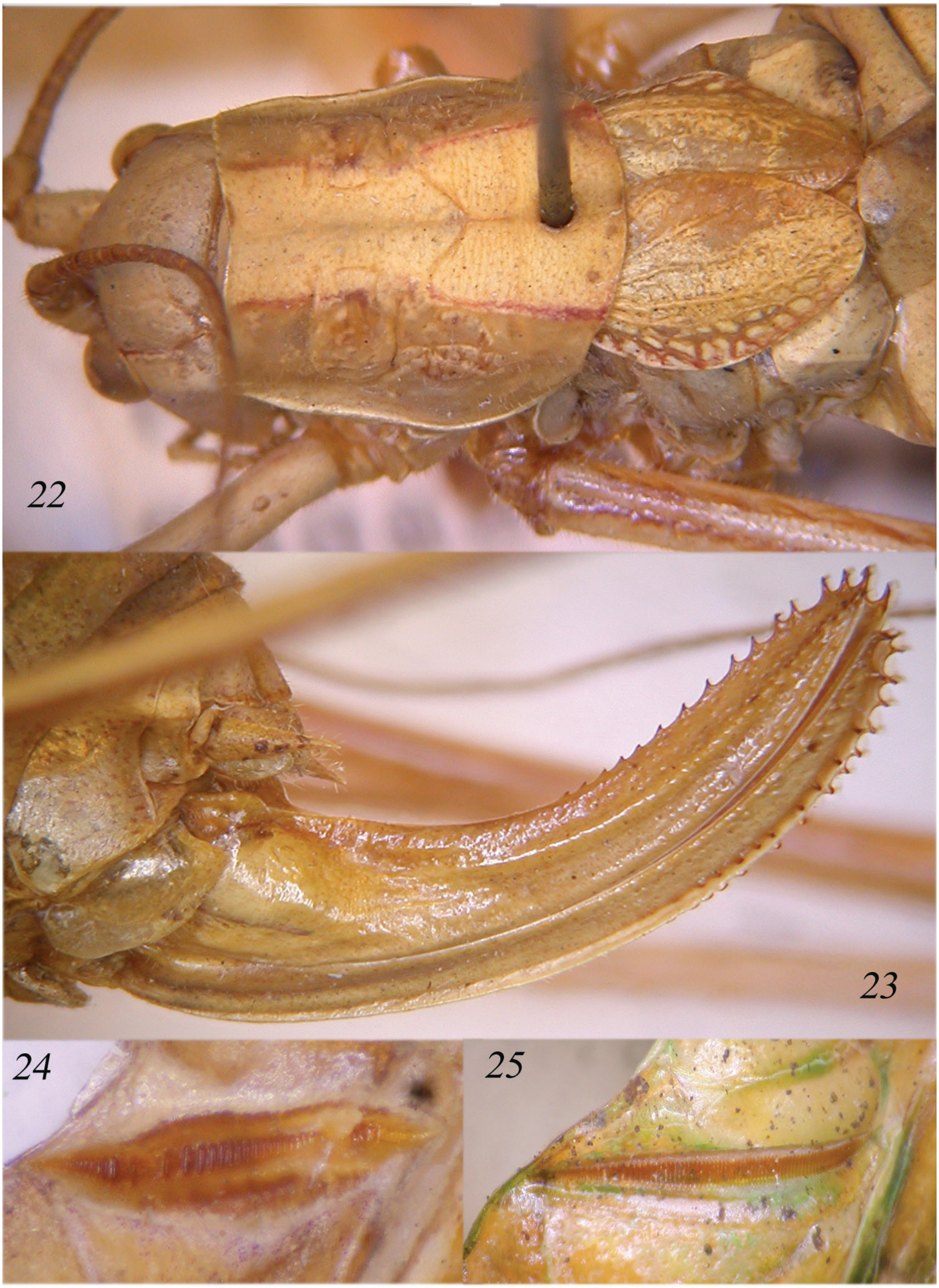
Cerci conical and pointed. Ovipositor up-curved and provided with many denticles on upper and lower margins (Fig. 23).

Measurements. See Table 2. *Horatosphaga aethiopica* is characterized by its very small size, compared to related species, in particular in the length of tegmina and ovipositor.

Diagnosis. Concerning the affinities between this and related species, there are only three *Horatosphaga* with the male having the tenth abdominal tergite greatly enlarged and completely concealing the supra-anal plate, namely *H. ruspolii* (Shulthess, 1898), *H. diminuta* (Chopard, 1954) and *H. vicina* (Chopard, 1954), all described from Kenya. *H. ruspolii* has fully developed wings, while the other two have reduced fore wings and rudimentary hind wings. According to Ragge (1960) *H. ruspolii* lives also in the eastern Ethiopia, in the area between Ethiopia and Somalia, and in Uganda. Its external genitalia are very variable, but appendices of the sub-genital plate are simply up-curved and shorter than those of *H. aethiopica* sp. n. However, Ragge (1960) suspected that *H. diminuta* could be a brachypterous form of *H. ruspolii*, and considered also that *H. vicina* could be a large form



Figures 17–21. *Horatosphaga aethiopica* sp. n. Dorsal view of male (**17**); lateral view of last abdominal tergites of male (**18**); sub-genital plate of male (**19**); dorsal view of last abdominal tergite, cerci and appendices of the sub-genital plate of male (**20**); left tegmen of male (**21**).



aethiopica n. sp. **leggei**

Figures 22–25. Dorsal view of head, pronotum and tegmina of female of *Horatosphaga aethiopica* sp. n. (**22**); lateral view of the ovipositor (**23**); stridulatory file of male of *Horatosphaga aethiopica* sp. n. (**24**); stridulatory file of *H. leggei* (**25**).

Table 2. Measurements of *Horatosphaga aethiopica* sp. n. and the related three species *H. ruspolii*, *H. vicina* and *H. diminuta* (after Ragge 1960). For all species the min-max range is reported.

Species	Total length	Pronotum length	Length of hind femora	Length of tegmina	Length of ovipositor
H. ruspolii	37.7–44.7 (♂)	4.7–5.7 (♂)	24.7–28.4 (♂)	29.4–35.2 (♂)	
	25.0–26.6 (♀)	5.9 (♀)	29.3 (♀)	17.9–19.0 (♀)	9.8–10.3
H. vicina	32.0–35.2 (♂)	6.9–7.1 (♂)	29.2–31.4 (♂)	25.0–26.9 (♂)	
	23.5–27.0 (♀)	7.2–7.4 (♀)	25.4 (♀)	14.8–17.0 (♀)	13.3
H. diminuta	26.3–32.0 (♂)	4.7–6.1 (♂)	22.7–28.2 (♂)	18.9–25.7 (♂)	
	20.5–26.1 (♀)	5.6–6.6 (♀)	23.4–27.8 (♀)	13.3–17.8 (♀)	9.8–10.8
H. aethiopica	20.8–22.1 (♂)	4.7–4.8 (♂)	19.5–20.0 (♂)	11.6–12.0 (♂)	
	20.5–22.0 (♀)	5.0–5.5 (♀)	21.3–21.5 (♀)	3.1–3.2 (♀)	8.2–9.1

of *H. diminuta*, that also Chopard (in Chopard and Mc Kevan 1954) considered almost an exact repetition of *H. vicina* on a rather smaller scale. *H. aethiopica* sp. n., which is smaller than the above three species (see Ragge 1960 and Table 2), differs from the previous species not only by its external male genitalia, but also by the high reduction of wings, mainly in the female, a character that forces individuals to an important isolation. The reduction of wings probably was also the cause for a very reduced stridulatory file. Regarding the reduction of the stridulatory file related to the wing reduction, it is possible that also *H. diminuta* has a different stridulatory file compared to the fully developed wings of *H. ruspolii*, and this should result in a different song, an important specific barrier.

Etymology. The Latin name *aethiopica* is a female adjective meaning "living in Ethiopia".

Discussion. In 1939, between March and September, Zavattari (1943) carried out an expedition to the territory of the Omo river in Ethiopia. During that trip, participants reached the northern part of the Turkana lake, where they collected also some Orthoptera. Among them there was the series of *Horatosphaga* specimens listed above. This new taxon is remarkably different from all related taxa. Indeed, in none of the species known till now, the tegmina of the female are so much reduced to two small scales, as in *H. aethiopica* sp. n. Concerning the tribe Acrometopini, the characters of this *Horatosphaga* species and those of other related species as provided by Hemp (2011) and Hemp et al. (2010) modify and update the key in Ragge (1960) partially based on the ratio between the length of the pronotum to that of the tegmina.

Tribe Phaneropterini Burmeister, 1838

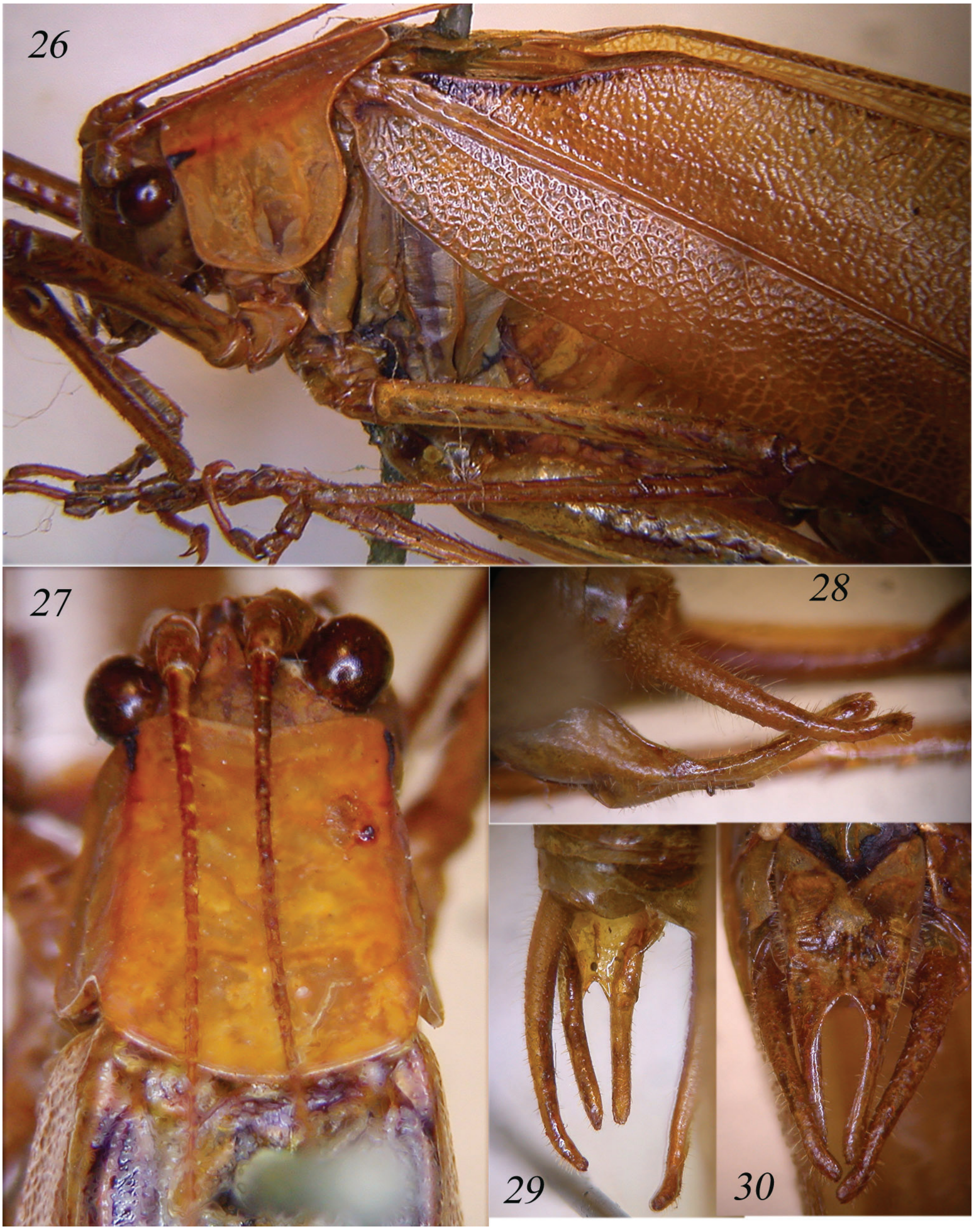
Symmetrokarschia plana (Walker, 1869), comb. n.

Figs 26–30

Material examined. South Africa, Kwa Zulu-Natal, Nhandla Forest, I.1937 (2♂) (ISAM).

Remarks. Walker (1869) described *Phaneroptera plana* from Kwa Zulu-Natal (South Africa). Later, Kirby (1906) transferred the taxon to the genus *Tylopsis* Fieber, and Ragge (1964) placed it in the genus *Symmetropleura* Brunner, 1878. Another species described by Chopard (1955), *Catoptropteryx latipennis* from Cape Province, Tsitzikama forest, was synonymized by Huxley (1970) with *Symmetropleura plana*. The genus *Symmetropleura* was based on a Neotropical type-species, *S. laevicauda* Brunner, 1878 and contained three further Neotropical and three African species. However, Ragge (1968, 1980) pointed out that *Symmetropleura* is a New World genus, occurring in South America, Mexico and the Eastern USA, and that the African species are neither very similar to each other nor to the Neotropical type-species of the genus. Finally, Massa (2015) described two new genera for two African species: *Symmetrokarschia africana* (Brunner von Wattenwyl, 1878) and *Symmetroraggea dirempta* (Karsch, 1889), but he was unable to examine specimens of the third species, *S. plana* (Walker, 1869). Now, the availability of the above listed specimens allows to propose the change of the taxonomic status of this species.

Characters of the genus *Symmetropleura* are: fastigium of vertex triangular and sulcate; pronotum disc flat, with lateral excisions; tegmina wide with rounded hind margin or narrow with straight hind margin; fore and mid femora with ventral inner spines, hind femora with double row of ventral spines. Fore and mid tibiae dorsally unarmed or with some spinules; cerci long, in-curved and pointed; male sub-genital plate short with rounded posterior margin or (in *S. africana*) long with triangular apex; styli absent; ovipositor longer than pronotum, not much curved, sharp, with upper and lower apices serrate; female sub-genital plate triangular, just concave. In the description Brunner von Wattenwyl (1878) referred mainly to *S. laevicauda*, both within the text and in the figure 73; thus, by subsequent designation, Kirby (1906) established *S. laevicauda* as the type-species of the genus. Massa (2015) transferred *S. africana* to the genus *Symmetrokarschia*, on the basis of its peculiar characters: pronotum disc with regular impressed punctures, fastigium of vertex compressed, narrower than first antennal segment, sulcate above, eyes oval, prominent; absence of fronto-genal carinae; pronotum just depressed, fore part with just definite lateral carinae, central and hind parts with vague lateral carinae; fore margin slightly concave, posterior margin rounded; surface dotted, matt; fore coxae with a long spine, fore tibiae with open tympanum on each side, furrowed on upper border; fore and mid femora with 3-5 spines, hind femora with 5-8 inner ventral and 6-7 outer ventral spines; fore and mid tibiae with 1 dorsal and 1 ventral spur, hind tibiae with 3 apical spurs on each side; male tenth tergite laminate and protruding, with straight posterior margin, cerci little in-curved, with flat apex and pointed, sub-genital plate long, narrow, with obtuse and short cut apex, styli absent. Ovipositor well developed, sharply bent upwards near the base, shorter than pronotum, with upper border and apex of lower border finely serrate, sub-genital plate triangular and pointed. Tegmina wide and oval, with rounded hind border more pronounced in female than in male.



Figures 26–30. *Symmetrokarschia plana* comb. n. Lateral view of head, pronotum and tegmina of male (**26**); dorsal view of head and pronotum (**27**); lateral (**28**) and dorsal view (**29**) of cerci and appendices of male sub-genital plate; sub-genital plate of male and cerci (**30**).

Characters of *S. plana* are testaceous-green, smooth, rather stout; head nearly as broad as the pronotum, with a short keel between eyes; front erect. Fastigium of vertex compressed, narrower than first antennal segment, sulcate above (Fig. 27). Eyes tawny, nearly round, rather prominent; absence of fronto-genal carinae. Disk of the pronotum flat, slightly widening hindward, with an abbreviated curved transverse line in middle; lateral keels just defined, each accompanied by an ochraceous line; fore margin slightly excavated; sides and hind margins slightly rounded, surface matt, characterized by a right and a left black spots on fore margin (Figs 26–27). Legs long, slender; fore coxae armed, fore tibiae with open tympanum on each side, furrowed on upper border. Fore tibiae with 6 inner + 1 spur and 7 outer spines + 1 spur on ventral margin, 3 outer spines + 1 spur on dorsal margin; mid tibiae with 8 inner + 1 spur and 10 outer spines + 1 spur on ventral margin, 2-3 inner and 7 outer spines + 1 spur on dorsal margin (on the whole both fore and mid tibiae have 1 dorsal and 2 ventral spurs); hind tibiae with 3 apical spurs on each side. Fore femora with 3-4 spines on each side of ventral margin, mid femora with 5 outer spines on ventral margin, unarmed on inner ventral margin. Hind femora with 3-4 small spines on each side of ventral margin. Fore wings rather narrow, with a ferrugineous streak along the anal vein and another nearer to base of hind margin (Fig. 26); interno-medial vein abruptly curved to the hind margin near tip; branch of externo-medial vein forked; veinlets very numerous, minute and irregular. Hind wings pellucid, longer than fore wings, green and with texture as in fore wings along apical part of costa; veins white. Male tenth tergite laminate with straight posterior margin (Fig. 29), cerci and lower appendages rounded at tips, nearly cylindrical, the former more curved than the latter, cerci very long, up-curved with flat and just pointed apex (Figs 28–29); subgenital plate very long, narrow, with two very long appendices, just shorter than cerci; styli absent (Fig. 30).

Diagnosis. Differences from *S. africana* are the absence of evident lateral carinae on metazona of pronotum, narrow tegmina, and fore and mid tibiae with 3 spurs. Considering the high variability of some characters found in other genera of African Phaneropterinae, it seems reasonable to consider also *S. plana* as belonging to the genus *Symmetrokarschia*, and to exclude the genus *Symmetropleura* definitively from the African fauna.

Preussia lobatipes Karsch, 1890

Material examined. Cameroon, Barombi Station (holotype ♀) (MfN); Ivory Coast, Man, Mt. Tonkoui (1200 m) 28.VI–1.VII.2014 (UV trap), P. Moretto (♂) (BMCP).

Remarks. *Preussia lobatipes* was described from one female from Barombi Station (Cameroon) and considered by the author as being related to *Symmetropleura africana* (see above); the male was described one year later from the same locality (Karsch 1891). Griffini (1908) recorded it from Mukonje Farm (Cameroon), Leroy (1985) from Central African Republic and Naskrecki (2008, 2009) from Ghana. This from Ivory Coast is new and the westernmost record known till now, Mt. Tonkoui is at NW of Man, next to the border with Guinea.

Genera *Dapanera* Karsch, 1889

Karsch, 1889. Berlin Ent. Z. 32: 423, 441

Gonatoxia Karsch, 1889, syn. n.

Karsch, 1889. Berlin Ent. Z. 32: 423, 441

Remarks. The genus *Dapanera* was erected by Karsch (1889) and is characterized by stout and long styli. Karsch (1889) described *D. genuteres*, and later (Karsch 1890) *D. irregularis*, very similar to the previous species, but with different cerci shape and length of styli (shorter than in *D. genuteres*). Further, Griffini (1908), Sjostedt (1912) and Massa (2013) have highlighted that *D. irregularis* is smaller than *D. genuteres* and has shorter ovipositor. The genus *Dapanera* contains another species, *D. eidmanni* (see below); all the species are morphologically very similar, with the exception of the shape of the male subgenital plate, cerci, styli length and stridulatory files (Figs. 31–49). The genus *Gonatoxia* was described by Karsch (1889) on the same page as *Dapanera* with the following differences: fastigium of vertex not sulcate, tegmina wider and genicular lobes of hind femora with a spine. However, the fastigium of *Gonatoxia* may be sulcate as shown in Fig. 48 and also the genicular lobes of the hind femora of *Dapanera* may present a small spine. Remaining as difference the width of tegmina, a variable character within the same genus in Phaneropterinae, it seems rather evident that *Dapanera* and *Gonatoxia* are synonyms, with priority for *Dapanera*, described by Karsch (1889) before *Gonatoxia*. Thus, the two *Gonatoxia* species become *Dapanera maculata* (Karsch, 1889), comb. n. and *Dapanera immaculata* (Karsch, 1889), comb. n. Species described in the genus *Gonatoxia* are known from East Africa, while those of the genus *Dapanera* from West and central Africa. A further new species of *Dapanera* is here described from the Central African Republic.

Dapanera maculata (Karsch, 1889), comb. n.

Figs 48, 49

Material examined. Somalia (1♀) (MNCN); Somalia, Mogadishu (1♂) (MZR).

Remarks. *Dapanera maculata* has very stout styli, stout cerci (Fig. 49) and punctured pronotum (Fig. 48). It is distributed in Somalia, Kenya and Tanzania (Hemp 2013).

Dapanera eidmanni Ebner, 1943

Figs 33, 34, 40, 46

Material examined. Ivory Coast, Man, Mt. Tonkoui (1200 m) 1-4.VII.2014 (UV trap), P. Moretto (1♂) (BMCP).

Remarks. Described from Bioko, Fernando Poo (Equatorial Guinea) (Ebner 1943), it is distinguished from *D. irregularis* Karsch, 1890 mainly by the cercus shape (Figs 33, 34, 40). This is the first record of the species since its description. The record from Ivory Coast extends its distribution remarkably eastwards. *D. eidmanni* is also distinguished from *D. irregularis* by its sub-genital plate, which is similar to that of *D. genuteres*, little divided and with slender and long styli (compare Fig. 40 with 41 and 42). However, the cerci of *D. eidmanni* are stout, more similar to those of *D. irregularis* (compare Figs 33–34 with 35–38).

Dapanera occulta sp. n.

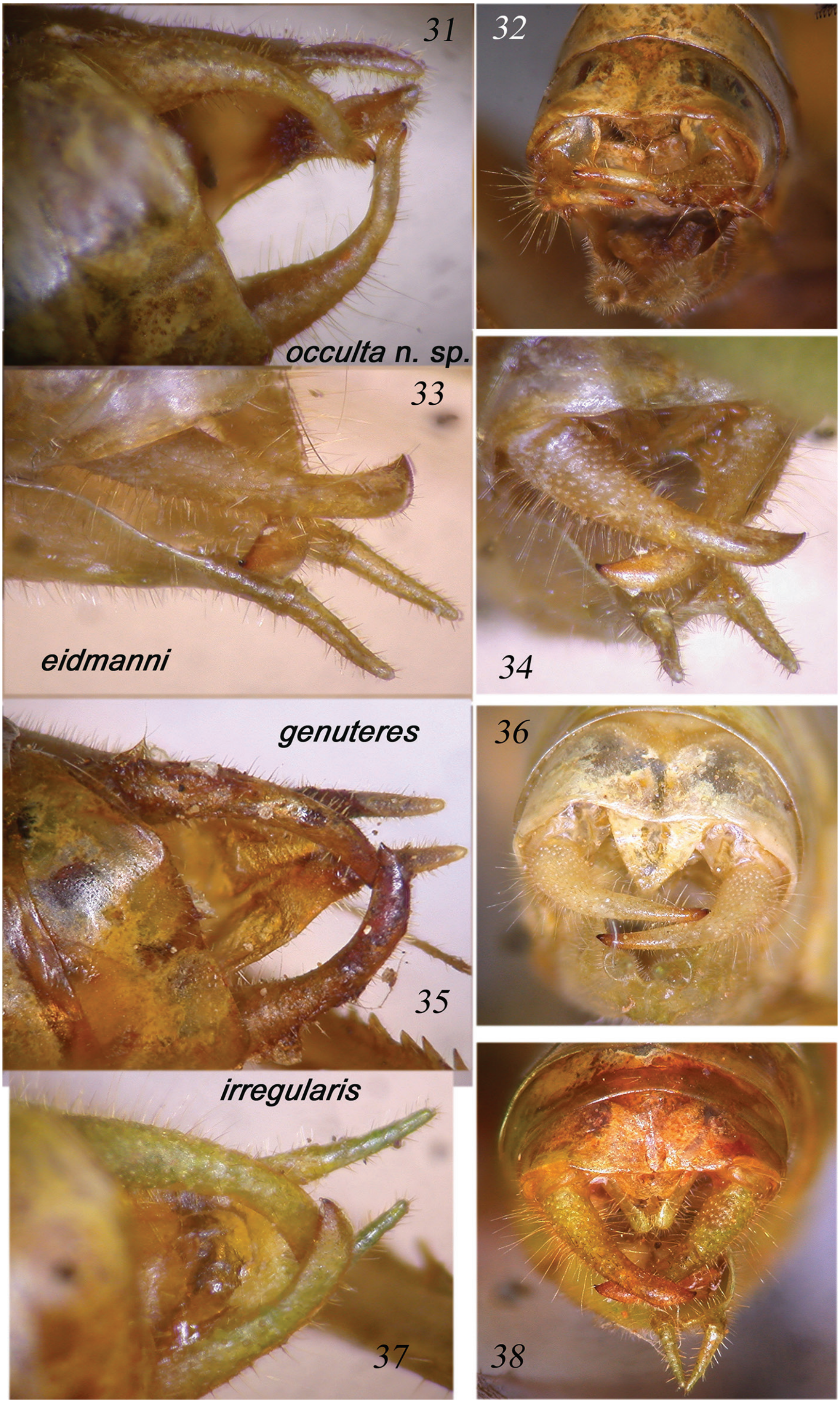
http://zoobank.org/C1384DAE-60D9-441E-A0DE-051D695CD4BF
Figs 31, 32, 39, 43, 47

Material examined and depository. Central African Republic, Dzanga-Ndoki National Park, Ndoki, Lake 1, UV trap 1, 02°28'40.5N, 016°13'02.6E, 31.I.-2.II.2012, P. Moretto (♂ holotype) (MSNG); same data (♂ paratype); Central African Republic, Dzanga-Ndoki National Park, Ndoki, Lake 1, UV trap 1, 02°28'40.5N, 016°13'02.6E, 10–11.II.2012, P. Moretto (♂ paratype); same data, 11–12.II.2012 (2♂ paratypes); same data, 20–23.II.2012 (♂ paratype); Central African Republic, Dzanga-Ndoki National Park, Ndoki, border of Lake 1, UV trap 02°28'51.0N, 016°13'04.5E, 13–14.II.2012, P. Moretto (♂ paratype) (BMCP).

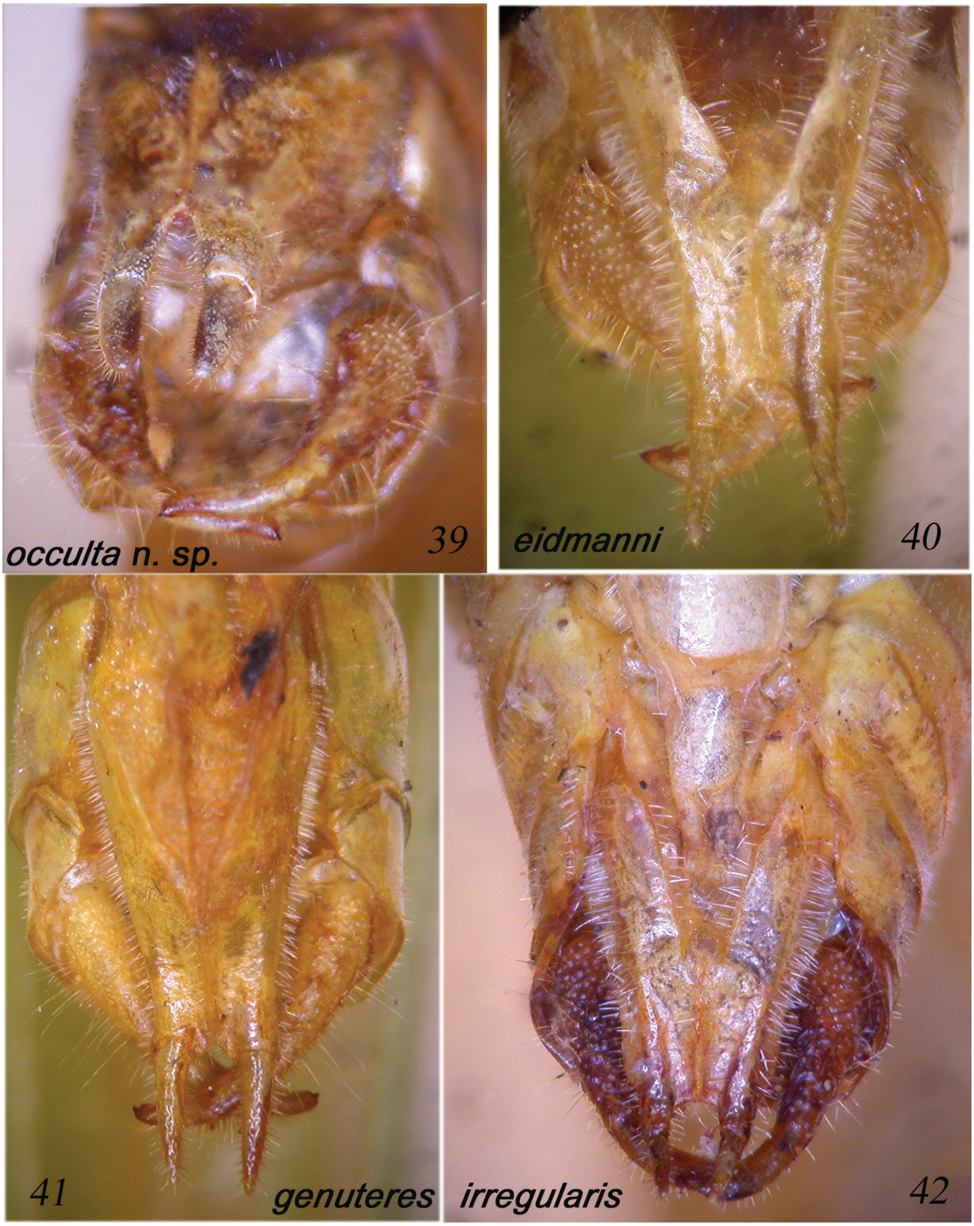
Colour. Yellow-green. Femora yellow with or without longitudinal brown stripe on outer side.

Description. Male. Medium sized. Head and antennae: fastigium of vertex narrow, furrowed above, separated from fastigium of frons that is tuberculated. Eyes rounded, well projecting (Fig. 47). Legs comparatively long. Fore coxae armed with a well-developed spine. Fore tibiae furrowed on upper margin, distinctly widening above tympanum, which is closed on inner and open on outer side. Fore femora armed on inner ventral margin with 3-4 spines, fore tibiae with 3 spines plus 1 spur on inner and outer ventral margins, 1 spur on outer dorsal margin, mid femora armed with 5 spines on outer ventral margin, mid tibiae with 8 on outer and 4-5 spines on inner ventral margins, plus 1 spur on each side, hind femora armed with 7-8 spines on outer and inner ventral margins, hind tibiae with many spines on ventral and dorsal margins and 3 spurs on each side. Thorax: pronotum little narrowing anteriorly, flat above, anterior margin straight, posterior margin rounded, humeral sinus evident, lobes of pronotum rounded. Tegmina comparatively wide with rounded apices. Wings longer than tegmina. Stridulatory region of left tegmen narrow, stridulatory file curved and composed of 70–75 teeth (Fig. 43). Abdomen: tenth tergite with straight hind margin; sub-genital plate long and deeply divided into two lobes; styli stout and long (Figs 31–32). Cerci long, thin, in-curved and sinuous, with small apical spine, longer than sub-genital plate (Figs 31, 32, 39).

Measurements. Males. Body length: 21.6–24.1; pronotum length: 5.5–5.6; pronotum height: 4.6–4.8; hind femur: 18.7–20.8; tegmina: 32.9–34.9.

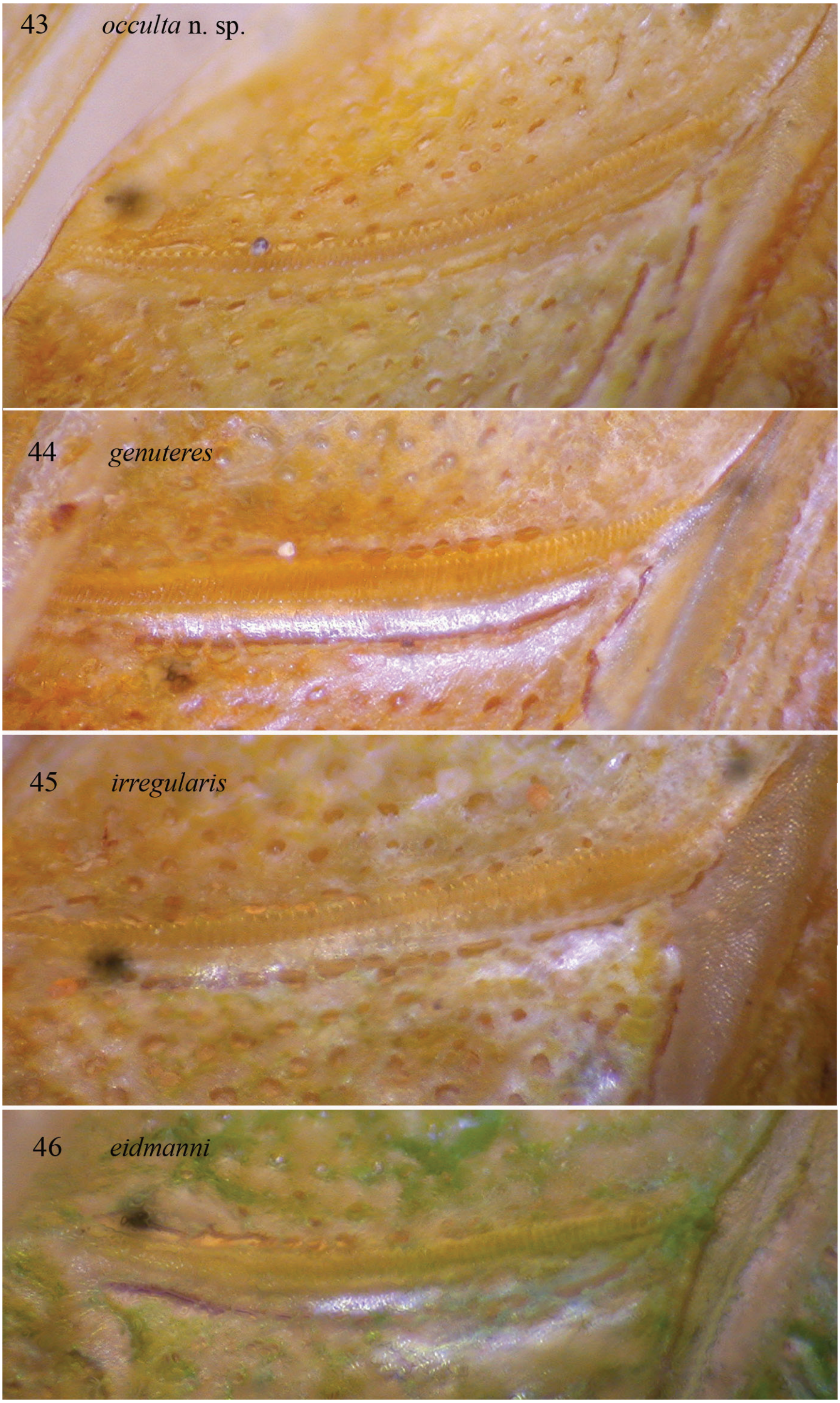


Figures 31–38. Lateral and dorsal view of male cerci and sub-genital plate of *Dapanera occulta* sp. n. (**31–32**), *D. eidmanni* (**33–34**), *D. genuteres* (**35–36**) and *D. irregularis* (37–38).

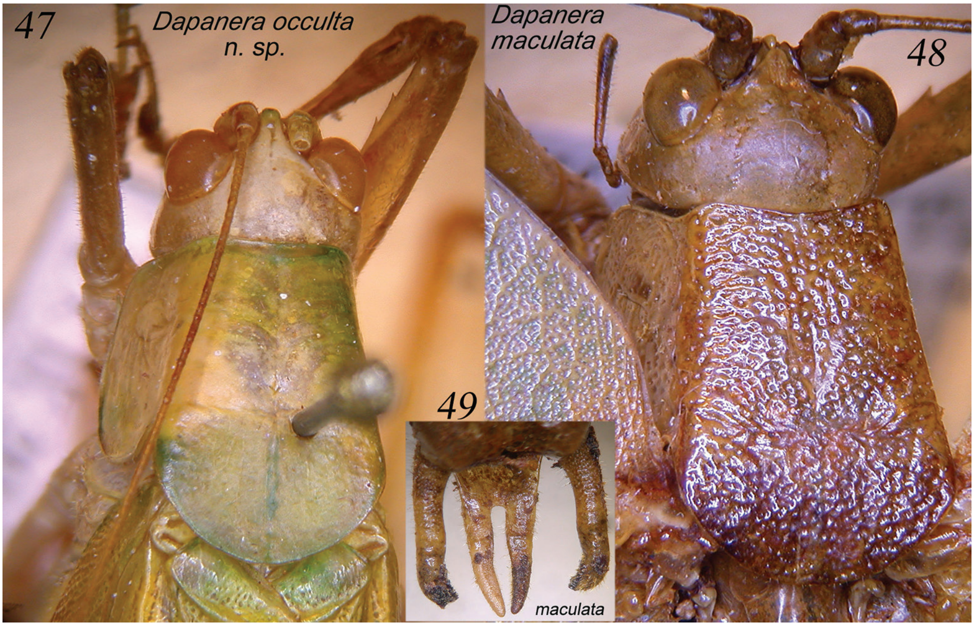


Figures 39–42. Male sub-genital plate of *Dapanera occulta* sp. n. (**39**), *D. eidmanni* (**40**), *D. genuteres* (**41**) and *D. irregularis* (**42**).

Diagnosis. *Dapanera occulta* sp. n. is mainly characterized by its cerci that in the other species of the genus *Dapanera* are stout and never sinuous; in addition, the styli are stout and short, while in *D. genuteres* and *D. eidmanni* they are slender and longer (Figs 33–36); the sub-genital plate is deeply divided, more than in *D. irregularis*, *D. eidmanni*



Figures 43–46. Stridulatory file of left tegmen of male of *Dapanera occulta* sp. n. (**43**), *D. genuteres* (**44**), *D. irregularis* (**45**) and *D. eidmanni* (**46**).



Figures 47–49. Dorsal view of head and pronotum of males of *Dapanera occulta* sp. n. (**47**) and *Dapanera maculata* comb. n. (**48**); cerci and sub-genital plate of male of *D. maculata* comb. n. (**49**).

and *D. genuteres* (in the latter two species it is very little divided) (Figs 39–42). The stridulatory files of *D. genuteres*, *D. eidmanni* and *D. irregularis* are less curved, also composed of 70–75 teeth or more; the teeth are larger in *D. genuteres* and *D. irregularis* than in *D. occulta* sp. n., while in *D. eidmanni* as small as in *D. occulta* sp. n. (Figs 43–46).

Female. Unknown.

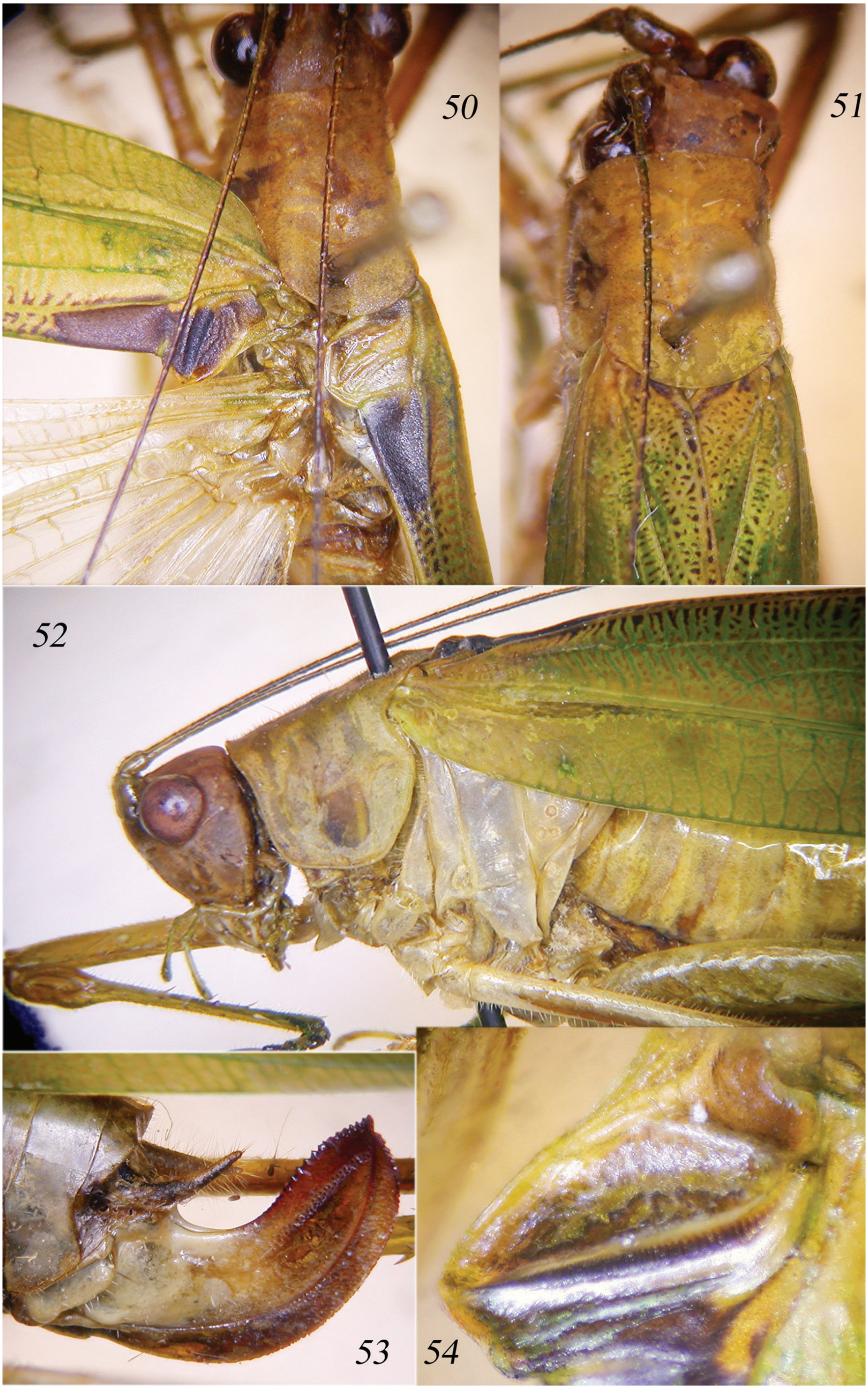
Etymology. From Latin (*occulta* = hidden), female adjective; the series of specimens remained unidentified and hidden in a box containing long series of *D. irregularis* and *D. genuteres* collected in the same localities during the same expedition (see Massa 2013).

Cestromoecha laeglae sp. n.

http://zoobank.org/589D3B04-164C-4011-B240-14A9DD25F1C1
Figs 50–57

Material examined and depository. Ivory Coast, Tuba, Biémasso (441 m), 8°04'00.09"N, 7°32'59.96"W (UV trap) 9.VII.2014, P. Moretto (♂ holotype) (MSNG); same locality, 7–11.VII.2014, P. Moretto (♂ paratype, ♀ allotype); same locality, 9.VII.2014, P. Moretto (♂ paratype) (BMCP).

The genus *Cestromoecha* Karsch, 1893 is related to *Poreuomena* Brunner von Wattenwyl, 1878, which also lives in central-western Africa and differs from it chiefly in the shape of the male tenth tergite, being slightly bilobate or rounded, in the male



Figures 50–54. *Cestromoecha laeglae* sp. n. Dorsal view of head, pronotum and tegmina of male (**50**) and female (**51**); lateral view of head, pronotum and tegmina of male (**52**); lateral view of ovipositor (**53**); stridulatory file of left tegmen of male (**54**).

Figures 55–57. *Cestromoecha laeglae* sp. n. Dorsal view of male cerci (**55**); sub-genital plate and cerci of male (**56**); lateral view of cerci (**57**).

sub-genital plate, being deeply bilobate, and in the shape of the cerci. Styli are absent. Five species are known, *C. crassipes* (Karsch, 1890), *C. tenuipes* (Karsch, 1890), *C. mundamensis* Karsch, 1896, *C. longicerca* Massa, 2013 and *C. magnicerca* Massa, 2013. Here a sixth species is described.

Colour. Brown or green, stridulatory area of left tegmen and area below it black. Small black spots are present on posterior margins of tegmina. Two longitudinal parallel dark lines are present on outer surface of hind femora.

Description. Male. Diagnostic characters of the genus. Eyes round (Fig. 52), fastigium of vertex triangular, sulcate. Fore coxae armed, fore and mid femora with 4–5 very small spines[2], fore tibiae with 3 ventral spines + 1 spur on each side, mid tibiae

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[2] Differing from what has been reported by Massa (2013), species of genera *Cestromoecha* and *Poreuomena* have 4–5 very small spines on ventral margins of fore and mid femora.

with 6–7 ventral spines + 1 spur on each side, hind tibiae with 3 spurs on each side. Ventral margins of hind femora with 2 small basal spines. Tegmina narrow, stridulatory area of left tegmen black and straight (Fig. 50); stridulatory file down-curved with ca. 50 teeth , distal part with asymmetrical and widely spaced teeth (Fig. 54). Tenth tergite slightly bilobate. Cerci stout, long and in-curved, with basal part rounded and apical part flattened and pointed; in middle with a well-developed flattened large inner spine, blackish at tip. Sub-genital plate concave, triangular and long, with a deep concavity, processes rather parallel (Figs 55–57).

Female. As male, but without blackish markings and with only brown spots (Fig. 51). Ovipositor up-curved and provided with small denticles on the upper and lower margins (Fig. 53).

Measurements. Males. Body length: 18.5–19.4; pronotum length: 4.0–4.2; pronotum height: 3.4–3.6; hind femur: 18.2–20.7; tegmina: 26.4–27.5. Female. Body length: 21.7; pronotum length: 4.0; pronotum height: 3.4; hind femur: 20.8; tegmina: 29.4; ovipositor: 6.1.

Diagnosis. *C. laeglae* sp. n. is related to *C. magnicerca*. The cerci of the male are stout, long and in-curved, with the basal part rounded and the apical part flattened and pointed; a wide flattened inner spine arises from its middle; in *C. magnicerca* the cerci have trifid apices. The sub-genital plate is concave, but not long, with parallel processes, very similar to those of *C. magnicerca*. The stridulatory file of *C. laeglae* sp. n. is also similar to that of *C. magnicerca* with distal part with less and more widely spaced teeth than the proximal part (see Massa 2013).

Etymology. Laegla is the nickname of Giovanna Varrica, to whom this species is dedicated.

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A new species of *Mollitrichosiphum* Suenaga from Taiwan Island (Hemiptera, Aphididae), based on morphological characteristics and DNA sequences

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Abstract

A new species of *Mollitrichosiphum* Suenaga, *Mollitrichosiphum tumorisiphum* Qiao & Jiang, **sp. n.**, from *Fagus longipetiolata* in Taiwan island is described. Siphunculi of *M. tumorisiphum* in alatae are distinctly swollen on the distal part, unlike those of the other known species in the genus. Updated keys to apterous and alate viviparous females of all known Chinese species of *Mollitrichosiphum* are provided. The specimens studied are deposited in the National Zoological Museum of China, Institute of Zoology, Chinese Academy of Sciences, Beijing, China and the Natural History Museum, London, United Kingdom.

Keywords

Mollitrichosiphum tumorisiphum, Greenideinae, morphology, DNA barcode, NJ tree

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[*] These authors contributed equally to this work.

Introduction

The oriental genus *Mollitrichosiphum* Suenaga (Greenideinae, Aphididae) is restricted mainly to south-east Asia, and is represented by 11 known species in China (Remaudière and Remaudière 1997, Zhang and Qiao 2010). It is distinguishable from other genera of Greenideinae by a series of transverse ridges on the hind tibia. At present, there are six species recorded in Taiwan Island (Tao 1990, 1999, Zhang and Qiao 2010). Amongst aphid samples in the recent survey of Taiwan, two samples of the genus *Mollitrichosiphum* were found that could not be identified to any known species. Based on morphological features and molecular data, one new species *Mollitrichosiphum tumorisiphum* Qiao & Jiang, sp. n., feeding on *Fagus longipetiolata*, from mountainous areas in the northern and central part of Taiwan is described here. This new species differs from any other *Mollitrichosiphum* species in having alatae with siphunculi distinctly swollen on the distal part. Updated keys to the Chinese species of this genus are provided.

Materials and methods

Morphological description. Aphid terminology and the measurements in this paper generally follow Blackman and Eastop (2006) and Zhang and Qiao (2010). The unit of measurement in this paper is millimetres (mm). Metrical data are listed in Table 1. The holotype and one alate viviparous female of the paratypes (No. 26510) are illustrated in Figures 1–36.

Molecular analyses. Fifty-seven samples belonging to eight *Mollitrichosiphum* species were included. The standard molecular barcode, mitochondrial cytochrome *c* oxidase subunit I (COI), and a faster-evolving gene, cytochrome *b* (Cytb), were used. All sequences were taken from Liu et al. (2013), Zhang et al. (2011) and Zhang et al. (2012). Voucher information and GenBank accession numbers for all samples are listed in Table 2. Multiple alignments were conducted with ClustalX 2.0.12 (Larkin et al. 2007) and then verified manually. Neighbor-joining (NJ) trees and genetic distances were estimated for both COI and Cytb sequences with MEGA 6.06 (Tamura et al. 2013), using Kimura's two-parameter (K2P) model (Kimura 1980). Bootstrap analyses were performed with 1000 replications.

Specimen depositories. The holotype, some paratypes of the new species and the other specimens examined are deposited in the National Zoological Museum of China, Institute of Zoology, Chinese Academy of Sciences, Beijing, China. Two paratypes (including to one apterous and one alate viviparous females) of the new species are deposited in the Natural History Museum (BMNH), London, the United Kingdom.

Table 1. Metrical data (mean, range and standard deviation) of *Mollitrichosiphum tumorisiphum* Qiao & Jiang, sp. n. (in mm, abbreviations see Materials and Methods). Ant. I, II, III, IV, V, VIb, antennal segments I, II, III, IV, V and the base of antennal segment VI, respectively; PT, processus terminalis; Ant. III BD, the basal diameter of antennal segment III; URS, ultimate rostral segment; URS BW, basal width of ultimate rostral segment; 2HT, second hind tarsal segment; Hind tibia MW, mid-width of hind tibia; SIPH, siphunculi; SIPH BW, basal width of siphunculi; SIPH DW, distal width of siphunculi; SIPH EW, width of expanded part on siphunculi; Cauda BW, basal width of cauda; Setae on Tergite I: marginal setae on abdominal tergite I; Setae on Tergite VIII: spinal setae on abdominal tergite VIII.

Parts		Apterous viviparae (n=5)			Alate viviparae (n=2)	
		Mean	**Range**	**Standard deviation**	**Mean**	**Range**
Length (mm)	Body length	2.14	1.92–2.34	0.12	2.11	2.07–2.15
	Body width	0.98	0.92–1.04	0.04	0.79	0.77–0.81
	Whole antennae	1.59	1.53–1.67	0.05	1.76	1.76
	Ant. I	0.11	0.11–0.12	0.002	0.11	0.11
	Ant. II	0.07	0.07	0	0.07	0.07
	Ant. III	0.54	0.51–0.59	0.03	0.62	0.58–0.67
	Ant. IV	0.18	0.16–0.21	0.01	0.24	0.23–0.25
	Ant. V	0.21	0.17–0.23	0.01	0.26	0.26
	Ant. VIb	0.20	0.19–0.21	0.005	0.21	0.21
	PT	0.27	0.26–0.29	0.01	0.30	0.30
	URS	0.21	0.18–0.22	0.01	0.21	0.21
	Hind femur	0.53	0.51–0.57	0.01	0.58	0.57–0.59
	Hind tibia	0.84	0.80–0.90	0.03	0.96	0.96
	2HT	0.13	0.125–0.134	0.004	0.13	0.13
	SIPH	0.77	0.73–0.86	0.03	1.16	1.12–1.2
	SIPH BW	0.07	0.07–0.09	0.007	0.07	0.06–0.09
	SIPH DW	0.07	0.06–0.08	0.005	0.05	0.048–0.053
	SIPH EW	0.16	0.13–0.19	0.02	0.10	0.09–0.12
	Cauda	0.05	0.05–0.07	0.008	0.05	0.05
	Cauda BW	0.19	0.18–0.20	0.006	0.18	0.17–0.18
	Ant. III BD	0.04	0.03–0.04	0.002	0.03	0.03
	Hind tibia MW	0.05	0.04–0.05	0.002	0.04	0.04
	Cephalic setae	0.18	0.16–0.19	0.01	0.16	0.15–0.16
	Setae on Tergite I	0.13	0.12–0.13	0.007	0.06	0.06–0.07
	Setae on Tergite VIII	0.09	0.08–0.12	0.01	0.13	0.12–0.13
	Setae on ANT. III	0.18	0.17–0.19	0.008	0.18	0.17–0.18
	Setae on Hind tibia	0.09	0.08–0.11	0.006	0.09	0.09–0.10
Ratio (times)	Whole antennae / Body	0.7	0.71–0.72	0.2	0.9	0.9
	Hind femur / Ant. III	1	0.9–1.0	0.03	0.9	0.9–1.0
	Hind tibia / Body	0.8	0.75–0.83	0.03	0.9	0.89–0.93
	PT / Ant. VIb	1.4	1.3–1.5	0.06	1.4	1.4
	URS / URS BW	5	4–6	0.6	5.5	5.5
	URS / 2HT	1.6	1.4–1.8	0.1	1.7	1.7
	Cauda / Cauda BW	0.3	0.2–0.4	0.04	0.3	0.26–0.28
	Cephalic setae / Ant. III BD	4.9	4.3–5.7	0.5	4.7	4.6–4.9
	Setae on Tergite I / Ant. III BD	3.5	3.3–4.0	0.2	1.9	1.7–2.0

Parts		Apterous viviparae (n=5)			Alate viviparae (n=2)	
		Mean	Range	Standard deviation	Mean	Range
	Setae on Tergite VIII / Ant. III BD	2.6	2.3–3.4	0.4	3.7	3.4–4.0
	Setae on ANT. III / ANT. III BD	5	4.5–5.7	0.4	5.3	5.1–5.4
	Setae on hind tibia / Hind tibia MW	2	1.8–2.2	0.1	2.4	2.2–2.5
	SIPH / Body	0.4	0.3–0.4	0.02	0.6	0.5–0.6
	SIPH / Ant. III	1.4	1.3–1.5	0.06	1.9	1.8–2.0
	SIPH / SIPH BW	10.7	8.7–12.6	1.12	16.7	13.9–19.5
	SIPH / SIPH DW	11.4	10. 7–13.0	0.8	23.1	21.3–25.0
	SIPH / SIPH EW	5.0	4.2–5.6	0.5	11.7	10.4–13.0

Taxonomy

Mollitrichosiphum (*Metatrichosiphum*) *tumorisiphum* Qiao & Jiang, sp. n.

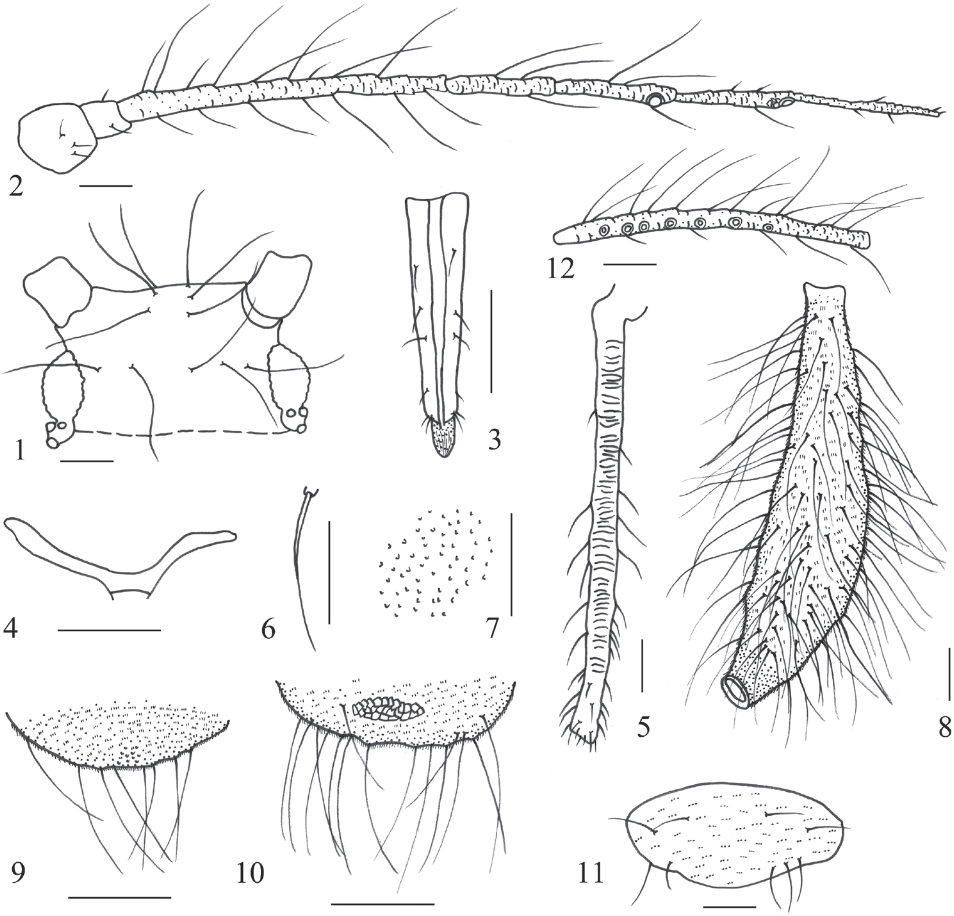
http://zoobank.org/D85E577E-D2FA-40CA-84AD-112101E86024

Descriptions. *Apterous viviparous female*: Body elongated oval (Fig. 13), yellow green in life, with pairs of emerald green dorsal markings and pale brown siphunculi (Figs 38–41).

Mounted specimens. Body pale brown, with head and prothorax fused. Dorsal setae thick, long and pointed (Figs 6, 21).

Head. Ocular tubercles dark brown, well developed. Dorsum of head with three pairs of setae between antennae, and 4–6 setae between eyes. Maximum lengths of cephalic setae 4.3–5.7 times as long as basal diameter of antennal segment III. Front flat, antennal tubercles slightly developed (Figs 1, 14). Antennae 6-segmented (Figs 2, 16-17), 0.71-0.72 times as long as body length. Processus terminalis 1.3–1.5 times as long as base of the segment. Antennal segments I–IV, basal half of segment V and of base of segment VI pale brown, other parts of segment V and VI brown. Antennal segments III–VI with short imbrications. Antennal setae pointed. Antennal segment I with only short setae; segments II–V with long and short setae, setae on the inner side of the segment distinctly longer, thicker and more numerous than setae on the outer side of the segment; segments I–VI each with 4–6, 4 or 5 ,16–23, 3 or 4, 3 or 4, (3 or 4)+(4–6) setae, respectively; apex of processus terminalis with 3 or 4 short blunt setae; maximum length of setae on segment III 4.5–5.7 times as long as basal diameter of the segment. Rostrum reaching hind coxae, sometimes abdominal segment I; ultimate rostral segment pale brown, except for brown apex, long and wedge-shaped (Figs 3, 18), 4–6 times as long as its basal width, 1.4–1.8 times as long as second hind tarsal segment; segment IV and V obviously separated; with 3 pairs of primary and 3 pairs of secondary setae.

Thorax. Mesosternal furca with a short stem (Figs 4, 19). Pronotum with 1 pair of anterior spinal, 3 or 4 posterior spinal, 1 pair of anterior marginal and 2 pairs of posterior marginal setae Legs slender. Femora and tibiae pale brown. Hind femur 0.9–1 times as long as antennal segment III. Hind tibia 0.75–0.83 times as long as body, with



Figures 1–12. *Mollitrichosiphum tumorisiphum* Qiao & Jiang, sp. n. Apterous viviparous female: **1** dorsal view of head **2** antenna **3** ultimate rostral segment **4** mesosternal furca **5** hind tibia **6** dorsal seta on abdominal tergite I **7** spinules on venter of abdominal segment V **8** siphunculus **9** cauda **10** anal plate **11** genital plate. Alate viviparous female: 12. antennal segment III. Scale bars = 0.10 mm.

57–62 transverse ridges on basal 3/4 of the segment (Figs 5, 20). Setae on legs short, pointed or acuminate. Maximum length of setae on hind tibia 1.8–2.2 times as long as mid-width of the segment. Tarsi brown, with transverse imbrications. Chaetotaxy of first tarsomeres: 7, 7, 7.

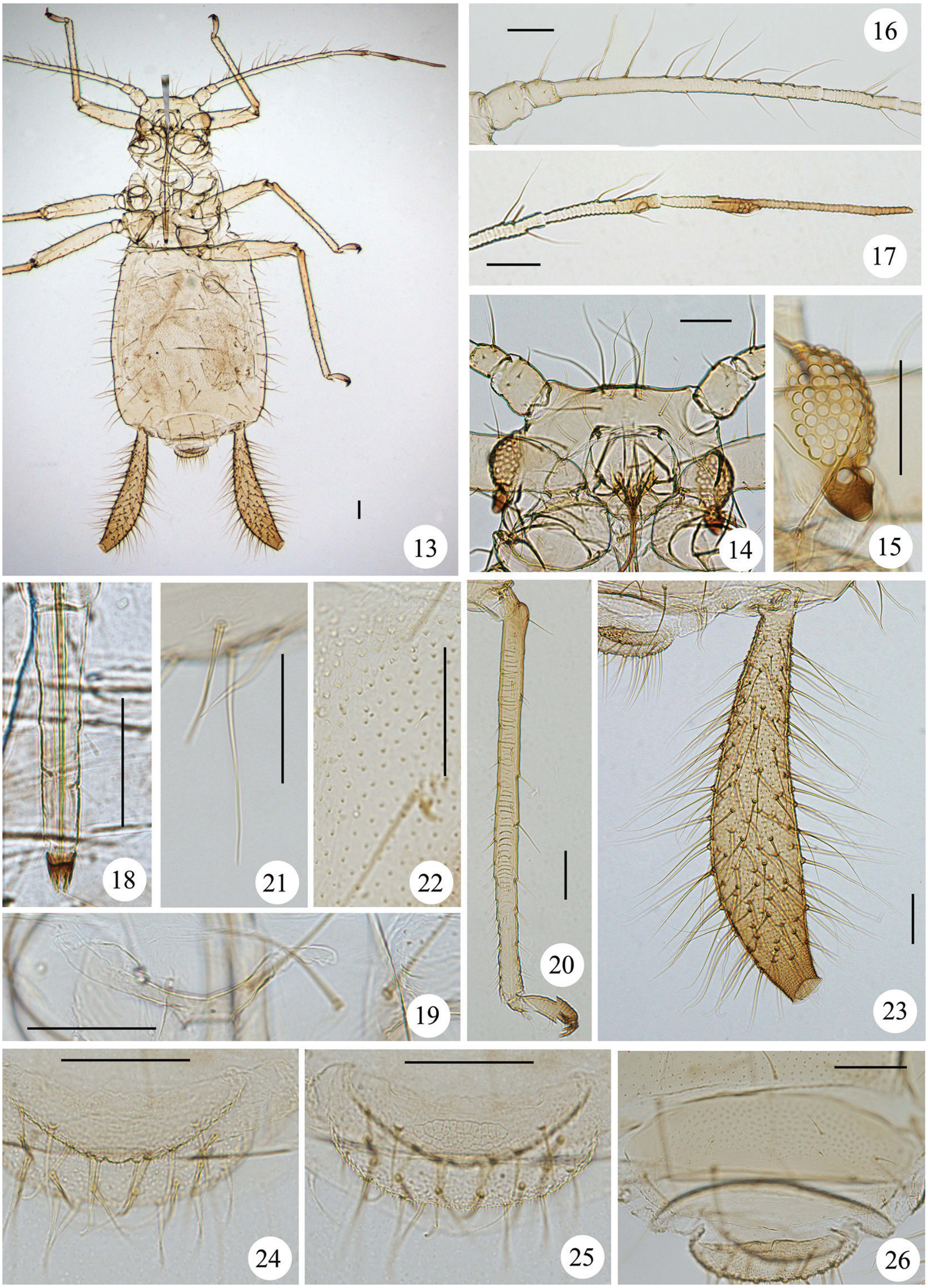
Abdomen. Abdominal tergite I with 4–6 spinal and pleural setae, and 2 pairs of marginal setae, tergite VIII with one pair of spinal setae. Maximum lengths of marginal setae on abdominal tergite I and dorsal setae on tergite VIII 3.3–4.0 and 2.3–3.4 times as long as basal diameter of antennal segment III, respectively. Venter of abdominal segments II–VI with coarse spinules on pleural and sub-marginal area (Figs 7, 22). Spiracles oval and open, on pale brown spiracular plates. Siphunculi brown, long and

Table 2. Voucher information and GenBank accession numbers for aphid samples used in the molecular study.

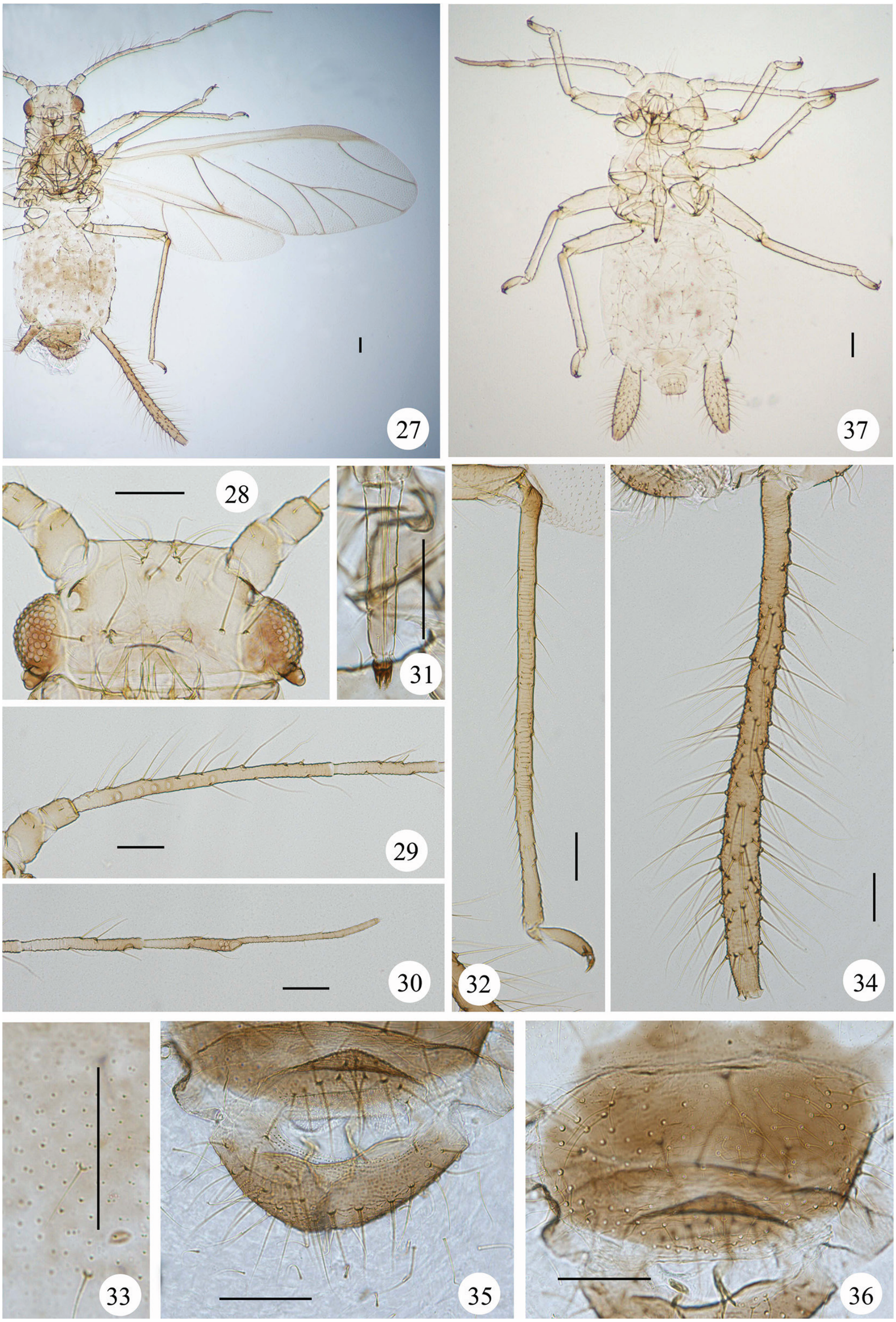
Species	Voucher number	Host plant	Collection locality	COI	Cytb
Mollitrichosiphum luchuanum (Takahashi)	14414	*Amygdalus persica*	Fujian: Mt. Wuyi	JQ926108 P[a]	JF969358 P[b]
Mollitrichosiphum luchuanum (Takahashi)	14488	*Amygdalus persica*	Fujian: Mt. Wuyi	JQ926107 P[a]	JF969361 P[b]
Mollitrichosiphum luchuanum (Takahashi)	18104	*Meliosma rigida*	Fujian: Mt. Wuyi	JQ926105 P[a]	JF969368 P[b]
Mollitrichosiphum luchuanum (Takahashi)	21910	Unknown	Guangdong: Shixing	JQ926106 P[a]	JF969389 P[b]
Mollitrichosiphum montanum (van der Goot)	16504	Unknown	Tibet: Zhangmu	JQ926104 P[a]	JF969367 P[b]
Mollitrichosiphum montanum (van der Goot)	18324	Unknown	Tibet: Zayu	JQ926103 P[a]	JF969393 P[b]
Mollitrichosiphum montanum (van der Goot)	23754	*Alnus nepalensis*	Yunnan: Jingdong	JQ926102 P[a]	JF969387 P[b]
Mollitrichosiphum nandii Basu	14712	*Alnus cremastogyne*	Yunnan: Baoshan	JQ926101 P[a]	JF969364 P[b]
Mollitrichosiphum nandii Basu	15370	Unknown	Tibet: Medog	JQ926100 P[a]	JF969365 P[b]
Mollitrichosiphum nandii Basu	18382	*Fagus longipetiolata*	Tibet: Tangmai	JQ926099 P[a]	JF969369 P[b]
Mollitrichosiphum nandii Basu	23101	Unknown	Sichuan: Mt. Luoji	JQ926148 P[a]	JF969394 P[b]
Mollitrichosiphum nigrofasciatum (Maki)	14560	*Lithocarpus glaber*	Fujian: Mt. Wuyi	JQ926098 P[a]	JF969363 P[b]
Mollitrichosiphum nigrofasciatum (Maki)	14805	*Cyclobalanopsis glauca*	Fujian: Mt. Wuyi	JQ926097 P[a]	JF969395 P[b]
Mollitrichosiphum nigrofasciatum (Maki)	17329	*Quercus* sp.	Zhejiang: Taishun	JQ926096 P[a]	JN645006 P[c]
Mollitrichosiphum nigrofasciatum (Maki)	17331	Fagaceae	Zhejiang: Taishun	JQ926095 P[a]	NA
Mollitrichosiphum nigrofasciatum (Maki)	17333	Fagaceae	Zhejiang: Taishun	JQ926094 P[a]	NA
Mollitrichosiphum nigrofasciatum (Maki)	17387	*Quercus aliena*	Zhejiang: Taishun	JQ926093 P[a]	NA
Mollitrichosiphum nigrofasciatum (Maki)	18499	*Castanopsis* sp.	Hainan: Mt. Diaoluo	JQ926092 P[a]	NA
Mollitrichosiphum nigrofasciatum (Maki)	18510	*Lithocarpus elmerrillii*	Hainan: Mt. Diaoluo	JQ926090 P[a]	JN645010 P[c]
Mollitrichosiphum nigrofasciatum (Maki)	21773	Unknown	Hunan: Mt. Bamian	JQ926089 P[a]	NA
Mollitrichosiphum nigrofasciatum (Maki)	21859	Unknown	Guangdong: Ruyuan	JQ926088 P[a]	NA
Mollitrichosiphum nigrofasciatum (Maki)	21916	Elaeocarpaceae	Guangdong: Shixing	JQ926087 P[a]	NA
Mollitrichosiphum nigrofasciatum (Maki)	21966	Unknown	Guangdong: Shixing	JQ926086 P[a]	JF969399 P[b]
Mollitrichosiphum nigrofasciatum (Maki)	22101	*Lithocarpus glaber*	Fujian: Longyan	JQ926085 P[a]	JF969400 P[b]
Mollitrichosiphum nigrum Zhang & Qiao	14405	*Castanea* sp.	Fujian: Mt. Wuyi	JQ926083 P[a]	JN645004 P[c]
Mollitrichosiphum nigrum Zhang & Qiao	14417	*Elaeagnus pungens*	Fujian: Mt. Wuyi	JQ926084 P[a]	JF969359 P[b]
Mollitrichosiphum nigrum Zhang & Qiao	18913	*Meliosma cuneifolia*	Guangxi: Longsheng	JQ926082 P[a]	JF969375 P[b]
Mollitrichosiphum nigrum Zhang & Qiao	19258	*Ailanthus altissima*	Guangxi: Xing'an	JQ926081 P[a]	JF969377 P[b]
Mollitrichosiphum nigrum Zhang & Qiao	21845	Unknown	Hunan: Mt. Mang	JQ926080 P[a]	JF969390 P[b]

Species	Voucher number	Host plant	Collection locality	COI	Cytb
Mollitrichosiphum nigrum Zhang & Qiao	21856	Unknown	Guangdong: Ruyuan	JQ926079 P[a]	JF969391 P[b]
Mollitrichosiphum nigrum Zhang & Qiao	21872	Unknown	Guangdong: Ruyuan	JQ926078 P[a]	JN645011 P[c]
Mollitrichosiphum rhusae Ghosh	18508	*Helicia hainanensis*	Hainan: Mt. Diaoluo	JQ926077 P[a]	JF969371 P[b]
Mollitrichosiphum rhusae Ghosh	18511	*Helicia hainanensis*	Hainan: Mt. Diaoluo	JQ926076 P[a]	JF969372 P[b]
Mollitrichosiphum rhusae Ghosh	18513	Fagaceae	Hainan: Mt. Diaoluo	JQ926075 P[a]	JF969373 P[b]
Mollitrichosiphum rhusae Ghosh	18514	*Helicia hainanensis*	Hainan: Mt. Diaoluo	JQ926074 P[a]	JF969374 P[b]
Mollitrichosiphum rhusae Ghosh	20811	Fagaceae	Hainan: Mt. Wuzhi	JQ926073 P[a]	JF969380 P[b]
Mollitrichosiphum rhusae Ghosh	20858	Meliaceae	Hainan: Mt. Diaoluo	JQ926072 P[a]	JF969381 P[b]
Mollitrichosiphum tenuicorpus (Okajima)	14421	*Castanea* sp.	Fujian: Mt. Wuyi	JQ926070 P[a]	JF969360 P[b]
Mollitrichosiphum tenuicorpus (Okajima)	14537	*Castanopsis sclerophylla*	Fujian: Mt. Wuyi	JQ926069 P[a]	JF969362 P[b]
Mollitrichosiphum tenuicorpus (Okajima)	18506	*Cyclobalanopsis neglecta*	Hainan: Mt. Diaoluo	JQ926067 P[a]	JF969370 P[b]
Mollitrichosiphum tenuicorpus (Okajima)	18614	*Castanopsis carlesii*	Guangdong: Shixing	JQ926066 P[a]	JF969396 P[b]
Mollitrichosiphum tenuicorpus (Okajima)	18892	Fagaceae	Guangxi: Longsheng	JQ926065 P[a]	JF969397 P[b]
Mollitrichosiphum tenuicorpus (Okajima)	19242	Fagaceae	Hainan: Mt. Bawang	JQ926064 P[a]	JF969376 P[b]
Mollitrichosiphum tenuicorpus (Okajima)	19521	*Quercus* sp.	Hainan: Mt. Jianfeng	JQ926063 P[a]	JF969378 P[b]
Mollitrichosiphum tenuicorpus (Okajima)	20530	*Castanopsis ferox*	Yunnan: Simao	JQ926062 P[a]	JF969379 P[b]
Mollitrichosiphum tenuicorpus (Okajima)	20866	Fagaceae	Hainan: Mt. Jianfeng	JQ926061 P[a]	JF969382 P[b]
Mollitrichosiphum tenuicorpus (Okajima)	20938	*Castanopsis fabri*	Hainan: Mt. Jianfeng	JQ926060 P[a]	JF969383 P[b]
Mollitrichosiphum tenuicorpus (Okajima)	22152	Unknown	Fujian: Zhangzhou	JQ926059 P[a]	JF969384 P[b]
Mollitrichosiphum tenuicorpus (Okajima)	22155	Unknown	Fujian: Zhangzhou	JQ926058 P[a]	JF969385 P[b]
Mollitrichosiphum tenuicorpus (Okajima)	22161	Unknown	Fujian: Zhangzhou	JQ926057 P[a]	JN645013 P[c]
Mollitrichosiphum tenuicorpus (Okajima)	22166	Unknown	Fujian: Zhangzhou	JQ926056 P[a]	JF969386 P[b]
Mollitrichosiphum tenuicorpus (Okajima)	23843	*Castanopsis hystrix*	Yunnan: Cangyuan	JQ926055 P[a]	JX186736 P[a]
Mollitrichosiphum tenuicorpus (Okajima)	26029	*Castanopsis eyrei*	Guangxi: Lingui	JN644999 P[c]	JN645015 P[c]
Mollitrichosiphum tenuicorpus (Okajima)	26261	*Castanopsis* sp.	Guangxi: Mt. Shiwandashan	JN645000 P[c]	JN645016 P[c]
Mollitrichosiphum tenuicorpus (Okajima)	26270	*Castanopsis* sp.	Guangxi: Mt. Shiwandashan	JQ418313 P[c]	JQ418317 P[c]
Mollitrichosiphum tumorisiphum Qiao & Jiang, sp. n.	26510	*Fagus longipetiolata*	Taiwan: Mt. Taman	JN645002 P[c]	JQ418315 P[c]
Mollitrichosiphum tumorisiphum Qiao & Jiang, sp. n.	26515	*Fagus longipetiolata*	Taiwan: Hualian	JN645003 P[c]	JQ418316 P[c]

Reference sequences form previous studies: P[a] P Liu et al. (2013), P[b]P Zhang et al. (2011), P[c]P Zhang et al. (2012).



Figures 13–26. *Mollitrichosiphum tumorisiphum* Qiao & Jiang, sp. n. Apterous viviparous female: **13** dorsal view of body **14** dorsal view of head **15** compound eyes **16** antennal segments I–IV **17** antennal segments V–VI **18** ultimate rostral segment **19** mesosternal furca **20** hind tibia, tarsi and claws **21** dorsal seta on abdominal tergite I **22** spinules on venter of abdominal segment V **23** siphunculus **24** cauda; **25** anal plate **26** genital plate. Scale bars = 0.10 mm.



Figures 27–37. *Mollitrichosiphum tumorisiphum* Qiao & Jiang, sp. n. Alate viviparous female: **27** dorsal view of body **28** dorsal view of head **29** antennal segments I–IV **30** antennal segments V–VI **31** ultimate rostral segment **32** hind tibia, tarsi and claws **33** spinules on venter of abdominal segment V **34** siphunculus **35** cauda and anal plate **36** genital plate. Second instar larva: 37. dorsal view of body. Scale bars = 0.10 mm.

tubular, strongly swollen over most of length and constricted near apex (Figs 8, 23), flange distinct; 0.3–0.4 times as long as body, 1.3–1.5 times as long as antennal segment III, 8.7–12.6 times as long as its basal width, 4.2–5.6 times as long as width of expanded part, 10.7–13 times as long as its distal width. Siphunculi with spinules evenly distributed and with spinulose imbrications at apex. Each siphunculus with 95–118 setae, long and pointed. Cauda, anal plate and genital plate pale brown. Cauda broadly rounded (Figs 9, 24), with spinules and round apex; 0.2–0.4 times as long as its basal width; with 8–10 setae. Anal plate transversely elliptical (Figs 10, 25), with spinules and with a transverse band of cell-like markings on spinal area, with 16 or 17 setae. Genital plate transverse oval (Figs 11, 26), with spinules, 4–6 anterior and 4–8 posterior setae. Gonapophyses three, spinal one with 6 setae and each pleural one with 3 setae.

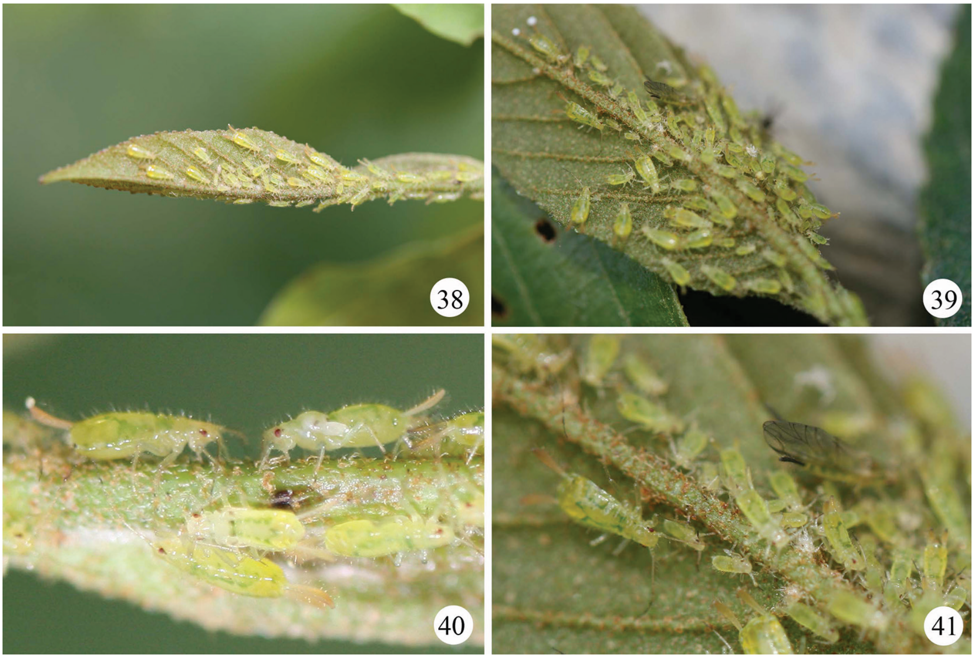
Alate viviparous female: Body elongate oval (Fig. 27), yellow green in life, with green dorsal markings (Figs 39, 41), dark brown forewing veins and dark brown siphunculi (Fig. 41).

Mounted specimens. Dorsal setae thick, long and pointed.

Head. Head, antennae and ultimate rostral segment dark brown. Dorsum of head with 6 setae between antennae, and 4–6 setae between eyes. Maximum lengths of cephalic setae 4.6–4.9 times as long as basal diameter of antennal segment III. Front flat (Fig. 28). Antennae 6-segmented (Figs 12, 29–30), 0.9 times as long as body length. Processus terminalis 1.4 times as long as base of the segment. Antennal segments III–VI with short imbrications. Antennal setae thick, long and pointed; segments I–VI each with 4, 4 or 5, 18, 4 or 5, 4, 4+5 setae, respectively; apex of processus terminalis with 4 short blunt setae; length of setae on segment III 5.1–5.4 times as long as basal diameter of the segment. Antennal segment III with 7–9 nearly round secondary rhinaria, distributed on basal 2/3 of the segment. Rostrum reaching abdominal segment I; ultimate rostral segment long wedge-shaped (Fig. 31), 5.5 times as long as its basal width, 1.7 times as long as second hind tarsal segment; segment IV and V obviously separated; with 3 pairs of primary and 2-3 pairs of secondary setae.

Thorax. Thorax, femora, tibiae and tasi dark brown. Pronotum with 6 spinal and pleural setae and 3 pairs of marginal setae. Legs slender. Inside of distal half of femora with short spare spinulose imbrications. Hind femur 0.9–1 times as long as antennal segment III. Hind tibia 2 times as long as body, with 69–72 transverse ridges on basal 3/4 of the segment (Fig. 33). Setae on legs short and pointed. Maximum length of setae on hind tibia 2.5–2.9 times as long as mid-width of the segment. Second tarsal segments with transverse imbrications. Chaetotaxy of first tarsomeres: 7, 7, 7. Fore wings with media twice branched and distal 1/3 of CuR_1 Rcurved to media; hind wings with 2 oblique veins.

Abdomen. Abdominal tergites I–VI with spinal, pleural and marginal sclerotic markings fused into a large brown patch; tergites VII and VIII each with one brown transverse patch. Abdominal tergite I with 8–10 setae, tergite VII with 4 setae, tergite VIII with 2 setae. Maximum lengths of marginal setae on abdominal tergite I and dorsal setae on tergite VIII 1.7–2.0 and 3.4–4.0 times as long as basal diameter of antennal segment III, respectively. Venter of abdominal segments III–VI with coarse



Figures 38–41. *Mollitrichosiphum tumorisiphum* Qiao & Jiang, sp. n. **38** colony on the bud of the host **39** colony on the underside of the leaf **40** apterous viviparous female and larvae **41** apterous, alate viviparous females and larvae.

spinules on pleural and sub-marginal area. Spiracles oval and open, on brown oval spiracular plates. Siphunculi long. tubular, distinctly swollen on distal half (Fig. 34), flange distinct, basal 2/3 of siphunculi dark brown and distal 1/3 brown, with spinules evenly distributed and with spinulose imbrications at apex; 0.5–0.6 times as long as body, 1.8–2 times as long as antennal segment III, 13.9–19.5 times as long as its basal width, 10.4–13 times as long as width of expanded part, 21.3–25 times as long as its distal width; each with 105–120 long and pointed setae. Cauda, anal plate and genital plate brown. Cauda broadly rounded (Fig. 35); 0.26–0.28 times as long as its basal width; with spare spinulose imbrications and 12 setae. Anal plate transversely elliptical, with spare spinulose imbrications and 52–58 setae (Fig. 35). Genital plate transverse oval (Fig. 36), with spinules and 84–104 setae. Gonapophyses three, spinal one with 8 setae and each pleural one with 4 setae.

Specimens examined. Holotype: apterous viviparous female, **CHINA**, Taiwan Island: Tamanshan Mountain, Fuxing Town, Taoyuan County, 24.70°N, 121.43°E, altitude 1630m, 14 June 2011, No. 26510–1–1–1, on *Fagus longipetiolata*, coll. X.L. Huang. Paratypes: 3 apterous viviparous females, 1 alate viviparous females and 1 second instar larva, 1 apterous viviparous female and 1 alate viviparous female (BMNH), with the same collection data as holotype; 1 apterous viviparous female, Bilu, Xiulin Town, Hualian County, 24.00°N, 121.21°E, altitude 2150m, 20 July 2011, No. 26515, on *Fagus longipetiolata*, coll. X.L. Huang.

Etymology. The name of this species is derived from its most distinctive feature, its markedly swollen siphunculi. The specific name is composed of "*tumor* (Latin, =inflated, swelling)" and "*siphum* (Latin, =tube)".

Diagnosis. The new species is distinctly different from the other known species in the genus, based on siphunculi of alatae distinctly expanded on the apical half. It is similar to the species *M. (Me.) niitakaensis* (Takahashi), but differs from the latter as follows: body with long and stout dorsal setae, pointed at apex (the latter: at least with some bifurcate dorsal setae); each siphunculus with more than 95 setae (the latter: less than 80); hind tibia with 20–63 short transverse ridges (the latter: with more than 84).

It is also similar to the species *M. (Me.) yamabiwae* Suenaga, but differs from the latter as follows in apterous viviparae: dorsal of abdomen pale brown, without sclerotic pattern (the latter: with fused dark brown sclerotic patterns); hind tibia with 57–62 transverse ridges (the latter: with 31–33); ultimate rostral segment 0.18–0.22 mm long, 4–6 times as long as basal width, 1.4–1.8 times as long as hind second tarsal segment (the latter: 0.28–0.41 mm, 6.1–8.4 times, 2.4–2.8 times); ultimate rostral segment with 3 pairs of secondary setae (the latter: with 7 pairs).

Biology. Colonizing the underside of young leaves of new growth of *Fagus longipetiolata*. (Figs 38–41).

Molecular analyses

The alignment sequences of COI and Cytb genes included 658 and 666 sites, of which 133 and 129 were parsimony-informative, respectively. The results of NJ analyses of COI and Cytb sequences are summarized. The NJ trees presented here are unrooted and do not reflect phylogenetic relationships, but are used to represent the genetic distance matrices (Foottit et al. 2008). The COI tree (Fig. 42) contained 57 samples of *Mollitrichosiphum* species and showed eight well-supported clades. All morphologically identified species, including *M. tumorisiphum* Qiao & Jiang, sp. n., formed monophyletic clusters, indicating that they are genetically distinct from one another. The Cytb tree (Fig. 43) containing 50 samples yielded a similar result, with *M. tumorisiphum* Qiao & Jiang, sp. n. again retrieved in a distinct clade.

For the sampled known species of *Mollitrichosiphum*, the mean intraspecific variation was 0.2% (range: 0–0.9%) in COI and 0.1% (range: 0–1.1%) in Cytb. The genetic distance between two distinct samples of *M. tumorisiphum* Qiao & Jiang, sp. n. was 0 in COI and 0.9% in Cytb. Interspecific genetic divergence between the known *Mollitrichosiphum* species averaged 8.7% (range: 0.3–12.5%) in COI and 8.1% (range: 0.2–12.3%) in Cytb. Pairwise sequence divergences of COI and Cytb among the *Mollitrichosiphum* species are presented in Table 3. The mean genetic distance between *M. tumorisiphum* Qiao & Jiang, sp. n. and the other *Mollitrichosiphum* species was 10.3% (range: 8.9–11.9%) in COI and 8.8% (range: 7.6%–11.0%) in Cytb, corresponding well to the interspecific divergence between the other known *Mollitrichosiphum* species.

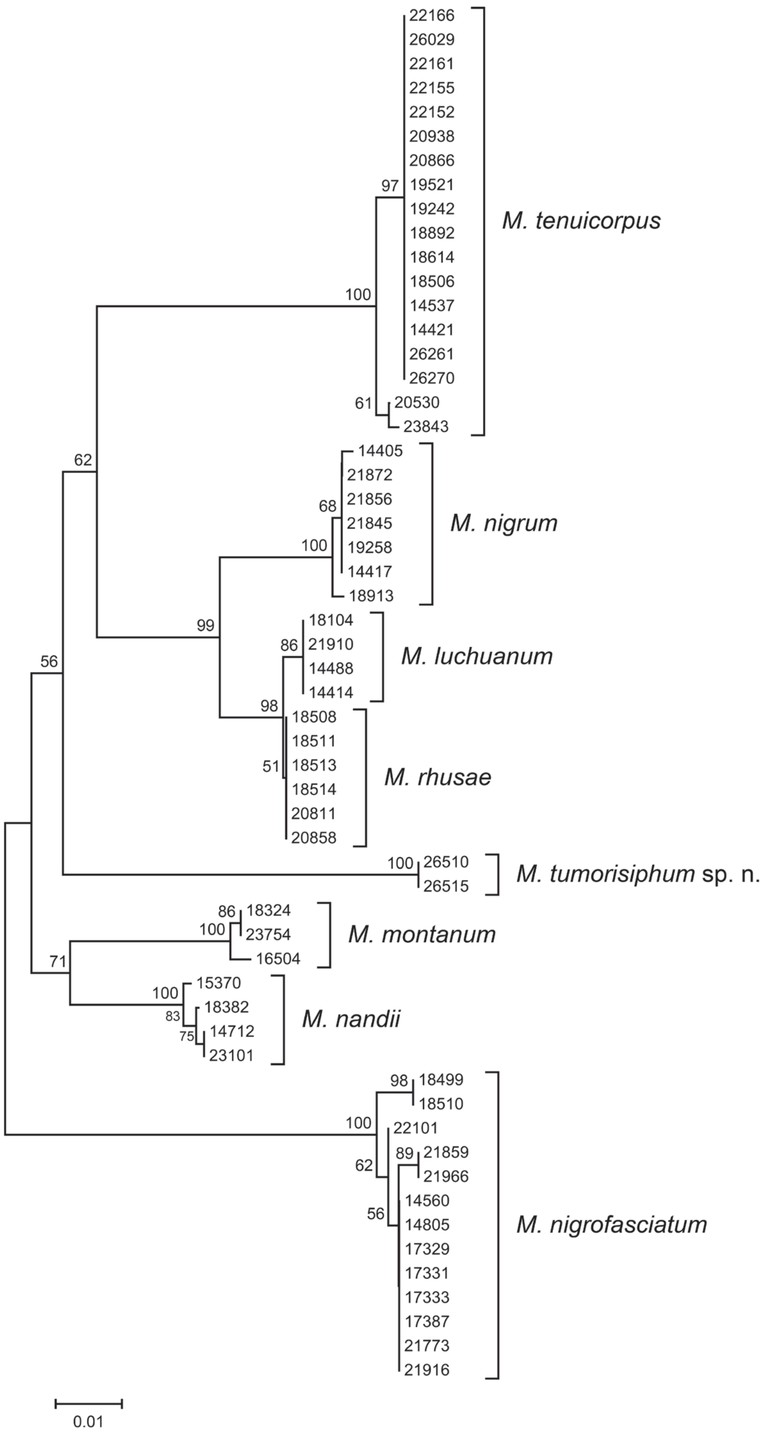


Figure 42. Neighbour-joining tree for *Mollitrichosiphum* samples based on COI sequences. Numbers above branches indicate bootstrap values (>50%).

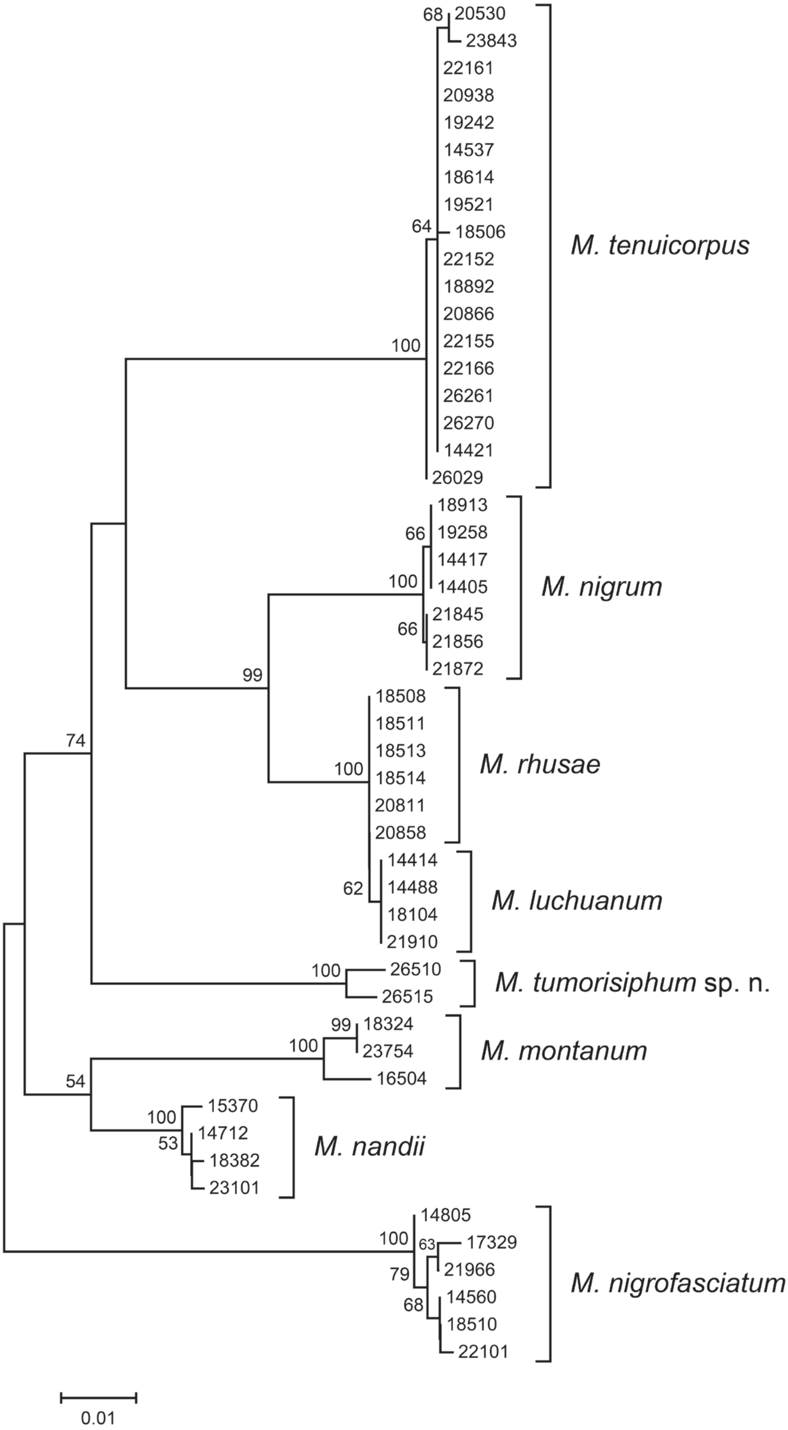


Figure 43. Neighbour-joining tree for *Mollitrichosiphum* samples based on Cytb sequences. Numbers above branches indicate bootstrap values (>50%).

Table 3. Kimura's two-parameter genetic distances (mean ± standard deviation) among *Mollitrichosiphum* species based on COI (lower half of matrix) and Cytb (upper half of matrix) sequences. The genetic distances between *Mollitrichosiphum tumorisiphum* Qiao & Jiang, sp. n. and the other *Mollitrichosiphum* species are shown in bold.

Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1. *M. luchuanum*		0.075±0.001	0.060±0.002	0.104±0.002	0.036±0.001	0.002±0	0.076±0.001	**0.082±0.001**
2. *M. montanum*	0.074±0.001		0.050±0.003	0.094±0.002	0.081±0.003	0.077±0.001	0.104±0.001	**0.089±0.001**
3. *M. nandii*	0.066±0.001	0.045±0.003		0.097±0.002	0.068±0.001	0.058±0.002	0.077±0.001	**0.078±0.002**
4. *M. nigrofasciatum*	0.102±0.001	0.089±0.002	0.095±0.002		0.114±0.002	0.102±0.002	0.117±0.002	**0.106±0.002**
5. *M. nigrum*	0.030±0.001	0.074±0.001	0.065±0.001	0.103±0.002		0.035±0.001	0.082±0.001	**0.094±0.001**
6. *M. rhusae*	0.003±0	0.074±0.001	0.063±0.001	0.100±0.001	0.030±0.001		0.075±0.001	**0.080±0.001**
7. *M. tenuicorpus*	0.077±0	0.088±0.001	0.082±0.002	0.121±0.003	0.084±0.001	0.074±0		**0.085±0.002**
8. *M. tumorisiphum* Qiao & Jiang, sp. n.	**0.096±0**	**0.090±0.001**	**0.094±0.001**	**0.117±0.002**	**0.095±0.001**	**0.096±0**	**0.105±0**	

The results of NJ analyses and genetic distances based on COI and Cytb sequences strongly confirmed that the new morphologically determined species *M. tumorisiphum* Qiao & Jiang, sp. n. was genetically different from the known *Mollitrichosiphum* species sampled in this study.

Updated key to species of *Mollitrichosiphum* from China

(Apterous viviparous females)

1 Antennal setae with similar length on inner and outer sides of the segment; hind tibia with 17–22 transverse ridges.. ....***Mollitrichosiphum* (*Mollitrichosiphum*) *tenuicorpus* (Okajima)**

– Antennal setae long or short, long setae being mainly on the inner side of the segment; hind tibia with 20–84 transverse ridges ....**2 *Mollitrichosiphum* (*Metatrichosiphon*) spp.**

2 Hind tibia with more than 84 short transverse ridges................................... .... ***M.* (*Me.*) *niitakaensis* (Takahashi)**

– Hind tibia with 20–63 short transverse ridges..**3**

3 Abdominal tergite VII with 13 or 14 setae; body with pointed and dense dorsal setae...***M.* (*Me.*) *nandii* Basu**

– Abdominal tergite VII with only 2–4 setae **4**

4 Siphunculi long, 0.7–0.9 times as long as body.. ....***M.* (*Me.*) *montanum* (van der Goot)**

– Siphunculi at most 0.7 times as long as body...**5**

5 Body with long and stout dorsal setae, pointed at apex **6**

– Body at least with some bifurcate dorsal setae **7**

6 Dorsal of abdomen with fused dark brown sclerotic patterns; hind tibia with 31–33 transeverse ridges; ultimate rostral segment 0.3–0.4 mm long, 6.1–8.4 times as long as basal width, 2.4–2.8 times as long as hind second tarsal segment, with 7 pairs of secondary setae...........***M.* (*Me.*) *yamabiwae* Suenaga**

– Dorsal of abdomen pale brown, without sclerotic pattern; hind tibia with 57–62 transeverse ridges; ultimate rostral segment 0.18–0.22 mm long, 4–6 times as long as basal width, 1.36–1.77 times as long as hind second tarsal segment, with 3 pairs of secondary setae........... ***M.* (*Me.*) *tumorisiphum* Qiao & Jiang, sp. n.**

7 Length of ultimate rostral segment less than 2 times that of hind second tarsal segment length..**8**

– Length of ultimate rostral segment more than 2 times that of hind second tarsal segment length **9**

8 Body 2.9 mm long; hind tibia with 37–43 transverse ridges .... ***M.* (*Me.*) *glaucae* Takahashi**

– Body 1.4–2.2 mm long; hind tibia with 27–38 transverse ridges ....***M.* (*Me.*) *nigrofasciatum* (Maki)**

9 Hind tibia with less than 30 transverse ridges **10**

– Hind tibia with more than 30 transverse ridges... **11**

10 Body setae mostly pointed; ultimate rostral segment 2.3–2.4 times as long as hind second tarsal segment; on plants of Fagaceae .... **_M._ (_Me._) _luchuanum_ (Takahashi)**

– Body setae mostly bifurcate; ultimate rostral segment 1.8 .... **_M._ (_Me._) _taiwanum_ (Takahashi)**

11 Body pale in mounted specimens, except for brown siphunculi; processus terminalis 1.6–1.8 times as long as the base of antennal segment VI; hind tibia with 35–46 transverse ridgest.......................... **_M._ (_Me._) _rhusae_ Ghosh**

– Body brown in mounted specimens; processus terminalis 1.3–1.6 times as long as the base of antennal segment VI; hind tibia with 53–63 transverse ridges.. **_M._ (_Me._) _nigrum_ Zhang & Qiao**

(Alate viviparous females)

(Remark: *M. glaucae* and *M. niitakaensis* are not included in the key to alatae, because no specimens are available).

1 Antennal setae on flagellum with similar length on inner and outer sides of the segment .... **_Mollitrichosiphum_ (_Mollitrichosiphum_) _tenuicorpus_ (Okajima)**

– Antennal setae on flagellum long or short, long setae mainly on the inner side of the segment .... **2 _Mollitrichosiphum_ (_Metatrichosiphon_) spp.**

2 Abdominal tergite VII with 9–12 setae .... **_M._ (_Me._) _nandii_ Basu**

– Abdominal tergite VII with 2–6 setae **3**

3 Antennal segment III with 5–10 secondary rhinaria.................................. **4**

– Antennal segment III with more than 14 secondary rhinaria...................... **5**

4 Hind tibia with 25–43 transverse ridges; ultimate rostral segment 3.9–4.5 times as long as its basal width; each siphunculus with 65–96 setae .... **_M._ (_Me._) _nigrofasciatum_ (Maki)**

– Hind tibia with 69–72 transverse ridges; ultimate rostral segment 5.5 times as long as its basal width; each siphunculus with 105–120 setae.. **_M._ (_Me._) _tumorisiphum_ Qiao & Jiang, sp. n.**

5 Hind tibia with more than 42 transverse ridges.. **6**

– Hind tibia with less than 38 transverse ridges **8**

6 Ultimate rostral segment 1.8–1.9 times as long as hind second tarsal segment.. **_M._ (_Me._) _montanum_ (van der Goot)**

– Ultimate rostral segment more than 2.4 times of hind second tarsal segment length 7

7 Hind tibia with 49–53 transverse ridges; antennal segment III with 14–16 secondary rhinaria.................................... **_M._ (_Me._) _nigrum_ Zhang & Qiao**

– Hind tibia with about 43 transverse ridges; antennal segment III with 20 secondary rhinaria... **_M._ (_Me._) _rhusae_ Ghosh**

8 Hind tibia with about 30 transverse ridges; antennal segment III with 20 or 21 secondary rhinaria; siphunculi 0.8 times as long as body length .... ***M.* (*Me.*) *taiwanum* (Takahashi)**

– Hind tibia with about 34 transverse ridges; antennal segment III with less than 20 secondary rhinaria; siphunculi at most 0.8 times as long as body length **9**

9 Ultimate rostral segmentIV about 5.2 times as long as segment V; siphunculi about 2.4 mm long, about 17.3 times as long as its basal width .... ***M.* (*Me.*) *luchuanum* (Takahashi)**

– Ultimate rostral segment IV 6.4-–7.0 times as long as segment V; siphunculi 1.7–1.8 mm long, 14.6–17.0 times as long as its basal width .... ***M.* (*Me.*) *yamabiwae* Suenaga**

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Immatures of the New World treehopper tribe Amastrini (Hemiptera, Membracidae, Smiliinae) with a key to genera

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Abstract

The immatures stages of 8 of the 11 genera (*Amastris* Stål, *Bajulata* Ball, *Erosne* Stål, *Harmonides* Kirkaldy, *Idioderma* Van Duzee, *Neotynelia* Creão-Duarte & Sakakibara, *Tynelia* Stål, and *Vanduzea* Goding) of the tribe Amastrini are described for the first time along with brief diagnoses of Membracidae and the subfamily Smiliinae. A key to genera and notes on biology are provided. Multiple species of most genera are illustrated. Based on its distinct nymphal morphology, *Vanduzea laeta nolina* Ball is elevated to specific rank as *Vanduzea nolina* **stat. n.**, and *Bajulata*, despite the superficial similarity of its adults to those of *Vanduzea*, is confirmed as warranting generic rank based on its unique nymphal morphology. Colombia is a new country record for *Tynelia*.

Keywords

Nymph, *Amastris*, *Bajulata*, *Erosne*, *Harmonides*, *Idioderma*, *Neotynelia*, *Vanduzea*

Introduction

Treehoppers (Membracidae, Aetalionidae, and Melizoderidae) are well known for the expanded, often extravagantly developed pronotum common to adults of nearly all of the more than 400 genera and 3,000 species (McKamey 1998). What is less well known is that the adult pronotum is usually displayed, in miniature form, in the last, fifth instar. In addition to this nascent enlarged pronotum, immatures are often covered with various arrangements of large spinelike structures (scoli) on the head, all thoracic segments, and the abdomen that are usually absent in the adults. Indeed, except for the nascent pronotum, treehopper immatures show a vast array of structures that to a large extent have evolved independently of the adult forms. Despite this wealth of potential diagnostic features, there has been no previous identification guide to genera of immature treehoppers.

Perhaps two of the earliest accounts of treehopper immatures were Scheller's (1783–1794) and Fairmaire's (1846, Pl. 3 fig. 17 of *Centrotus cornutus* [Linnaeus]). The former were cited by Buckton (1902), who also refers to "the Dutch paper read in 1868 before the Ent. Soc. of the Netherlands which treats the metamorphosis of these insects," and reproduces images in larger form of three species. Buckton's (1902) crude illustrations of several Neotropical species are also added, including that of a laterally compressed *Cymbomorpha* Stål nymph misidentified as *Membracis continua* Walker, which has laterally compressed adults, but not laterally compressed nymphs; Fowler (1894) also alludes to this "*Membracis*" nymph. Both references were apparently based on Westwood's misidentification of a nymph in the Hope Collection at Oxford.

Moreover, the first accounts of any merit on New World treehopper immatures were by Funkhouser (1917), which treated and illustrated the life histories of treehoppers of the Cayuga Lake Basin in New York, and Haviland (1925), who provided brief descriptions and illustrations of the nymphs and egg masses of various species found in the Republic of Guyana. Further works are by Richter (1941a, b, 1942a, b, 1947, 1955) in Colombia; Quisenberry et al. (1978) in the United States; Strümpel (1986), who described eggs and nymphs of *Havilandia spiralis* (Haviland); Flock and Gill (1987), who illustrated and briefly described the nymph of *Parantonae* Fowler in Arizona; Pratt and Wood (1992) on the *Enchenopa binotata* (Say) species complex; Miyazaki and Buzzi (1985) on *Membracis*; Creão-Duarte and Sakakibara (1987), who described the immatures of *Kronides* Kirkaldy; Dietrich and Deitz (1991) on Aconophorini; and McKamey and Deitz (1996) on Hoplophorionini. Beyond other isolated descriptions, the features of immatures of New World taxa had received little attention until 11 characters of 56 genera (2 Amastrini genera) were included in the first phylogenetic estimate of membracid phylogeny (Dietrich et al. 2001). More recently, Godoy et al. (2006) provided images of immatures of many Neotropical genera, and Strümpel and Strümpel (2014) illustrated nymphs of a few *Enchenopa* and *Enchophyllum* species. Lencioni-Neto and Sakakibara (2013) described the immature of *Alcmeone* Stål (Darninae). The immatures of the unusual Antillean endemic genera *Antillotolania* Ramos and *Deiroderes* Ramos have also been described (McKamey and Brodbeck

2013). Regardless, formal descriptions or even illustrations of New World taxa are restricted to very few genera, and keys are nonexistant with the exception of Quisenberry et al. (1978) and Pratt and Wood (1992), severely hindering identification.

Immatures of Old world treehoppers, consisting of most of Centrotinae (Membracidae) and *Darthula* Kirkaldy (Aetalionidae) have received even less attention (Capener 1962, 1968; Ananthasubramanian 1978, 1982; Ananthasubramanian and Ghosh 1982; Ahmad and Perveen 1984, Yuan and Chou 2002). Despite having many variable features, they are morphologically less diverse than New World forms and beyond the scope of this study. No other subfamilies occur in both hemispheres.

This is the first installment describing the nymphs of New World treehopper genera, with examples of multiple species of some, egg masses of some, and other biological information. This contribution covers the tribe Amastrini, a predominantly Neotropical tribe, and includes 8 of the 11 genera (immatures of *Aurimastris* Evangelista & Sakakibara, *Hygris* Stål, and *Lallemandia* Funkhouser are unknown).

Photographs of adults of all membracid genera are available online (Deitz and Wallace 2010).

Materials and methods

Some of the species examined are new species but their nymphal descriptions below are not intended to constitute a description recognized by the International Code of Zoological Zomenclature (International Commission on Zoological Nomenclature 1999).

Late instars of Membracidae are usually sturdy enough to maintain their form when dried, so pinned specimens were used to determine characters. The only characater that would likely be affected is the length of abdominal segment IX relative to other body parts, due to contraction. Nevertheless, this effect should be roughly equivalent in all pinned specimens.

Because some form of parental care or at least aggregation of nymphs is widespread among treehoppers, for many subfamilies it is easy to associate adults, nymphs, and eggs. In the case of solitary taxa, repeated adult-nymph-host association, rearing, and in a few cases the extrapolation of the miniature pronotom have been used to associate adults and nymphs. Generally, treehopper immatures will be identifiable to genus, and sometimes to species, so the genus is described but multiple species, if known and distinctive, are also shown. Characteristics such as oviposition style, parental care, nymphal aggregation, and ant-attendance are usually uniform within tribes. Host plants and location of feeding are also reported here as far as known.

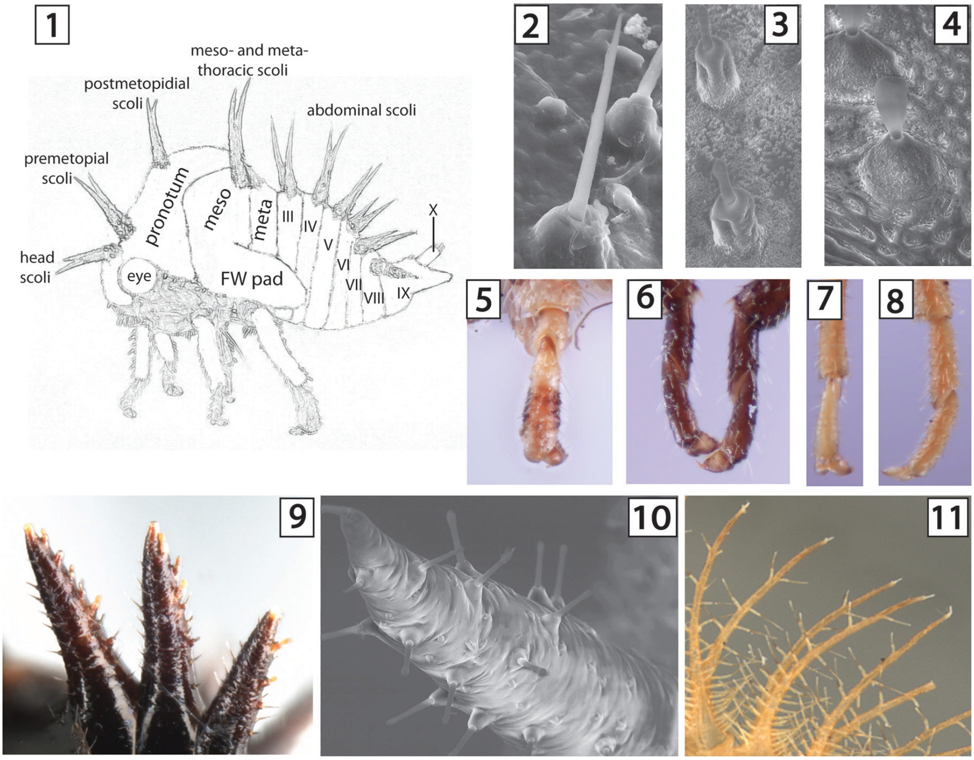
Most vouchers are deposited in the National Museum of Natural History in Washington, D.C. (USNM) in cabinet drawers designated “McKamey et al. Membracidae Immatures Vouchers,” except those of Tynelia (see below). Each voucher also has the label “Immatures Project Voucher, McKamey et al. 2015” and the species name or, if unidentified, its species number. In most cases, additional nymphs were examined, but only those placed into the separate, synoptic collection are listed in Material examined.

Images were captured with a Microvision system and Cartograph 8.0.6 automontage software and adjusted in Adobe Photoshop. Scanning Electron Micrographs taken with A Philips XL-30 SEM using a gaseous phase on uncoated specimens.

Morphology, characters, and terminology

The features used by (Dietrich et al. 2001) in their first phylogenetic estimate are used, except the protrusions on abdominal tergum II, which are difficult to determine in many specimens and not critical to differentiate nymphs. Also, because many states occur on the ventrolateral margins of the abdomen exist, our definition of "lamellae" has been refined, such that the nymph of *Tolania* Stål figured in the above paper (their Fig. 8b) is no longer considered as having lamellae but rather as having a row of enlarged chalazae. Dietrich et al. (2001) used 11 nymphal characters and 28 character states; and for many taxa the nymphs were unknown. Presently the current authors have 76 nymphal characters and 322 character states with multiple genera of every New World membracid tribe except Centronodini and the monobasic tribes, which are also represented. Because new characters are expected to be discovered as more higher taxa are surveyed, and it is desirable to keep characters grouped by body sections, listing the characters and character states in each paper would complicate comparative studies and use of the character matrix in future phylogenetic studies. The character descriptions and data matrix are therefore, instead, posted online on the Systematc Entomology Laboratory website (https://www.ars.usda.gov/Main/docs.htm?docid=25448). Because many of the character states have never been observed before, some of the terms used here are likewise novel or require elaboration.

The morphology of Amastrini and other Smiliinae are illustrated in Figs 1–11. As in adults, the pronotum of nymphs consists of a **premetopidium** (basally) and a **postmetopidium** (posteriorly), separated by a **metopidial sulcus**, which is usually marked by lateral callosties (see below) or by a transverse indentation. In contrast to the adults, all three of these structures provide useful characters in Smiliinae, and the pre- and postemetodidium bear scoli, or not, as if they were separate segments. **Chalazae** consist of a base, which can be tuberculate or stalked, and a seta, which can be needle- or hairlike (Fig. 2), subcylindrical and capitate (Fig. 3), or paleate (Fig. 4). Chalazae can cover the entire body, be restricted to certain areas, or be entirely absent, and enlarged chalazae can occur in various places as well, There are sometimes up to 3 **longitudinal rows** of enlarged chalazae or even scoli present on the abdomen, which sometimes extend onto the meso- and metanotum. On abdomial tergum IX, chalazae may be in paired longitudinal rows, irregularly arranged, or completely absent preapicaly and at or very near the apex. The larger, spinelike **scoli** (Figs 1, 9–11) may occur on every segment (Fig. 1), on none (Fig. 13), or some combination, often bear chalazae (Figs 9–11), and are almost always paired in the Amastrini genera currently represented and most other membracids. The placement of scoli, their basal and distal direction, and sizes relative to other scoli and lengths compared to their basal widths are all character states useful in distinguishing genera and, in some cases, species within genera. Flock and Gill (1987) illustrated scoli similar



Figures 1–11. Structure and character states of Smiliinae. **1** *Neotynelia nigra*, with principal structures of an membracid nymph labelled **2–4** Needlelike, subcylindrical, and paleate setae (in *Bajulata*) of chalazae with turbuculate bases, respectively **5–6** Length of first tarsomere relative to second, distinctly shorter than, or subequal in length to, respectively **7–8** *Quadrinarea* sp., Length of pro- and mesothoracic first tarsomere relative to length of metathoracic first tarsomere **9–11** Tuberculate chalazae on scoli (**9–10**) and stalked chalazae (**11**).

to those of Fig. 11 and referred to them as "spinose tubercles," which is insufficient to account for the morphological variation among all membracids bearing scoli with chalazae. Instead of scoli, but in the same places, there may occur paired enlarged chalazae or paired clusters of them (Fig. 41). As noted by Dietrich et al. (2001), the enlarged chalazae (or chalazal clusters) in the same placement of scoli suggest that the enlarged chalazae are homologous. In addition to the form and arrangement of chalazae on the tibiae, an important feature of the legs is the length of the **metathoracic first tarsomere** relative to the first tarsomere of the more anterior legs (Fig. 7 vs. 8) and to the metathoracic second tarsomere (Figs 5, 6). There are also smooth **callosities** sometimes present on the head, pronotum, or mesonotum that are diagnostic.

Characters are described from the overal body form, the head, all thoracic segments including legs and forewing wingpads, and segments III-IX of the abdomen with special emphasis on segment IX. Because new characters will undoubtedly be discovered as we explore other taxa, each of the above major regions is assigned a number and the characters are indicated by that number and a letter in the character descriptions posted online (see above). Many of these character states are related. For example, if scoli are present on the pronotum, they often occur on all thoracic and abdominal segments. There are enough exceptions, however, that separate characters are warranted for each segment. Abdominal segment X, which is the first anal segment, is sometimes long and sclerotized, but because it is often retracted into segment IX, is not included among the characters.

Results

Membracidae Rafinesque

Nymphs of Membracidae can be distinguished from all other Auchenorrhyncha, including the treehopper families Aetalionidae and Melizoderidae, by a ventrally fused abdominal segment IX, which thereby forms a tube through which the anal segments (X and XI) can be exerted by the nymph in defense or to proffer exudate to attendant ants, melaponine bees, or *Parachartergus* Ihering vespid wasps. Ants include the opportunistic genera *Azteca*, *Camponotus*, *Crematogaster*, and *Ectatomma*, which sometimes build vegetative enclosures around membracids, and which also collect from extrafloral nectaries and sometimes consume membracids (SHM observations, Haviland 1925). No nymphs of any of the treehopper families jump, but this is a feature shared with some leafhoppers (e.g., Eurymelinae and *Macropsis*) and some planthoppers (e.g., Tettigometridae).

Eggs of treehoppers are either laid in masses of 40–70 eggs, inserted singly or in groups of 2–5 into the tissue or not, and covered, uncovered, or enveloped by a white or brown secretion (whose characteristics have not yet been investigated) in usually distinct patterns. In Membracinae there is sometimes auxillary deposits by the female of waxlike or clear and sticky material above, below, or around the egg mass. Oviposition surfaces include crossvein leaf surfaces, leaf midribs, petioles, tendrils, twigs and thicker stems. In most genera of Hoplophorionini (Membracinae), additional incisions are made, prior to eclosion, through which the nymphs feed.

The descriptions below and in other installments are for the fifth instar, but most features apply equally to earlier instars. In younger instars some features are more pronounced, including an increased length of the scoli relative to their basal widths and to the overall body size, an increased the length of the abdominal segment IX relative to the rest of the body, and less development of the pronotum and wing pad.

Amastrini Goding

Note. Deitz (1975) characterized the adults of the tribe and listed eight genera in Amastrini: *Amastris* Stål, *Bajulata* Ball, *Erosne* Stål, *Harmonides* Kirkaldy, *Idioderma* Van Duzee, *Lallemandia* Funkhouser, *Tynelia* Stål, and *Vanduzea* Goding. *Hygris* Stål was later referred to Amastrini (Sakakibara 1998) and the genera *Neotynelia* Creão-Duarte & Sakakibara (2000) and *Aurimastris* Evangelista & Sakakibara (2007) were later described. The nymphs of *Lallemandia*, *Aurimastris* and *Hygris* are unknown. Below we provide a description of the immatures of the tribe and the other genera, and their character states are posetd online (see Methods). Members of Amastrini are subsocialso, in contrast with solitary taxa such as Darninae, the association of the immatures with adults is straightforward (Fig. 65).

Nymphal description. *Overal body.* Cross-section subtriangluar; chalazae dense on thorax and abdomen, obvious throughout body (except sparse in *Harmonides reticulata* and some *Neotynelia*); no parts of body covered with waxlike substance; overall body in dorsal view elongate. ***Head.*** Dorsal or anterior rounded protuberances absent (except present in some *Neotynelia*); chalazal bases tuberculate; compound eye surface setae present (except absent in *Idioderma* and some *Neotynelia*); no enlarged chalazae between eyes; enlarged chalazae in front of ventral margin of eye absent (except present in *Amastris exigua*); enlarged chalazae adjacent to central or dorsal margin of eye absent (except present in *Harmonides* and *Vanduzea laeta*); frons not extending over central margin of eye (exception: *Bajulata bajula*). ***Prothorax.*** Dorsal and lateral suprahumeral horn buds absent; pronotal lateral margin simple (except emarginate in *Bajulata*); postmetopidium without elevation and carination that is absent in adult; metopidial sulcus not incised, continuous with adjacent surfaces above and below it; posterior extension distally narrowly convex or acute. ***Mesothorax.*** Anterior basal side of scoli, if present, without cluster of enlarged chalazae. ***Legs.*** Prothoracic tibia form simple (except foliaceus in *Bajulata*); metathoracic tarsal length subequal to pro- and mesothoracic tarsal length; all first tarsomeres distinctly shorter than second tarsomeres. ***Abdomen.*** Terga III-IV dorsally with paired apically acute scoli (except none in *Idioderma*, a single middorsal projection in *Bajulata*, and paired apically rounded or blunt scoli in *Amastris elevata*); terga V-VI dorsally with paired apically acute scoli (except paired enlarged chalazae in *Idioderma*, single middorsal projection in *Bajulata*, paired apically rounded or blunt scoli in *A. elevata*); tergum VII with spaired apically acute scoli dorsally (except single middorsal projection in *Bajulata*, and paired apically rounded or blunt scoli in *A. elevata*); tergum VIII with paired apically acute scoli dorsally (except none in *Neotynelia* sp. 1, single middorsal projection in *Bajulata*, and paired apically rounded or blunt scoli in *A. elevata*); lamellae absent; scoli bearing tuberculate chalazae (expect scoli absent in *A. exigua*). Segment IX. Distal half in cross-section usually subtriangular; preapically covered with irregularly arranged chalazae (except paired row of enlarged chalazae in some *Neotynelia*); fused portion of segment IX distal to unfused portion; unfused portion distally not bifurcate.

Discussion. Although each genus of Amastrini can be distinguished within the tribe, it is difficult to neatly circumscribe Amastrini. Immatures of most amastrine genera have paired, straight scoli on abdominal terga III-VIII, some also have them on the head, or thoracic nota, or the head and all thoracic nota. The genus *Bajulata* Ball is the most divergent, in having a single middorsal process on each abdominal segment, a unique condition among Smiliinae. In contrast to other Amastrini, *Bajulata* also has paleate setae on the head and thorax.

Key to Amastrini to 5th Instars

(excluding *Aurimastris*, *Hygris*, and *Lallemandia*)

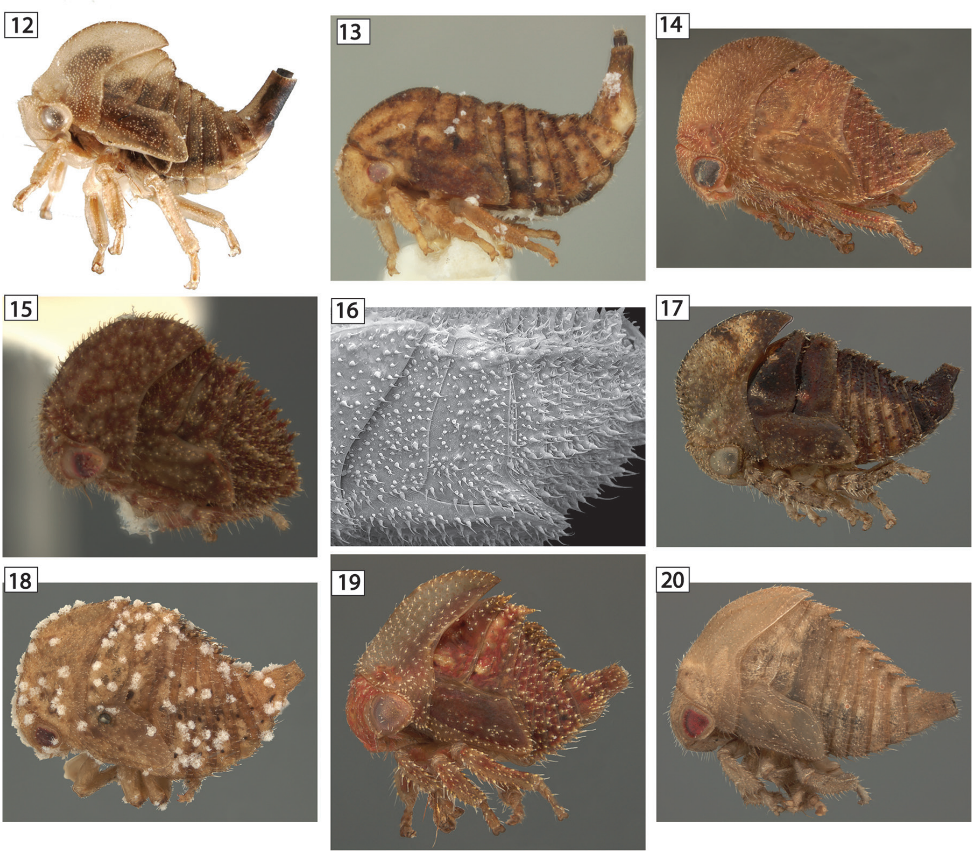
1 Postmetopidium with pair of scoli (Fig. 1) **2**
– Postmetopidium without scoli (Figs 12–26)... **3**
2 Chalazae of body and scoli with long setae, sternum IX posteriorly projected no further ventrally than dorsally (Fig. 35) .... ***Tynelia***
– Chalazae of body and scoli with very short setae, sternum IX posteriorly projected further ventrally than dorsally (Fig. 1, 30–31, 33–34) ....***Neotynelia***
3 Abdominal terga III-VIII each with single middorsal scolus (Fig. 22)....***Bajulata***
– Abdominal terga III-VIII each with paired scoli or without any scoli......... **4**
4 Abdominal scoli present and larger posteriorly (Fig. 27) ....***Idioderma***
– Abdominal scoli absent or subequal in size to each other (Fig. 20)............. **5**
5 Meso- and metanota each with paired scoli (Figs 24–25) ....***Harmonides***
– Meso- and metanota without scoli (Figs 26–40) **6**
6 Meso- and metanotum each with cluster of enlarged chalazae (Fig. 40) .... ***Vanduzea***
– Meso- and metanotum without enlarged chalazae (Fig. 12) 7
7 Pronotum extending posteriorly beyond anterior margin of metanotum...***Erosne***
– Pronotum extending posteriorly no further than anterior margin of metanotum (Figs 12–20).. ***Amastris***

Amastris Stål

Figs 12–20, 42–49, 65

Diagnosis. Usually with the following characters: head and thorax without scoli; posterior extension of pronotum not surpassing anterior margin of metanotum; terga III-VIII with paired, short, chalazal scoli of subequal size; body including wing pad densely covered with chalazae bearing short setae.

Nymphal description. ***Overal body.*** Chalazal setae short; dorsal contour of abdomen in lateral view curvilinear or linear; scoli parallel (except tightly appressed in *Amastris* sp. 5). ***Head.*** Scoli absent; chalazal setae simple, needlelike. ***Prothorax.*** Pre- and postmetopidum without scoli; posterior extension of pronotum not surpassing anterior margin of metanotum. ***Mesothorax.*** With paired enlarged chalazae dorsally; scoli absent; forewing pad costal margin straight or sinuate, with enlarged chalazae only along base; forewing pad chalazae sparse, chalazal setae short; lateral rows of abdomen not extending onto meso- and metathorax. ***Metathorax.*** Dorsally with paired scoli; scolar chalazae bearing tuberculate chalazae; scolar directed dorsally or posteriorly; dorsal scoli relative size to themselves scoli 2-4 5 basal width. ***Legs.*** Chalazae of tibia on lateral margins and many on dorsal surface. ***Abdomen.*** Terga III-VIII ventrolateral margins with single enlarged chalaza; terga III-VIII dorsal scoli all subequal in size,



Figures 12–20. *Amastris* species in lateral view. **12** *Amastris elevata* **13** *A. exigua* **14** *A. obtegens* **15–16** *Amastris* sp. **16** habitus and detail **17** *Amastris* sp. 2. **18** *Amastris* sp. 3 **19** *Amastris* sp. 4 **20** *Amastris* sp. 5.

tallest about 2-4 5 basal width, apices acute; tergum IV dorsal scoli basally directed dorsoposteriorly, distally directed posteriorly; terga III-VIII with 2 lateral rows of enlarged chalazae. Segment IX. Dorsal length subequal to combined length of segments IV-VIII; apex without dorsal enlarged chalazae or scoli; ventral extension subequal to dorsal extension.

Material examined. *Amastris elevata*, 1 nymph, 1 ant, GUYANA: Demerera Co., nr Lukabuna Crk, Georgetown-Linden Hwy, ca km55, 13 July 1987, elev. ca 50m. S.H. McKamey lot #87-14c (USNM); *Amastris obtegens* (Fabricius), 1 adult, 1 nymph, Mazaruni-Potaro, ca 13 rd km S Bartica, ca 100m, 17 August 1987, S.H. McKamey lot#87-0817-g (USNM); *Amastris* sp. 1, 1 adult, 1 nymph, Mazaruni-Potaro, Bartica, 94m. 8 August 1987, S.H. McKamey lot#87-140a (USNM); *Amastris exigua* Broomfield, 1 adult, 1 nymph, ECUADOR: Pastaza-Puyo, 960m, 2 March 1986, S.H. McKamey lot#86-0302-34 (USNM); *Amastris* sp. 2, 1 adult, 1 nymph, Napo. Coca. 9–19 February 1986, 249m. McKamey, Coll. #86-0212-10 (USNM); *Amastris* sp.

3, 1 adult, 1 nymph, Moroni-Santigao. Macas, 9 May 1986, 1070m, S.H. McKamey lot# 86-0509-2 (USNM). *Amastris* sp. 4, 1 adult, 1 nymph, GUYANA, Demerara Co., ca 46 rd km S of Linden, ca. 70m, 13-Aug 1987, S.H. McKamey lot#87-160a,b USNM); *Amastris* sp. 5, 1 adult, 1 nymph, Pichincha, Tinalandia, 16 km E Sto. Domingo de los Colorados. 16–20 April 1986. ca 600m, S.H. McKamey lot#86-0419-2 (USNM); *Amastris* sp. 6, 2 adults, 1 nymph, Napo, Limoncocha, 22 August 1988, S.H. McKamey coll#88-42d (USNM).

Distribution. Brazil and Peru northward to the United States.

Biology. As far as known, all *Amastris* are subsocial, with the female parent sitting atop her uncovered egg mass, which are inserted into stems of the host, and tending her nymphs after hatching (Fig. 65). Nymphal aggregations are almost always ant-attended. Ant specimens pinned under vouchers include *Camponotus*, *Crematogaster*, and *Azteca*.

Discussion. Broomfield (1976) revised this large genus, but many species remain undescribed, including some of the specimens examined here. Nymphs of the genus *Amastris* Stål are difficult to characterize because some species bear no distinguishing enlarged chalazae or scoli or other features and thus resemble some taxa of other Smiliinae tribes and even other subfamilies.

Bajulata **Ball**

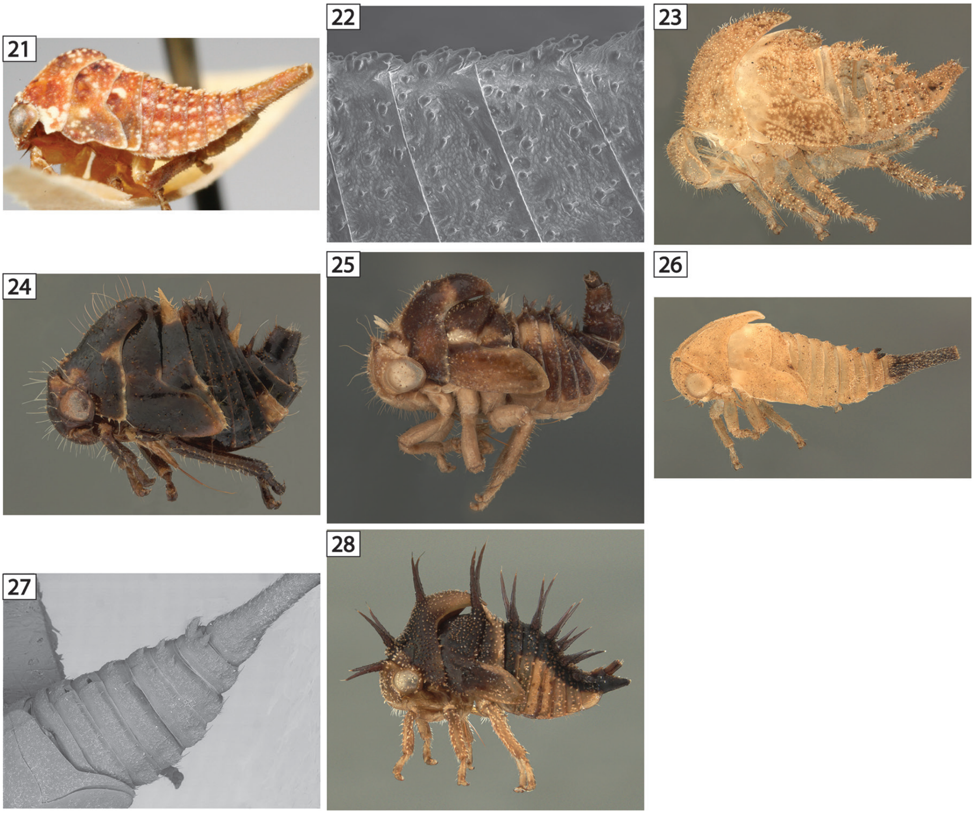
Figs 21–22, 50

Diagnosis. head and thorax without scoli; abdominal terga each with single middorsal, heavily chalazal scolus; head and thorax with paleate setae.

Nymphal description. ***Overal body.*** Chalazal setae short; dorsal contour of abdomen in lateral view linear; frons extending over central margin of eye. ***Head.*** Without scoli; chalazal setae paleate. ***Prothorax.*** Pre- and postmetopidium without scoli; posterior extension of pronotum not surpassing anterior margin of metanotum. ***Mesothorax.*** Without dorsal enlarged chalazae or scoli; forewing pad costal margin emarginate; forewing pad chalazae sparse, chalazal setae short, without costal chalazae; lateral rows of abdomen not extending onto meso- and metathorax. ***Metathorax.*** Without dorsal enlarged chalazae or scoli. ***Legs.*** Prothoracic tibia foliaceus; chalazae of tibia on anterior and posterior lateral margins, absent or very few on dorsal surface. ***Abdomen.*** Terga III-VIII ventrolateral margins with row of enlarged chalazae, dorsal scoli all subequal in size, tallest dorsal scolus about 2-4 5 basal width, dorsal scoli consisting of single middorsal projection directed posteriorly, distally appressed to following tergum; tergum IV dorsal scolus distally directed posteriorly; terga III-VIII with 2 lateral rows of enlarged chalazae. Segment IX. Dorsal length subequal to combined length of segments IV-VIII; with paired enlarged chalazae apically; ventral extension subequal to dorsal extension.

Material examined. *Bajulata bajula* (Goding), 1 adult, 1 nymph, USA: Tucson, Arizona, April 1942 (USNM).

Distribution. United States.



Figures 21–28. Amastrine lateral views. **21–22** *Bajulata bajula*, habitus and detail, showing the single medial scoli appressed to the following segments **23** *Erosne* sp. exuvia **24** *Harmonides reticulata* **25** *Harmonides* sp. 1. **26–27** *Idioderma virescens*, exuvia, habitus and detail **28** *Neotynelia nigra*.

Erosne Stål

Figs 23, 51

Diagnosis. Head and thorax without scoli; posterior extension of pronotum slightly surpassing anterior margin of metanotum; terga III-VIII with paired, short, chalazal scoli of subequal size; body including wing pad densely covered with chalazae bearing short setae.

Nymphal description. ***Overal body.*** Chalazal setae short; dorsal contour of abdomen in lateral view curvilinear. ***Head.*** Scoli absent; chalazal setae simple, needlelike; ***Prothorax.*** Pre- and postmetopidium without scoli; posterior extension of pronotum slightly surpasses anterior margin of metanotum. ***Mesothorax.*** With paired cluster of enlarged chalazae dorsally; scoli absent; forewing pad anterior costal margin straight; forewing pad chalazae dense, chalazal setae short; forewing pad costal chalazae only present at base. ***Metathorax.*** With paired cluster of enlarged chalazae dorsally; scoli absent. ***Legs.*** Chalazae of tibia on anterior and posterior lateral margin and dorsal surface. ***Abdomen.*** Terga III-VIII ventrolateral margins with single enlarged chalaza; dorsal scoli all subequal in size, tallest dorsal scoli about 2-4 5 basal width; tergum IV dorsal scoli basally directed dorsally or almost so, distally directed posteriorly; terga III-VIII lateral rows not manifested; tergum III with paired dorsal, apically acute scoli. Segment IX. Dorsal length subequal to combined length of segments V-VIII; dorsally without enlarged chalazae or scoli at apex; ventral extension subequal to dorsal extension.

Material examined. *Erosne* sp., 2 adults, 1 exuvia, VENEZUELA: Ed. Merida Lagunillas, 17 July 1984, S.H. McKamey, Coll. (USNM).

Distribution. Brazil to northern South America.

Discussion. At present, the only feature found to distinguish *Erosne* nymphs from *Amastris* is the slightly further posterior extension of the pronotum in *Erosne*, which is undoudtedly coupled with the more extensive pronotum in the adults. The *Erosne* species examined is new.

Harmonides Kirkaldy

Figs 24–25, 52–53

Diagnosis. Head and pronotum without scoli; meso- and metanota and terga III-VIII each with short paired scoli; body evenly covered with chalazae with long setae.

Nymphal description. ***Overal body.*** Chalazal setae long; dorsal contour of abdomen in lateral view curvilinear; scoli splayed away from each other. ***Head.*** Scoli present or absent; scoli, if present, directed dorsad; chalazal setae simple, hairlike. ***Prothorax.*** Premetopidium scoli present or absent; premetopidium scoli, if present, directed anteriorly, and about 2-4 5 basal width; postmetopidium scoli absent; posterior extension of pronotum surpasses anterior margin of metanotum. ***Mesothorax.*** With paired scoli dorsally; scoli bearing tuberculate chalazae or without chalazae; scoli directed anteriorly or dorsally; forewing pad costal margin straight; forewing pad chalazae sparsly, their setae short; dorsal scoli 2-4 5 basal width; forewing pad without costal chalazae. ***Metathorax.*** With paired scoli dorsally, directed dorsally or almost so, 2-4 5 basal width, bearing tuberculate chalazae. ***Legs.*** Chalazae of tibia on both lateral margins but with or without chalazae on dorsal surface also. ***Abdomen.*** Terga III-VIII ventrolateral margins with single enlarged chalaza or without enlarged chalazae; terga III-VIII dorsal scoli all subequal in size or size decreasing posteriorly, tallest dorsal scoli 2-4 5 basal width; tergum IV dorsal scoli directed dorsally or almost so; terga III-VIII lateral rows not manifested; tergum III with paired apically acute scoli dorsally. Segment IX. Dorsal length subequal to combined length of segments V-VIII or VI-VIII; without dorsal enlarged chalazae or scoli at apex; ventral extension subequal to dorsal extension.

Material examined. *Harmonides reticulata* (Fabricius), 2 nymphs, 1 adult, VENEZUELA: Estado Zulia, Dist. Pirija, Tocuco, 28-29 June 1984, S.H. McKamey lot#680. (USNM). Harmonides sp. 1, 1 adult, 1 nymph, PANAMA, Barro Colorado Island, Canal Zone,VII-VIII 1942, JasZetel No. 4485 (USNM).

Distribution. Brazil northward to Mexico.

Discussion. *Harmonides reticulata* is a common widespread species that SHM has often found in aggretations of adults and nymphs. *Harmonides* sp. 1 is curious in that it has delicate premetopidial scoli (Fig. 25) and therefore resembles *Neotynelia*. The two genera differ in the presence, in *Neotynelia*, of scoli on the head as well.

Idioderma Van Duzee

Figs 26–27, 54

Diagnosis. Head and thorax without scoli; terga IV-V with paired enlarged chalazae, terga VI-VIII with short paired scoli increasing in size posteriorly.

Nymphal description. *Overal body.* Chalazal setae short; dorsal contour of abdomen in lateral view linear; scoli parallel. ***Head.*** Without scoli; chalazal setae simple, needlelike. ***Prothorax.*** Pre- and postmetopidium scoli absent; posterior extension of pronotum not surpassing anterior margin of metanotum. ***Mesothorax.*** Without dorsal enlarged chalazae or scoli; forewing pad costal margin straight, without costal chalazae; forewing pad chalazae dense, chalazal setae long. ***Metathorax.*** Without dorsal enlarged chalazae or scoli. ***Legs.*** Chalazae of tibia on lateral margins and many on dorsal surface. ***Abdomen.*** Terga III-VIII ventrolateral margins with single enlarged chalaza; terga IV-VIII dorsal structures increasing in size posteriorly, tallest dorsal scoli about as tall as basal width; tergum IV dorsal scoli directed dorsoposteriorly; terga III-VIII lateral rows not manifested; tergum III without dorsal enlarged chalazae or scoli. Segment IX. Dorsal length subequal to combined length of segments IV-VIII; without dorsal enlarged chalazae or scoli at apex; ventral extension subequal to dorsal extension.

Material examined. *Idioderma virescens* Van Duzee, 1 adult, 1 nymph. CUBA, Mi. 8407, VIII-3-59-18112, (USNM); 1 nymph, USA, Florida, Indian River Co., Vero Beach, 31 May 1968, J.S. Haeget, *Serenoa repens* (Bartram) [saw palmetto, Arecaceae] (USNM).

Distribution. Bahamas (South Minini Island), Cuba, Jamaica, United States (Florida).

Biology. Adults and nymphs of *I. virescens* aggregate, feed, and develop on *Seronoa repens* (Bartram) Small (i.e. saw palmetto palm) and *Phoenix roebelenii* O'Brien (i.e. pygmy date palm) (Kopp and Tsai 1983). This species is often found tended by several species of ants (*Pseudomyrmex brunneus* Smith, *Componotus floridanus* Buckley, and *Solenopsis invicta* Buren) and may be a vector of lethal yellowing disease of palm. This is a common and widespread species occurring in the Bahamas, West Indies, and the United States (Metcalf and Brunner 1925, Metcalf 1954, Howard et al. 1981, Deitz and Wallace 2012).

Neotynelia Creão-Duarte & Sakakibara

Figs 1, 28–33, 55–60

Diagnosis. Postmetopidium of pronotum, meso- and metanota, and abdominal terga IV-VII (usually III-VIII) each with pair of long scoli; segment IX posteriorly projected further ventrally than dorsally; body with chalazae with short subcylindrical setae; head with large or small scoli.

Nymphal description. ***Overal body.*** Chalazal setae short; dorsal contour of abdomen in lateral view curvilinear; scoli splayed away from each other (except scoli parallel in *N. pubescens* (Fabricius)). ***Head.*** Simple conical scoli present or absent, if present then directed anterad; chalazal setae subcylindrical. ***Prothorax.*** Premetopidium scoli present, directed anteriorly; postmetopidium scoli present, directed dorsally; posterior extension of pronotum not surpassing anterior margin of metanotum. ***Mesothorax.*** With paired dorsal scoli, directed dorsally or almost so, bearing tuberculate chalazae; forewing pad costal margin straight, without chalazae (except present on base of costal margin in *Neotynelia* sp. 4); forewing pad surface chalazae sparse with short setae; dorsal scoli usually at least 5 5 basal width, rarely 2-4 5 basal width. ***Metathorax.*** Usually with paired scoli dorsally, directed anteriorly, up to 5 5 basal width, bearing tuberculate chalazae. ***Legs.*** Chalazae of tibia on anterior and posterior lateral margins, absent or very few on dorsal surface. ***Abdomen.*** Terga III-VIII ventrolateral margins with or without single enlarged chalaza; terga IV-VII, and usually III and VIII, with dorsal scoli domen, very unequal in size, but not clinally, tallest dorsal scoli about 5 5 basal width, apically acute; tergum IV scoli basally directed dorsally or almost so, distally directed posteriorly; terga III-VIII lateral rows not manifested. Segment IX. Dorsal length subequal to combined length of segments V-VIII; apex with paired enlarged chalazae dorsally; ventral extension distinctly greater than dorsal extension.

Material examined. *Neotynelia nigra* (Funkhouser), 1 adult, 2 nymphs, ECUADOR; Napo. Finca, San Jorge, ca.10 air, km E Coca, on Rio Napo. 7-10 March 1986, S.H. McKamey lot#86-0310-4, lot#86-0310-16 (USNM); *Neotynelia pubescens*, 1 adult, 1 nymph, GUYANA: Rupunini, Karanambu, 69 air, km NE Lethem, 100m. 24-26 July, 1987 S.H. McKamey lot#87-95a (USNM); *Neotynelia* sp. 1, 1 nymph (unassociated), GUYANA: Demerara, Co., Kairuni Crk., Georgetown-Linden Hwy, ca km80, ca 50m, 12 August 1987, S.H. McKamey lot#87-1746 (USNM); *Neotynelia* sp. 2, 1 nymph (unassociated) ECUADOR: Napo, Garzacocha, 68 air km E Coca. 13–17, March 1986. ca 210m, S.H. McKamey #86-0316 (USNM); *Neotynelia* sp. 3, 1 nymph (unassociated), ECUADOR: Napo 2.5 rd km E Lumbaqui, 20 January 1986. 540m, S.H. McKamey lot#86-0120-29 (USNM); *Neotynelia* sp. 4, 1 nymph (unassociated), BRAZIL: Amazonas, Parana do Xiboreninho, 03°15'-06° 00'W, 5 August 1979 (USNM).

Distribution. Brazil and Peru northward to Mexico.

Discussion. Contrary to the majority of *Neotynelia* species examined in this study, *Neotynelia* sp. 1 has sparse to almost absent chalazae covering its entire body.

Figures 29–37. Amastrine lateral views. **29** *Neotynelia pubescens* **30** *Neotynelia* sp. 1 **31** *Neotynelia* sp. 2 (abdominal segment IX missing) **32** *Neotynelia* sp. 3 **33** *Neotynelia* sp. 4. **34** *Tynelia godoyae* (courtesy of Camilo Flóres) **35** *Vanduzea arquata* **36** *V. laeta*. **37** *V. nolina* (raised to specific rank).

Tynelia Stål

Fig. 34

Diagnosis. Postmetopidium of pronotum, meso- and metanota, and abdominal terga III-VIII each with pair of long scoli; sternum IX posteriorly projected no further ventrally than dorsally; body with chalazae with hairlike long setae.

Nymphal description. ***Overal body.*** Chalazal setae long; dorsal contour of abdomen in lateral view curvilinear; scoli splayed away from each other. ***Head.*** Simple conical scoli present, directed anterally; chalazal setae hairlike. ***Prothorax.*** Premetopidium scoli present, directed dorsoanteriorly; postmetopidium scoli present, directed dorsally; posterior extension of pronotum not surpassing anterior margin of metanotum. ***Mesothorax.*** With paired scoli dorsally, directed dorsally or almost so, bearing tuberculate chalazae; forewing pad costal margin straight; forewing pad chalazae sparse, chalazal setae long, without costal chalazae; dorsal scoli 2-4 5 basal width; condition of lateral rows undetermined. ***Metathorax.*** With paired scoli dorsally, directed dorsoanteriorly, length 2-4 5 basal width, bearing tuberculate chalazae. ***Legs.*** Chalazae of tibia on anterior and posterior lateral margins, absent or very few on dorsal surface. ***Abdomen.*** Terga III-VIII ventrolateral marginal condition undetermined; terga III-VIII with paired dorsal scoli, unequal in size, but not clinally; terga III-VIII tallest dorsal scoli 2-4 5 basal width, apically acute; tergum IV dorsal scoli directed dorsally or almost so; terga III-VIII with lateral rows. Segment IX. Dorsal length subequal to combined length of segments V-VIII; apex with paired enlarged chalazae dorsally; ventral extension subequal to dorsal extension.

Material examined. *Tynelia godoyae* Creão-Duarte & Sakakibara, images of 3 nymphs, 1 adult, COLOMBIA. Antioquia. Remedios, vereda La Cruz, finca La Brillantina, N 6.8840833 W 74.5713056, 500m, rastrojo manual, abr-2014, C. Flórez (Camilo Flórez collection).

Distribution. Brazil, Peru, and Colombia.

Discussion. This voucher material represents a new country record for both the genus and species. *Tynelia* most closely resembles *Neotynelia*, but differs in having long chalazal setae and in lacking the extended ventral apex of abdominal segment IX.

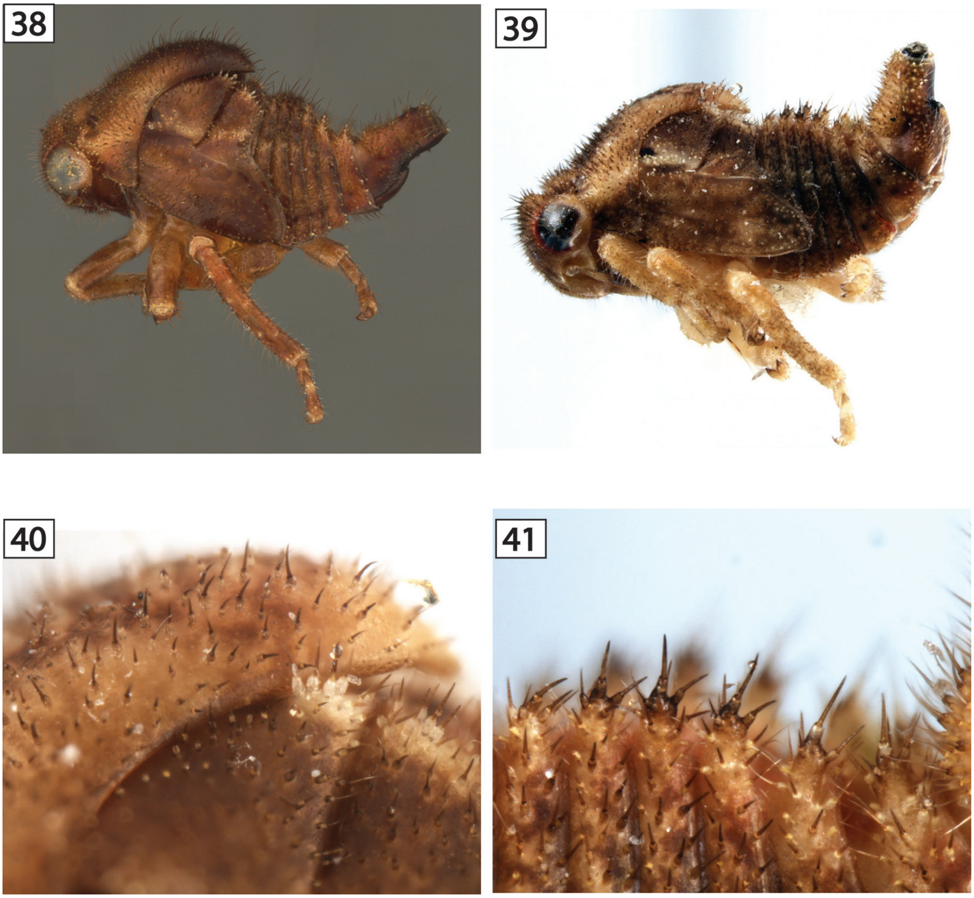
Vanduzea Goding

Figs 35–41, 61–64

Diagnosis. Head and thorax without scoli; meso and metanota with enlarged cluster of chalazae (Fig. 40), terga III-VIII each with pair of short, densely chalazal scoli (Fig. 41).

Nymphal description. ***Overal body.*** Chalazal setae long; dorsal contour of abdomen in lateral view curvilinear; scoli parallel. ***Head.*** Scoli absent; chalazal setae simple, hairlike. ***Prothorax.*** Without pre- or postmetopidium scoli; posterior extension of pronotum surpassing anterior but no posterior margin of metanotum. ***Mesothorax.*** With paired cluster of enlarged chalazae dorsally; scoli absent; forewing pad costal margin straight, without costal chalazae; forewing pad densely covered with chalazae, chalazal setae long. ***Metathorax.*** With paired cluster of enlarged chalazae dorsally. ***Legs.*** Chalazae of tibia on lateral margins and many on dorsal surface. ***Abdomen.*** Terga III-VIII ventrolateral margins without enlarged chalazae; terga III-VIII dorsal scoli all subequal in size, tallest dorsal scoli 2-4 5 basal width; tergum IV dorsal scoli directed dorsally; terga III-VIII lateral rows not manifested; tergum III with paired apically acute scoli dorsally. Segment IX. Dorsal length subequal to combined length of remaining visible abdominal terga or at least V-VIII; without dorsal enlarged chalazae or scoli at apex; ventral extension subequal to dorsal extension.

Material examined. *Vanduzea arquata* Say, 1 adult, 1 nymph, USA: Maryland, Frederick County, Frederick, 2 August 1994, M.J. Rothschild, near Linden, Virginia,

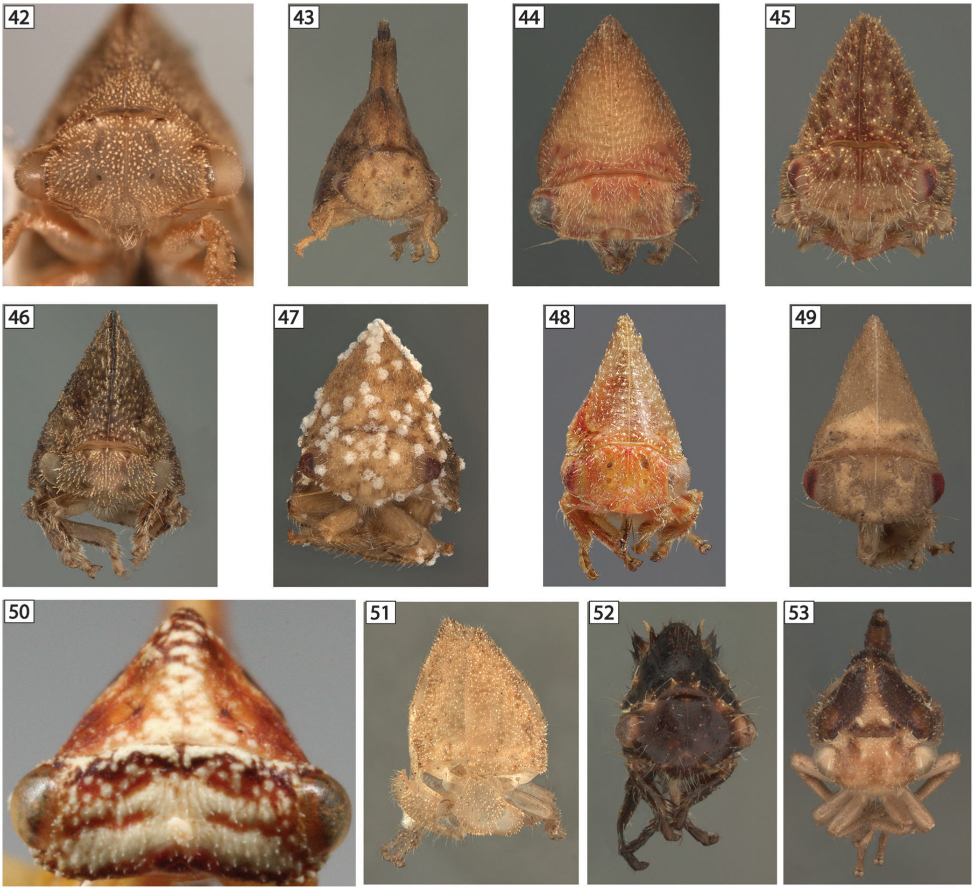


Figures 38–41. Amastrine lateral views. **38** *Vanduzea triguttata* **39–41** *Vanduzea* sp. 1 from Ecuador, habitus and detail of thoracic nota and abdominal terga.

March 28, 1922 (USNM), 1 nymph, 1 adult, USA: North Carolina, Wake Co., Raleigh, 8 Aug 1986, S.H. McKamey lot #86-0808-2 (USNM), *Robinia pseudoacacia* L., Fabaceae; *Vanduzea laeta* Goding, 1 adult, 4 nymphs, USA: Tuscon, Arizona, 5-12-29 E.D. Ball (USNM); *Vanduzea nolina* Ball, 1 adult, 1 nymph, Nogales, E.D. Ball, Ar., 8-14-35, 7-30-37 (USNM); *Vanduzea segmentata* Fowler, 1 adult, 1 nymph, USA: Brownsville, Texas, 5-3-38, Los Angles Co., California (USNM); *Vanduzea triguttata* (Burmeister), 1 adult, 1 nymph, USA: Tucson, Arizona, June 16, 1933, P.W. Oman, (USNM). *Vanduzea* sp. 1, 1 adult, 1 nymph, ECUADOR (USNM).

Distribution. Northern South America northward to Canada, Hawaii.

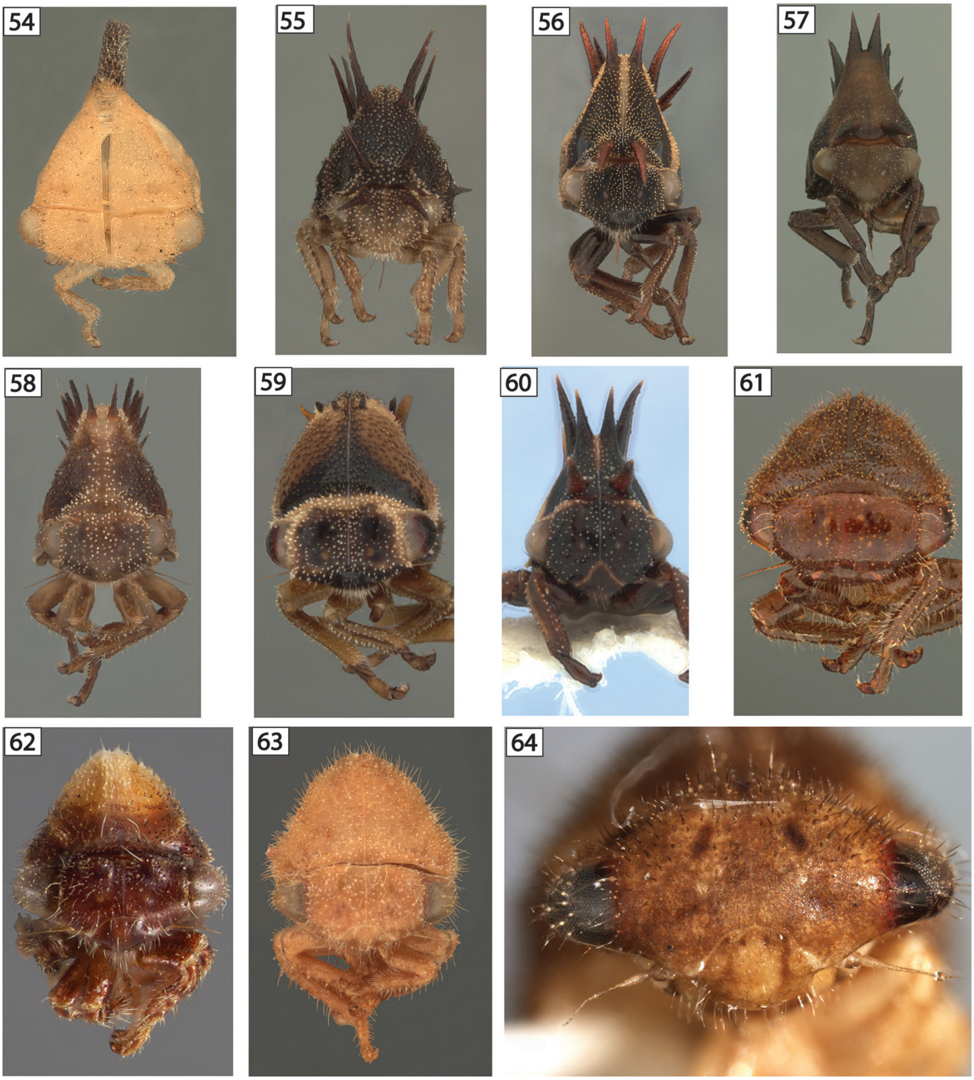
Biology. Similar to other Amastrini genera, *Vanduzea* aggregate on their host plants and some species, for example *Vanduzea arquata* (Funkhouser, 1915), are tended by *Formica* ants (Funkhouser 1915, Fritz 1983, Crocroft 2003). These treehoppers feed



Figures 42–53. Amastrine anterior views. **42** *Amastris elevata* **43** *A. exigua* **44** *A. obtegens* **45** *Amastris* sp. 1 **46** *Amastris* sp. 2 **47** *Amastris* sp. 3 **48** *Amastris* sp. 4 **49** *Amastris* sp. 5 **50** *Bajulata bajula* **51** *Erosne* sp. exuvia **52** *Harmonides reticulata* **53** *Harmonides* sp. 1.

on herbaceous and woody dicot hosts, such as *Albizia julibrisson*, *Citrus* sp., *Melilotus alba*, *Bidens alba*, *Eupetorium capillofolium*, *Lespedeza* sp., *Quercus* sp., and *Robinia pseudoacacia* (Kopp and Yonke 1973c, Dietrich et al. 1999). *Vanduzea* is a common and widespread genus in the Nearctic, Neotropics, West Indies, and has been introduced to the Hawaiian Islands (Deitz and Wallace 2012). SHM has observed them in Hawaii tended by ants, which are also introduced.

Discussion. The nymph of *Vanduzea laeta* has unequal but not posteriorly increasing or decreasing sizes of abdominal scoli with greatly elongate scoli on terga IV and V (Fig. 36). In contrast, *V. laeta nolina* has abdominal scoli that are subequal in length and all short (Fig. 37), so the latter is here elevated to specific status.



Figures 54–64. Amastrine anterior views. **54** *Idioderma virescens* exuvia **55** *Neotynelia nigra* **56** *N. pubescens* **57** *Neotynelia* sp. 1 **58** *Neotynelia* sp. 2 **59** *Neotynelia* sp. 3 **60** *Neotynelia* sp. 4 **61** *Vanduzea arquata* **62** *V. laeta* **63** *V. nolina* **64** *Vanduzea* sp. 1 from Ecuador.

Figure 65. *Amastris* sp. (apparently undescribed) adult and nymphs in Brazil on *Byrsonima* sp. (Malpighiaceae), with ant in background (courtesy of Javier Ibarra Isassi).

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Pseudofornicia gen. n. (Hymenoptera, Braconidae, Microgastrinae), a new Indo-Australian genus and one new species from Vietnam

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Abstract

Pseudofornicia **gen. n.** (Hymenoptera: Braconidae: Microgastrinae) is described (type species: *P. nigrisoma* **sp. n.** from Vietnam) including three Oriental (type species, *P. flavoabdominis* (He & Chen, 1994), **comb. n.** and *P. vanachterbergi* Long, (**nom. n.** for *Fornicia achterbergi* Long, 2007; not *F. achterbergi* Yang & Chen, 2006) and one Australian species (*P. commoni* (Austin & Dangerfield, 1992), **comb. n.**). Keys to genera with similar metasomal carapace and to species of the new genus are provided. The new genus shares the curved inner middle tibial spur, the comparatively small head, the median carina of the first metasomal tergite and the metasomal carapace with *Fornicia* Brullé, 1846, but has the first tergite movably joined to the second tergite and the third tergite 1.1–1.6 × as long as the second tergite medially and is flattened in lateral view. One of the included species is a primary homonym and is renamed in this paper.

Keywords

Fornicia, *Diolcogaster*, *Buluka*, key, new genus, Oriental, China, Australia

Introduction

During the review of the genus *Fornicia* Brullé, 1846 (Braconidae: Microgastrinae) by the first two authors (van Achterberg and Long, in prep.), it was discovered that some of its Indo-Australian species and a new species from Vietnam did not fit in *Fornicia* because the first tergite of the carapace is movably connected to the second tergite. During the evolution of the Microgastrinae a carapace was independently developed several times in various ways (Mason 1981), but the exact phylogenetic history of this character and its states is still largely unknown. A new genus (*Pseudofornicia* gen. n.) is named herein to accommodate for these very similar but overall smaller species.

Material and methods

For identification of the subfamily Microgastrinae, see van Achterberg (1990, 1993), for identification of the genus *Fornicia*, see Mason (1981), for references to the genus *Fornicia* and other genera mentioned in this paper, see Yu et al. (2012). Photographic images were made with the Keyence VHX-5000 digital microscope and processed with Adobe Photoshop CS5, mostly to adjust the size and background. Morphological terminology follows van Achterberg (1988, 1993), including the abbreviations for the wing venation. Measurements are taken as indicated by van Achterberg (1988) for the length and the width of a body part the maximum length and width is taken, unless otherwise indicated. The length of the mesosoma is measured from the anterior border of the mesoscutum till the apex of the propodeum and of the first tergite from the posterior border of the adductor till the medio-posterior margin of the tergite.

The specimens are deposited in the following collections: Institute of Insect Sciences, Zhejiang University (ZJUH), Hangzhou; Institute of Ecology & Biological Resources (IEBR), Hanoi, Vietnam National Museum of Nature (VNMN), Hanoi, Naturalis Biodiversity Center (RMNH), Leiden and Australian National Insect Collection (ANIC), Canberra. In the keys we use in some couplets "if", "then" or "and" in bold to be explicit that in those cases more than one character state has to be considered. Additional non-exclusive characters are between brackets.

Key to microgastrine genera with complete metasomal carapace

(only to females of genera with carapace covering most of metasoma and having the dorsal face of the first tergite shorter than the second tergite)

1 Three anterior metasomal tergites forming a strongly convex carapace in lateral view, with first tergite immovably joined to second tergite **and** prepectal carina present behind fore coxae; outer aspect of scapus strongly concave apically; axilla of scutellum wide laterally, lamelliform and sub-vertically curved up above base

of hind wing; head unusually small, 0.7–0.8 × as wide as mesoscutum in dorsal view; [vein r-m of fore wing absent; vein 1-SR of fore wing linear with vein 1-M; vein cu-a of hind wing mostly sinuate and inclivous] ....***Fornicia* Brullé, 1846**

– Three anterior tergites forming a flattened carapace in lateral view and first tergite movably joined to second tergite (best seen laterally as a distinct separation between both tergites: Figs 4, 14, 24), **if** immovably joined (some *Diolcogaster* and *Xanthapanteles*) **then** prepectal carina completely absent; outer aspect of scapus often truncate apically or nearly so, but with oblique apex in *Pseudofornicia* (Fig. 10); axilla of scutellum narrow laterally, less lamelliform and almost flat above base of hind wing, rarely rather curved up (e.g. *Buluka*); head medium-sized, 0.8–1.0 × as wide as mesoscutum in dorsal view **2**

2 Vein r-m of fore wing absent (Figs 2, 22); second suture of metasoma curved and together with lateral grooves of medial area forming a more or less X-shaped figure (Figs 3, 13, 23); vein 1-SR of fore wing 0.3–0.4 × as long as vein 1-M (Figs 2, 12); dorsal carinae of first metasomal tergite united into median carina posteriorly and with a lamella separating dorsal and anterior face of tergite (Figs 13, 23); medio-longitudinal carina of propodeum absent (Fig. 13); height of head 0.5–0.7 × height of mesosoma (Figs 1, 11); third tergite 1.1–1.6 × as long as second tergite medially (Figs 2, 13, 23)......................***Pseudofornicia* van Achterberg, gen. n.**

– Vein r-m of fore wing present; second suture straight and without X-shaped impression; vein 1-SR of fore wing 0.1–0.3 × as long as vein 1-M; dorsal carinae of first metasomal tergite separated throughout and without a lamella separating dorsal and anterior face of tergite; propodeum with complete medio-longitudinal carina; height of head 0.8–0.9 × height of mesosoma; third tergite 1.0–2.0 × as long as second tergite medially **3**

3 Second tergite with distinct medial area surrounded by grooves and tergite about as long as third tergite; second submarginal cell of fore wing (“areolet”) petiolate and hardly wider than width of surroundings veins; fourth and following tergites of ♀ more or less exposed........***Diolcogaster* Ashmead, 1900**, p.p.

– Second tergite without distinct medial area, at most vaguely indicated and tergite about half as long as third tergite; second submarginal cell of fore wing sessile and distinctly wider than width of surroundings veins; fourth and following tergites of ♀ retracted................................ ***Buluka* de Saeger, 1948**

Systematics

***Pseudofornicia* van Achterberg, gen. n.**

http://zoobank.org/60B6A212-2344-493B-9168-F4E277EA8977
Figs 1–30

Etymology. The specific name is derived from “pseudos” (Greek for “fallacy”) and the generic name *Fornicia* Brullé, because it is similar to that genus. Gender: feminine.

Type species. *Pseudofornicia nigrisoma* van Achterberg & Long, sp. n.

Diagnosis. Height of head 0.5–0.7 × height of mesosoma in lateral view (Figs 1, 11) and width of head 0.8–0.9 × width of mesoscutum; scapus moderately oblique apically; prepectal carina absent; axilla curved up over base of hind wing; metanotum with lobe-shaped protuberance postero-dorsally; medio-longitudinal carina of propodeum absent (Fig. 13); vein r-m of fore wing absent (Figs 2, 22); vein 1-SR of fore wing 0.3–0.4 × as long as vein 1-M (Figs 2, 12); inner middle tibial spur as long as basitarsus and curved (Fig. 1); three anterior tergites of metasoma forming a flattened carapace covering most of metasoma dorsally (Figs 4, 14, 24); first tergite movably joined to second tergite (Fig. 4); dorsal carinae of first metasomal tergite united into median carina posteriorly and with a lamella separating dorsal and anterior face of tergite (Figs 13, 23), anterior face smooth and flat; second suture of metasoma sinuate, crenulate and together with lateral grooves of medial area forming a more or less X-shaped figure (Figs 3, 13, 23); third tergite 1.1–1.6 × as long as second tergite medially (Figs 2, 13, 23); fourth-sixth tergites more or less sclerotized; ovipositor short and decurved; ovipositor sheath largely glabrous, narrow and only apically with some long setae; hypopygium of female fully sclerotized and acute apically. Males unknown.

Distribution. Indo-Australian.

Biology. Unknown, but the species of the very similar genus *Fornicia* are koinobiont endoparasitoids of limacodid caterpillars (Yu et al. 2012).

Comments. The genus will run in the key to world genera of Microgastrinae by Mason (1981) to the genus *Fornicia* Brullé. The new genus can be separated as follows:

1 Third tergite 1.1–1.6 × as long as second tergite medially and flattened in lateral view; first tergite movably joined to second tergite; second tergite with wide and anteriorly widened medial area; second suture of metasoma curved and together with lateral grooves of medial area more or less X-shaped; head 0.8–1.0 × as wide as mesoscutum; prepectal carina absent; fourth-sixth tergites more or less sclerotized; scapus moderately oblique apically .... ***Pseudofornicia* van Achterberg, gen. n.**

– Third tergite 0.5–0.9 × as long as second tergite medially and curved in lateral view; first tergite immovably joined to second tergite; second tergite with narrow and anteriorly parallel-sided medial area; second suture of metasoma straight and not connected to lateral grooves of medial area and not X-shaped; head 0.7–0.8 × as wide as mesoscutum; prepectal carina present behind fore coxa; fourth-sixth tergites mainly membranous; scapus strongly oblique apically .... ***Fornicia* Brullé**

Key to species of the genus *Pseudofornicia*

1 Medial area of second metasomal tergite wide triangular (Fig. 46 in Austin and Dangerfield 1992); fore wing with two dark patches; scutellum with a

slender (in lateral view tooth-like, but in dorsal view obtuse) protuberance posteriorly; height of head 0.5 × height of mesosoma in lateral view; median carina of first tergite 0.3–0.4 × as long as dorsal face of tergite; [metasoma black]; Australian region (Australia: Queensland).. ....***P. commoni* (Austin & Dangerfield, 1992), comb. n.**

\- Medial area of second tergite largely subparallel-sided and only anteriorly widened (Figs 3, 23) or vase-shaped (Fig. 13); fore wing without dark patches; scutellum without protuberance, at most with a more or less up curved subposterior rim; height of head 0.6–0.7 × height of mesosoma in lateral view (Figs 1, 11); median carina of first tergite nearly as long as dorsal face of tergite (Figs 3, 13, 23); Oriental region..**2**

2 Metasoma black dorsally and parallel-sided (Fig. 13); vein m-cu of fore wing about as long as vein 2-SR+M (Fig. 12); apical half of hind tibia dark brown (Figs 11, 15); height of head 0.7 × height of mesosoma in lateral view (Fig. 11); propodeum without elevated medio-basal area (Fig. 13); medial area of second tergite vase-shaped (Fig. 13); median length of third tergite 1.2 × second tergite (Fig. 13); vein cu-a of hind wing nearly straight (Fig. 19)....... ....***P. nigrisoma* van Achterberg & Long, sp. n.**

– Metasoma brownish-yellow dorsally, at most second and third tergites medially dark brown and roundly narrowed posteriorly (Figs 3, 23); vein m-cu of fore wing shorter than vein 2-SR+M (Figs 2, 22); apical half of hind tibia yellowish brown (Figs 5, 25); height of head 0.6 × height of mesosoma in lateral view (Fig. 1); propodeum with small elevated medio-basal area (Fig. 3); medial area of second tergite largely subparallel-sided and only anteriorly widened (Figs 3, 23); median length of third tergite 1.3–1.5 × second tergite (Figs 3, 23); vein cu-a of hind wing moderately sinuate (Figs 8, 24) **3**

3 Head 0.8 × as wide as mesoscutum; anterior half of medial area of second metasomal tergite largely sculptured (especially laterally) and more gradually narrowed posteriorly (Fig. 3); first tergite near median carina hardly depressed and X-shaped groove superficial (Fig. 3, but posteriorly impressed); first discal cell nearly as setose as apical third of fore wing; apical rim of scutellum remaining far below upper level of scutellum; second and third tergites dark brown medially (Fig. 3); third tergite densely finely reticulate medially (Fig. 3)...........................***P. flavoabdominis* (He & Chen, 1994) comb. n.**

\- Head 0.9 × as wide as mesoscutum; anterior half of medial area of second metasomal tergite largely smooth, except some punctures laterally and more abruptly narrowed posteriorly (Fig. 23); first tergite near median carina depressed because of distinctly impressed X-shaped groove (Fig. 23); first discal cell less setose than apical third of fore wing; apical rim of scutellum nearly reaching upper level of scutellum (Fig. 29); second and third tergites brownish yellow medially (Fig. 23); third tergite coarser reticulate medially (Fig. 23) ....***P. vanachterbergi* Long, nom. n.**

Pseudofornicia commoni (Austin & Dangerfield, 1992), comb. n.

Fornicia commoni Austin & Dangerfield, 1992: 29–31, figs 44–47 (only holotype (ANIC) known: Australia, Queensland, 25 miles N of Gin Gin; not examined).

Diagnosis. Easily to recognize by having the second metasomal tergite with a large triangular medio-basal area (Fig. 46 in Austin and Dangerfield 1992), the fore wing with two dark patches, the scutellum with a slender (in lateral view tooth-like, but in dorsal view obtuse) protuberance and the median carina of the first tergite short.

Distribution. Australia (Queensland).

Biology. Unknown. Holotype collected in March.

Pseudofornicia flavoabdominis (He & Chen, 1994), comb. n.

Figs 1–10

Fornicia flavoabdominis He & Chen (in Chen et al.), 1994: 130–131, 134, figs 22–26.

Type material. Holotype ♀ (ZJUH), "[S. China], Zhejiang, Linan Xian, Yuqian, 2.vi.1958, Hu Cui", "5845.1". Paratype (ZJUH): 1 ♀, same label data, but "5845.1P".

Additional material. 1 ♀ (ZJUH) from Zhejiang, viii.1984.

Diagnosis. Metasoma brownish yellow, at most second and third tergites medially dark brown; first tergite moderately coarsely reticulate (Fig. 3); medial area of second metasomal tergite gradually narrowed, largely sculptured and posteriorly narrower than medial area of third tergite anteriorly (Fig. 3); second tergite 0.6–0.7 × as long as third tergite and third tergite with moderately wide parallel-sided elevation and densely finely reticulate medially; scutellum in lateral view not protruding apically, with narrow curved lamella remaining far below upper level of scutellum, medially punctate or distinctly rugose; hind leg (except largely dark brown basitarsus) brownish-yellow.

Distribution. China (Zhejiang).

Biology. Unknown. Adults collected in June and August.

Pseudofornicia nigrisoma van Achterberg & Long, sp. n.

http://zoobank.org/9F821EAE-CC41-4370-92C4-90A15C01D87B

Figs 11–20

Type material. Holotype, ♀ (IEBR), "Vietnam: Ha Tinh, Huong Son, 18°22'N, 106°13'E, 300 m, 20.iv.–1.v.1998, Malaise [trap], AMNH, K. Long". Paratypes: 1 ♂ (VNMN), same data, except 2–11.v.1998, Mic.739; 1 ♀ (RMNH), same data, except 900 m, 5.v.1998, Mic. 1049.

Diagnosis. Height of head 0.7 × height of mesosoma in lateral view (Fig. 11) and its width equal to width of mesoscutum; vein m-cu of fore wing about as long as vein

Figure 1. *Pseudofornicia flavoabdominis* He & Chen, female, paratype, habitus lateral.

2-SR+M (Fig. 12); fore wing without dark patches; vein cu-a of hind wing nearly straight (Fig. 19); scutellum punctate, without protuberance, with a more or less up curved subposterior rim remaining far below upper level of scutellum; propodeum without elevated medio-basal area (Fig. 13); apical half of hind tibia dark brown (Figs 11, 15); metasoma black dorsally and parallel-sided (Fig. 13); median carina of first tergite nearly as long as dorsal face of tergite (Fig. 13); medial area of second tergite vase-shaped (Fig. 13); median length of third tergite 1.2 × second tergite (Fig. 13); length of body 2.4–2.5 mm.

Description. Holotype, ♀, length of body 2.4 mm, of fore wing 2.7 mm.

Head. Height of head 0.7 × height of mesosoma in lateral view (Fig. 11) and its width equal to width of mesoscutum; antennal articles 18, length of third article 1.1

Figures 2–10. *Pseudofornicia flavoabdominis* He & Chen, female, paratype. **2** fore wing **3** metasoma dorsal **4** metasoma lateral **5** hind leg **6** head dorsal **7** head anterior **8** mesosoma dorsal **9** mesosoma lateral **10** antenna.

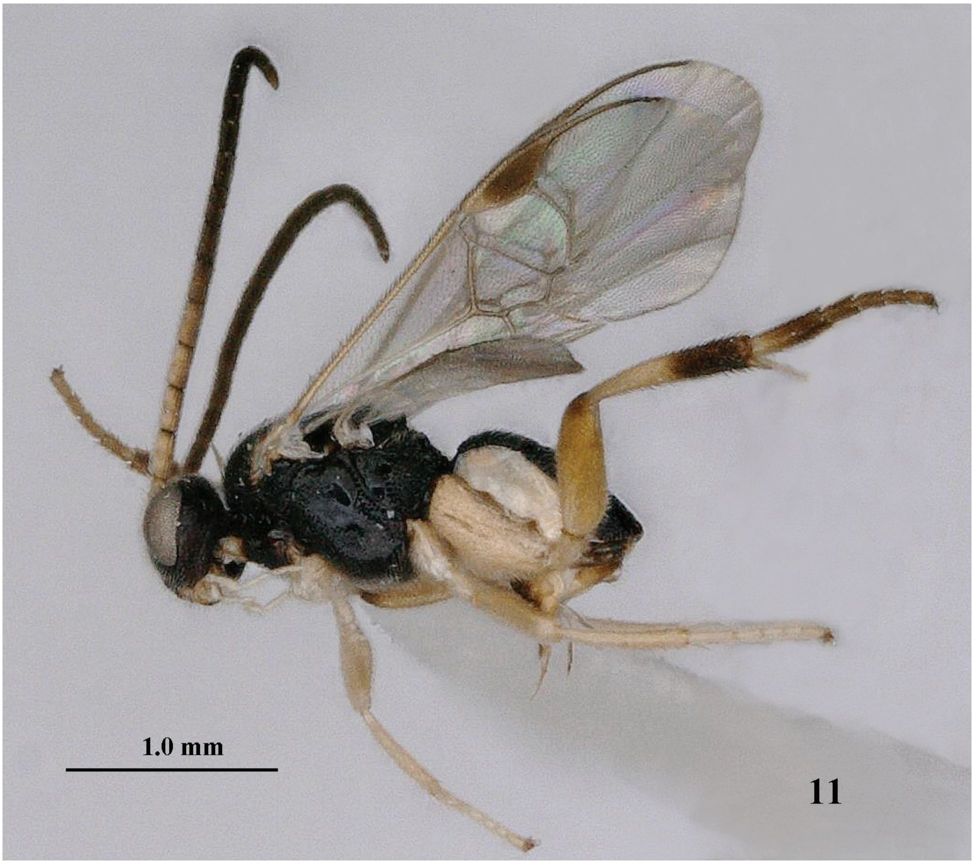
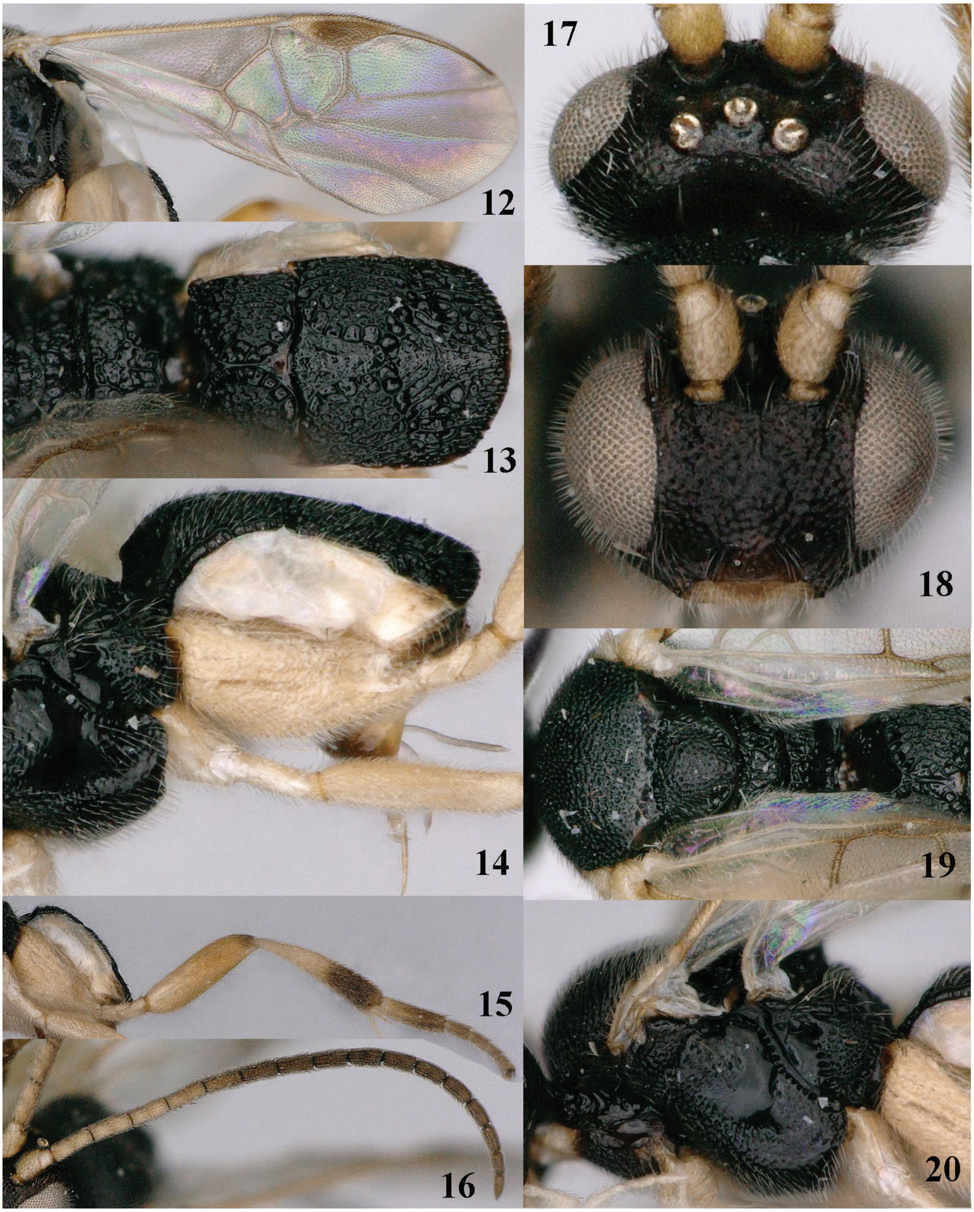


Figure 11. *Pseudofornicia nigrisoma* sp. n., female, holotype, habitus lateral.

× fourth segment, length of third, fourth and penultimate segments 3.3, 3.0 and 2.2 × their width, respectively (Fig. 16); maxillary palp 0.9 × height of head; malar space 0.7 × as long as basal width of mandible; length of eye in dorsal view 2.2 × temple; temple directly narrowed posteriorly (Fig. 17); POL:OD:OOL= 12:5:5; face pimply with smooth interspaces; frons shiny and smooth, vertex laterally and temple with superficial rugae (Fig. 17).

Mesosoma. Length of mesosoma 1.3 × its height; propleuron densely rugose; pronotum shiny, with some rugae and smooth posteriorly; mesopleuron densely rugose-punctate anteriorly and remainder largely smooth (Fig. 20); mesosternum shiny and moderately densely punctate; mesoscutum with satin sheen, densely punctate and notauli indicated by reticulate-punctate bands; scutellum rather convex, punctate, without protuberance, its subposterior rim slightly up curved and remaining far below upper level of scutellum; propodeum areolate and rather shiny, without elevated medio-basal area (only with small areola) or median carina (Fig. 13).



Figures 12–20. *Pseudofornicia nigrisoma* sp. n., female, holotype. **12** fore wing **13** metasoma dorsal **14** metasoma lateral **15** hind leg **16** antenna **17** head dorsal **18** head anterior **19** mesosoma dorsal **20** mesosoma lateral.

Wings. Fore wing: vein m-cu about as long as vein 2-SR+M (Fig. 12); vein 1-SR 0.35 × as long as vein 1-M; vein 1-R1 1.2 × as long as pterostigma; r:2-SR:2-SR+M = 10:10:7; vein 1-CU1 half as long as vein 2-CU1. Hind wing: vein cu-a nearly straight and its surroundings glabrous; vein M+CU about as long as vein 1-M.

Legs. Hind coxa nearly up to apex of third tergite (Fig. 14), mainly rather sparsely punctate but dorso-apically densely punctate and with some striae; length of hind femur, tibia and basitarsus 3.4, 5.2 and 4.0 × their width, respectively (Fig. 15); outer apical half of hind tibia and ventrally hind tarsus with dark brown spines; length of outer and inner spur of middle tibia 0.5 and 1.0 × middle basitarsus, respectively and inner spur curved (Fig. 11); length of outer and inner spur of hind tibia 0.5 and 0.7 × hind basitarsus, respectively and inner spur straight; tarsal claws without lobe.

Metasoma. Metasoma parallel-sided in dorsal view (Fig. 13); first tergite short, parallel-sided apically, mainly longitudinally rugulose, its median carina nearly as long as dorsal face of tergite ending in a smooth triangular area and crenulate grooves along dorsal carinae X-shaped (Fig. 13); medial area of second tergite vase-shaped, largely smooth but anteriorly superficially punctate and its surroundings coarsely longitudinally rugose (Fig. 13); third tergite coarsely irregularly rugose, but medially superficially sculptured and sublaterally depressed and medially 1.2 × longer than second tergite; ovipositor sheath 0.11 × as long as fore wing and 0.7 × hind basitarsus, narrow (Fig. 14).

Colour. Black; palpi, tibial spurs and tegula white; clypeus, mandible, galea, humeral plate, scapus and pedicellus (except brown stripe), third-fifth antennal articles ventrally, legs (but apical half of hind tibia and tarsus (except pale yellow basal 0.4 of hind basitarsus) dark brown), anterior half of metasoma ventrally, wing veins (but 1-M, 1-CU1 and cu-a brown) pale yellow; fore leg, middle leg (but coxa brown and femur yellowish-brown) and metasoma yellow; pterostigma (except basally) and fourth-seventh tergites dark brown; apex of hind femur, hypopygium and ovipositor sheath largely brown; wing membrane subhyaline.

Variation. Length of body 2.3–2.5 mm, of fore wing 2.6–2.8 mm; vein 1-R1 of fore wing 1.0–1.2 × as long as pterostigma; medial area of second tergite mainly distinctly rugose or superficially punctate. Male is very similar and has vein 1-CU1 0.6 times vein 2-CU1.

Distribution. Vietnam.

Biology. Unknown. Adults collected in April-May.

Etymology. Name derived from “nigro” (Latin for “blacken”) and “soma” (Greek for “body”) because of the mainly black body.

Pseudofornicia vanachterbergi **Long, nom. n.**

Figs 21–30

Fornicia achterbergi Long, 2007: 37–38, 41–42, figs 7–15 (not *Fornicia achterbergi* Yang & Chen, 2006).

Type material. Holotype, ♀ (IEBR), “VN [= Vietnam]: Hà Tây, Thach Thât, vuòn chè, M[alaise]T[rap], 25.v–5.vi.2002, K.D. Long”.

Diagnosis. Head 0.9 × as wide as mesoscutum in dorsal view and height of head 0.6 × height of mesosoma in lateral view (Fig. 21); scutellum medially distinctly rugose

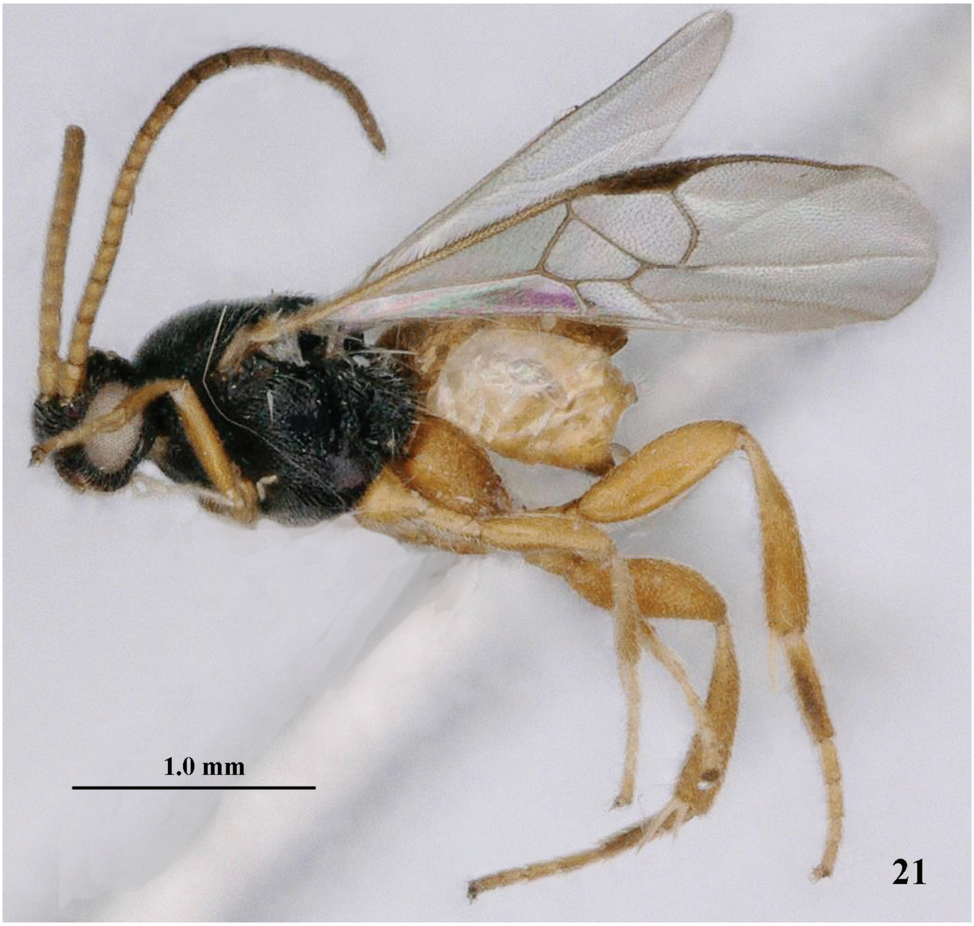


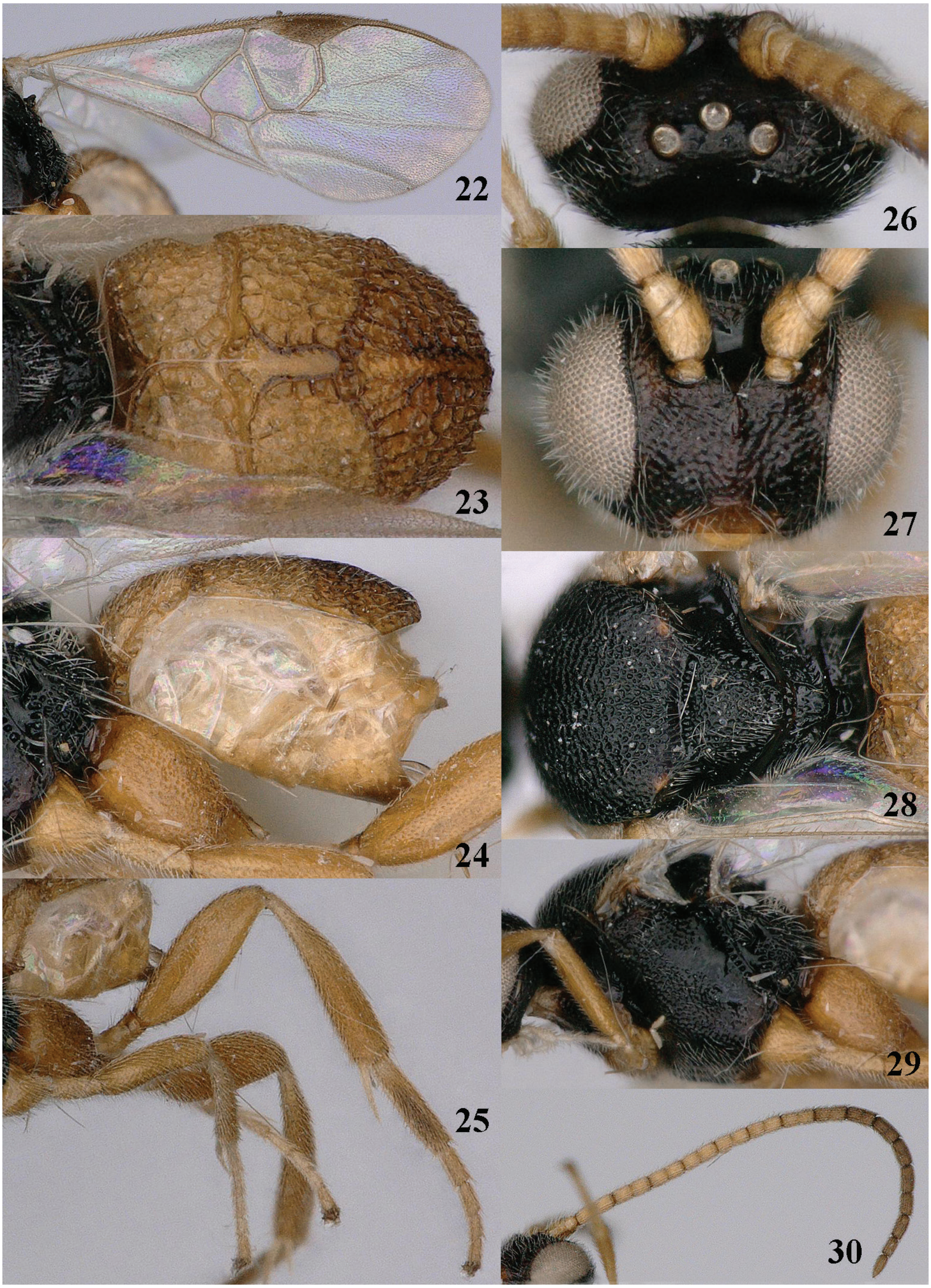
Figure 21. *Pseudofornicia vanachterbergi* nom. n., female, holotype, habitus lateral.

(Fig. 28), its apical rim nearly reaching upper level of scutellum (Fig. 29); first discal cell less setose than apical third of fore wing; vein m-cu of fore wing shorter than vein 2-SR+M (Fig. 22); vein cu-a of hind wing moderately sinuate (Fig. 24); apical half of hind tibia yellowish brown (Fig. 25); metasoma brownish yellow dorsally and roundly narrowed posteriorly (Fig. 23); first tergite near median carina depressed (Fig. 23); propodeum with small elevated medio-basal area (Fig. 28); medial area of second tergite largely subparallel-sided and only anteriorly widened (Fig. 23), its anterior half largely smooth, except some punctures laterally and area rather abruptly narrowed posteriorly (Fig. 23); second and third tergites brownish yellow medially (Fig. 23); third tergite rather coarsely reticulate medially, its median length 1.3 × second tergite (Fig. 23).

Distribution. Vietnam.

Biology. Unknown, but reared from a host on a litchi tree.

Notes. Dr Khuat Dang Long renames here his *F. achterbergi* Long, 2007, into *P. vanachterbergi* nom. n., because it is a primary homonym of *F. achterbergi* Yang & Chen, 2006.



Figures 22–30. *Pseudofornicia vanachterbergi* nom. n., female, holotype. **22** fore wing **23** metasoma dorsal **24** metasoma lateral **25** hind leg **26** head dorsal **27** head anterior **28** mesosoma dorsal **29** mesosoma lateral **30** antenna.

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RESEARCH ARTICLE

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A review of Canadian and Alaskan species of the genera *Clusiota* Casey and *Atheta* Thomson, subgenus *Microdota* Mulsant & Rey (Coleoptera, Staphylinidae, Aleocharinae)

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Abstract

This paper treats 13 species of the subgenus *Microdota* Mulsant & Rey of *Atheta* Thomson and 3 species of the genus *Clusiota* Casey in Canada and Alaska. We report here 4 species new to science, and 3 new provincial records. The following species are new to science: *A.* (*M.*) *curtipenis* Klimaszewski & Webster, **sp. n.**, *A.* (*M.*) *formicaensis* Klimaszewski & Webster, **sp. n.**, *A.* (*M.*) *macesi* Klimaszewski & Webster, **sp. n.,** and *Clusiota grandipenis* Klimaszewski & Webster, **sp. n.** The new provincial records are: *A.* (*M.*) *pseudosubtilis* Klimaszewski & Langor, new to AB, and *A.* (*M.*) *subtilis* (Scriba), an adventive Palaearctic species new to North America, first reported in LB and NB. The two *Clusiota* Casey species are reviewed, and their distribution is revised. A female *C. impressicollis* was discovered in Ontario and is illustrated here for the first time. A key to all Canadian species of the subgenus *Microdota* and genus *Clusiota* are provided. *Atheta* (*Microdota*) *holmbergi* Bernhauer and *A.* (*M.*) *alesi* Klimaszewski & Brunke are transferred here to the subgenus *Dimetrota* Mulsant & Rey.

Keywords

Alaska, Canada, Coleoptera, Staphylinidae, Aleocharinae, *Clusiota*, *Microdota*, new records, adventive species

Introduction

Aleocharines are species rich in the boreal forest of Canada but knowledge of them, despite recent progress (Klimaszewski et al. 2015), is still fragmentary and there are many species likely to be discovered as new to science or as new records of adventive or formerly known species from the USA (Klimaszewski et al. 2015).

This paper deals with Canadian species of the subgenus *Microdota* Mulsant and Rey of the genus *Atheta* Thomson and Rey, and the genus *Clusiota* Casey occurring in Canada and Alaska. The subgenus *Microdota* contains about 215 species in the Palaearctic region (Lee and Ahn 2015). In the Nearctic region the true number of species is unknown but Ashe (2000) reported 27 species. *Microdota* species may be confused with those of *Clusiota* due to their small size, and other superficial similarities. That is why both groups are treated here. *Microdota* species may also be confused with members of the subgenus *Datomicra* Mulsant and Rey from which they may be separated by having a fully exposed pronotal hypomeron in lateral view, whereas in *Datomicra* it is only partially exposed (Seevers 1978, Ashe 2000). In Canada we recognize 13 *Microdota* species including 3 species described here as new to science, and 3 species of *Clusiota*, including one species new to science. These *Clusiota* species constitute all known Nearctic species of the genus. We provide diagnoses of new or newly recorded species, illustrations of habitus and genital structures of all *Microdota* species, and keys to their identification. We hope that this publication will lead to the proper identification of species in this difficult group and will make them available for ecological, environmental, and other studies.

Materials and methods

About 100 adults of the genera *Microdota* and *Clusiota* from Canada and Alaska were studied, and most specimens were dissected to examine the genitalic structures that were dehydrated in absolute alcohol, mounted in Canada balsam on celluloid microslides, and pinned with the specimens from which they originated. Images of the entire body and the genital structures were taken using an image processing system (Nikon SMZ 1500 stereoscopic microscope; Nikon Digit-like Camera DXM 1200F, and Adobe Photoshop software).

Morphological terms mainly follow those used by Seevers (1978), Ashe (2000), and Klimaszewski et al. (2011). The ventral side of the median lobe of the aedeagus is considered to be the side of the bulbus containing the foramen mediale, the entrance of the ductus ejaculatorius, and the adjacent ventral side of the tubus of the median lobe with internal sac and its structures (this part is referred to as the parameral side in some recent publications); the opposite side is referred to as the dorsal part. In the species descriptions, microsculpture refers to the surface of the upper forebody (head, pronotum and elytra).

Distribution. Each species is cited with its currently known distribution in Canada and Alaska. The following abbreviations are used in the text for Canadian provinces and territories:

AB – Alberta, BC – British Columbia, LB – Labrador, MB – Manitoba, NB – New Brunswick, NF – Newfoundland (island), NS – Nova Scotia, NT – Northwest Territories, NU – Nunavut, ON – Ontario, PE – Prince Edward Island, QC – Quebec, SK – Saskatchewan, YT – Yukon Territory.

USA state abbreviations follow those of the US Postal Service.

Two labels were used on some specimens (RWC), one that included the locality, collection date, and collector, and one with macro and micro habitat data and collection method. Information from the two labels is separated by a // in the data presented for these specimens.

Depository/institutional abbreviations

CNC	Canadian National Collection of Insects, Arachnids and Nematodes, Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada.
LFC	Natural Resources Canada, Canadian Forest Service, Laurentian Forestry Centre, R. Martineau Insectarium, Quebec City, Quebec, Canada.
RWC	Reginald Webster Collection, Charters Settlement, New Brunswick, Canada.
UAM	University of Alaska Museum, University of Alaska, Fairbanks, Alaska, U.S.A. http://dx.doi.org/doi:10.7299/X75D8S0H
ZMB	Zoological Museum of Humboldt University, Berlin, Germany.
ZML	Museum of Zoology, Lund University, Lund, Sweden.

Checklist of Canadian *Microdota* and *Clusiota* species

New jurisdictional records are indicated in bold type.

Genus *Atheta* Thomson, 1858
Subgenus *Microdota* Mulsant & Rey, 1873

1) *Atheta* (*Microdota*) *amicula* (Stephens, 1832). Palaearctic; adventive in Canada: NF, NS. USA: WA.
2) ***Atheta* (*Microdota*) *curtipenis*** Klimaszewski & Webster, **sp. n. Canada: NB**.
3) *Atheta* (*Microdota*) *festinans* (Erichson, 1839). Canada: ON. USA: IN, ME, MI, PA.
4) ***Atheta* (*Microdota*) *formicaensis*** Klimaszewski & Webster, **sp. n. Canada: NB**.
5) ***Atheta* (*Microdota*) *macesi*** Klimaszewski & Webster, **sp. n. Canada: NB.**
6) *Atheta* (*Microdota*) *microelytrata* Klimaszewski & Godin, 2012. Canada: YT.
7) *Atheta* (*Microdota*) *pennsylvanica* Bernhauer, 1907. Canada: LB, NB, NF, NS, ON, QC. USA: IN, PA, RI, VA.

8) *Atheta* (*Microdota*) *platonoffi* Brundin, 1948. Holarctic; Canada: AB, BC, LB, NB, NF, NS, ON, YT. USA: AK.
9) *Atheta* (*Microdota*) *pratensis* (Mäklin, 1852). USA: AK, WA.
10) *Atheta* (*Microdota*) *pseudosubtilis* Klimaszewski & Langor, 2011. Canada: **AB**, LB, NB, NF, QC, YT.
11) *Atheta* (*Microdota*) *riparia* Klimaszewski & Godin, 2012. Canada: YT.
12) *Atheta* (*Microdota*) *sculptisoma* Klimaszewski & Langor, 2011. Canada: NF, QC.
13) *Atheta* (*Microdota*) *subtilis* (Scriba, 1866). Palaearctic, adventive in **Canada: LB, NB.**

Species transferred to the subgenus *Dimetrota* Mulsant & Rey
14) *Atheta* (*Microdota*) *alesi* (Klimaszewski & Brunke, 2012). Canada: ON.
15) *Atheta* (*Microdota*) *holmbergi* Bernhauer, 1907. Canada: BC. USA: AK.

Species removed from NF and LB species list (misidentification for *A. subtilis* Mulsant and Rey)
16) *Atheta* (*Microdota*) *pratensis* (Mäklin, 1852). Canada: YT. USA: AK.

Subgenus *Clusiota* Casey, 1910
17) *Clusiota antennalis* Klimaszewski and Godin, 2008. Canada: **BC**. USA: AK.
18) *Clusiota impressicollis* (Bernhauer, 1907). Canada: BC, **ON**, NB, NF.
19) ***Clusiota grandipenis*** Klimaszewski and Webster, **sp. n. Canada: NB**.

Taxonomic review

Genus *Atheta* Thomson

Subgenus *Microdota* Mulsant & Rey

(Mouthparts illustrated by Lee and Ahn 2015)

Diagnosis. The following combination of characters is distinctive for *Microdota*: small and subparallel body (Figs 1, 9, 17, 25, 33, 41, 49, 56, 61, 69, 80, 84), length 1.5–2.7 mm, antennomere I enlarged but not extremely swollen, longer than II, II longer than III, V–X slightly to strongly transverse; median region of prementum very narrow and without pseudopores; labial palpus with 3 articles; glossa split apically forming Y-shaped structure; maxillary palpus with 3 articles, last one narrowly elongate; pronotum transverse, more than 1.2 times as wide as long, midline pubescence directed in most specimens anteriorly and laterad elsewhere (Figs 1, 9, 17, 25, 33, 41, 49, 56, 61, 69, 80, 84); pronotal hypomeron fully visible laterally; elytra in some species with wavy pattern of pubescence in postero-sutural section of disc (Figs 33, 49); median lobe of aedeagus with large bulbus and triangularly shaped apex of tubus in dorsal view, internal sac of median lobe of aedeagus with well-developed complex structures

(Figs 4, 5, 12, 13, 20, 21, 28, 29, 36, 37, 44, 45, 51, 52, 64, 65, 72–75, 87); spermatheca of variable shape, L- or S-shaped, capsule usually in a form of a narrow sac or club-shaped, and stem often sinuate (Figs 8, 16, 24, 32, 40, 48, 55, 59, 60, 68, 78, 79, 83); male tergite VIII in most species simple, truncate apically and without teeth, sometimes with minute crenulation and small pairs of teeth (Figs 2, 10, 18, 26, 34, 42, 50, 62, 70, 85).

Some species of *Microdota*, due to small body size and some superficial external similarity, may be confused in collections with members of the subgenus *Datomicra* Mulsant and Rey, from which they may be distinguished by having a fully exposed pronotal hypomeron in lateral view; the pronotal hypomeron is only partially visible in *Datomicra*. Many species of *Datomicra* also have a more densely and coarsely punctate forebody than that of *Microdota*.

Microdota may be distinguished from *Dimetrota* by the following combination of characters: body usually parallel-sided, small, on average 2 mm long (*Microdota* – 1.5–2.8 mm; *Dimetrota* – 1.8–3.8 mm, with elytra usually distinctly broader than pronotum); glossae Y-shaped (deeply split in *Dimetrota*); pronotum with sparse to moderately dense and slightly asperate punctation (dense and strongly asperate in *Dimetrota*); lateral margins of pronotum and elytra, and middle and hind tibiae with moderately pronounced macrosetae (strong bristles in *Dimetrota*); hypomera fully visible in lateral view (partially to less often fully visible in *Dimetrota*); and male tergite VIII truncate apically, rarely crenulated, and usually without large lateral teeth (with two large lateral teeth and often distinctive form of margin between them or with pattern of smaller teeth in *Dimetrota*). Details on diagnostics of *Microdota* are provided by Brundin (1948), and Lee and Ahn (2015). Species of Nearctic *Dimetrota* badly need revision.

Clusiota may be distinguished from *Microdota* by the following combination of characters: basal antennal article swollen (some species); antennal articles V-X strongly transverse; glossae deeply split medially; pronotum narrower than elytra; elytra flattened, truncate posteriorly and without distinct lateral emargination; abdomen often swollen; spermatheca more or less sinuate with narrowly pear-shaped capsule and small and short apical invagination; and by the median lobe of the aedeagus with large bulbus, strongly ventrally produced tubus bearing elongate subapical part, and with crista apicalis located on elevated part of bulbus.

Key to Canadian and Alaskan species of *Microdota*

1 Elytra at suture about as long as or shorter than pronotum (Figs 9, 17, 25, 56, 61, 69) **2**

– Elytra at suture longer than pronotum (Figs 1, 33, 41, 49, 80, 84) **7**

2 Body bicoloured, head and abdomen dark brown, and pronotum and elytra or elytra only yellowish brown or orange brown (Figs 61, 69); genitalia as illustrated (Figs 64, 65, 68, 72–75, 78, 79) **3**

– Body approximately uniformly brown to black; genitalia differently shaped .. **4**

3 Pronotum in most specimens orange and elytra yellowish brown (Fig. 69); median lobe of aedeagus and spermatheca as illustrated (Figs 72-75, 78, 79)... **_Atheta_ (_Microdota_) _pennsylvanica_ Bernhauer**

– Pronotum brown to light brown and entire elytra or only central part of disc yellowish (Fig. 61); median lobe of aedeagus and spermatheca as illustrated (Figs 64, 65, 68)........... **_Atheta_ (_Microdota_) _formicaensis_ Klimaszewski & Webster, sp. n.**

4 Elytra distinctly broader than maximum width of pronotum (Figs 17, 56); genitalia as illustrated (Figs 20, 21, 24, 59, 60)... **5**

– Elytra about as wide as maximum width of pronotum (Figs 9, 25); genitalia differently shaped (Figs 12, 13, 16, 28, 29, 32)... **6**

5 Pubescence on forebody sparse, on elytra directed straight posteriad (Fig. 56); spermatheca as illustrated (Figs 59, 60); male unknown.................................. **_Atheta_ (_Microdota_) _festinans_ (Erichson)**

– Pubescence on forebody dense, on elytra directed obliquely posteriad (Fig. 17); genitalia as illustrated (Figs 20, 21, 24)............... **_Atheta_ (_Microdota_) _curtipenis_ Klimaszewski & Webster, sp. n.**

6 Pronotum as broad as head (Fig. 25); abdomen subparallel (Fig. 25); antennal articles VI–X moderately transverse (Fig. 25); genitalia as illustrated (Figs 28, 29, 32)....... **_Atheta_ (_Microdota_) _microelytrata_ Klimaszewski & Godin**

– Pronotum broader than head (Fig. 9); abdomen swollen apically (Fig. 9); antennal articles VI–X strongly transverse (Fig. 9); genitalia as illustrated (Figs 12, 13, 16)...................... **_Atheta_ (_Microdota_) _pseudosubtilis_ Klimaszewski & Langor**

7 Elytra almost twice as long as pronotum; median lobe of aedeagus with enlarged oval bulbus and narrow tubus that is ventrally produced at apex; spermatheca S-shaped .... **_Atheta_ (_Microdota_) _pratensis_ (Mäklin)**

– Elytra 1.2–1.3 times longer than pronotum (Figs 1, 33, 41, 49, 80, 84); genitalia differently shaped... **8**

8 Pronotum dark brown to black and elytra light brown to yellowish-brown (Fig. 49); antennae with articles VII–X strongly transverse, at least twice as wide as long (Fig. 49); pubescence of forebody not soft in appearance; genitalia as illustrated (Figs 51, 52, 55) [males absent in North America].................................. **_Atheta_ (_Microdota_) _amicula_ (Stephens)**

– Pronotum and elytra about the same colour, dark brown with elytra in some specimens only slightly paler (Figs 1, 33, 41, 80, 84) [group of species difficult to distinguish externally]... **9**

9 Elytra 1.2 times broader than pronotum, shoulders moderately angular (Fig. 80); spermatheca with broad, sac-shaped capsule without apparent invagination, stem straight, narrow, half looped posteriorly and slightly twisted at apex (Fig. 83); male unknown .... **_Atheta_ (_Microdota_) _sculptisoma_ Klimaszewski & Langor**

– Elytra at least 1.3 times broader than pronotum, shoulders strongly angular (Figs 1, 33, 41, 84); spermatheca of a different shape................................**10**

10 Pronotal punctation coarse and sparse (Fig. 41); spermatheca with club-shaped capsule bearing deep apical invagination, stem sinuate and twisted apically (Fig. 48); median lobe of aedeagus in lateral view with approximately oval bulbus dorsally (Fig. 45), and sinuate and narrowly elongate tubus laterally (Fig. 44) ....***Atheta* (*Microdota*) *riparia* Klimaszewski & Godin**

– Pronotal punctation fine and dense (Figs 1, 33, 84); genitalia of a different shape **11**

11 Body dark brown, almost black, strongly glossy, with dense, meshed and strongly pronounced microsculpture, punctation and pubescence sparse (Fig. 84); male tergite VIII truncate apically, with two small lateral teeth and minute crenulation on apical margin of disc (Fig. 85); median lobe of aedeagus as illustrated (Fig. 87); female unknown ....***Atheta* (*Microdota*) *macesi* Klimaszewski & Webster, sp. n.**

– Body dark brown, moderately glossy, meshed microsculpture present but not strongly pronounced, punctation and pubescence dense (Figs 1, 33): male tergite VIII and genitalia differently shaped **12**

12 Pubescence on elytra forming wavy pattern (Fig. 33); median lobe of aedeagus with sinuate venter of tubus in lateral view (Fig. 36), and internal sac with two apical lobes in dorsal view (Fig. 37); spermatheca with tubular capsule, deep and narrow invagination and S-shaped stem (Fig. 40) ....***Atheta* (*Microdota*) *platonoffi* Brundin**

– Pubescence on elytra directed obliquely posteriad from midline of disc (Fig. 1); median lobe of aedeagus with large bulbus and moderately long tubus, its ventral margin arcuate and narrowly elongate apically (Fig. 4); spermatheca with long, sac-shaped, tubular capsule bearing shallow but broad apical invagination, stem broad and club-shaped (Fig. 8) [adventive in Canada]........ ....***Atheta* (*Microdota*) *subtilis* (Scriba)**

***Subtilis* species group (new)**

Species of this group are characterized by: elytra at suture at least as long as pronotum (Figs 1, 9), male tergite VIII truncate and sometimes slightly emarginated medially (Figs 2, 10), median lobe of aedeagus with broadly oval bulbus streamlined with broadly triangular tubus in dorsal view (Figs 5, 13), in lateral view tubus straight medio-basally and narrowly elongate and strongly produced ventrally at apex (Figs 4, 12), internal sac structures complex with two prominent elongate structures in bulbus (Figs 4, 5, 12, 13), spermatheca L-shaped with long, broad sac-shaped capsule bearing wide and shallow apical invagination and with short and swollen apically stem (Figs 8, 16). Two species are known from eastern Canada.

***Atheta* (*Microdota*) *subtilis* (Scriba)**
Figs 1–8

Homalota subtilis Scriba 1866: 128. As *Atheta* (*Microdota*): Brundin 1948, Palm 1970, Benick and Lohse 1974, Smetana 2004 (review of literature and description).

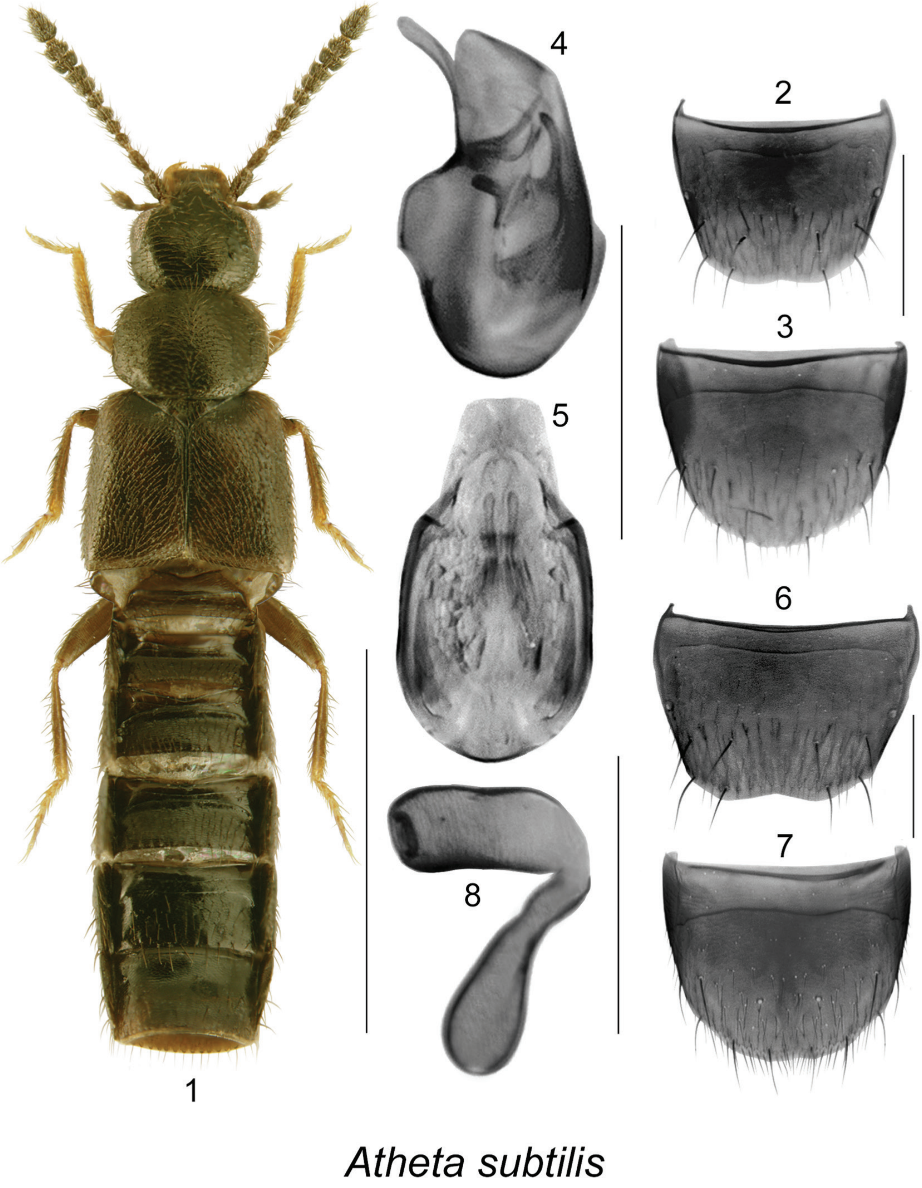
Material examined. Canada, Labrador, Goose Bay, Rts. 500 and 520 jct., 53°16.9 N, 60°24.6 W, 13-26.VIII.2001, S. and J. Peck, Flight Intercept Trap, elevation 10 m, spruce-poplar forest (LFC) 3 females, 1 male; Goose Bay, Goose River Bridge, 53°22.2 N, 60°26.2 W, 15-20.VIII.2001, S. and J. Peck, elevation 10 m, spruce-birch forest (LFC) 1 male. **New Brunswick**, **Albert Co.**, Caledonia Gorge P.N.A., 45.7941°N, 64.7736°W, 13.IX.2011, R.P. Webster // near Crooked Creek, mixed forest (red spruce and yellow birch) in decaying gilled mushrooms (RWC) 1 male; Carleton Co., Wakefield, Meduxnekeag Valley Nature Preserve, 46.1940°N, 67.6800°W, 3.VII.2006, R.P. Webster coll. // mixed forest on *Pleurotus* sp. on dead standing *Populus tremuloides* (RWC) 1 male; York Co., New Maryland, Charters Settlement, 45.8331°N, 66.7410°W, 27.VII.2005, R.P. Webster coll. // mixed forest on flowers of *Spiraea alba* (LFC) 1 male; **Restigouche Co.**, off Bellone Road, 47.7755°N, 68.2501°W, 24.VIII.2011, R. Webster and M. Turgeon // Old spruce and fir forest, mossy forest floor, in gilled mushrooms in various stages of decay (RWC) 1 female.

Diagnosis. Body length 1.5–2.0 mm, subparallel, flattened, reddish brown to dark brown, head and abdomen darker than pronotum and elytra in some specimens, legs yellowish brown (Fig. 1); integument moderately glossy, densely punctate and densely pubescent on forebody and less so on abdomen, microsculpture fine; head slightly narrower than pronotum, strongly narrowed posteriad, eyes large and about as long as postocular area dorsally; pronotum transverse, narrower than elytra; elytra wider and longer than pronotum; abdomen subparallel. MALE. Tergite VIII truncate apically (Fig. 2); sternite VIII broadly rounded apically (Fig. 3); median lobe of aedeagus narrow, and strongly ventrally produced apically in lateral view (Fig. 4); internal sac structures complex (Figs 4, 5). FEMALE. Tergite VIII broadly emarginated apically (Fig. 6); sternite VIII slightly emarginated apically (Fig. 7); spermatheca L-shaped with long, broad sac-shaped capsule bearing wide and shallow apical invagination and club-shaped short and swollen apically stem (Fig. 8).

Natural history. The LB specimens were collected in flight intercept traps set in spruce-poplar forest. The NB specimens were found in gilled mushrooms at various stages of decay in spruce/fir forest, in *Pleurotus* sp. on dead standing *P. tremuloides*, in mixed forest on flowers of *S. alba*, and in a mixed forest with red spruce and yellow birch. Adults were captured from July to September.

Distribution. *Atheta* (*M.*) *subtilis* is a Palaearctic species (for details, see Brundin 1948, Palm 1970, Benick and Lohse 1974, Smetana 2004), and it is reported here as adventive for the first time from Canada (LB, NB) and North America.

Comments. Adults of *A. subtilis* from LB were captured in association with *A. pseudosubtilis* Klimaszewski and Langor. Some females of the former species, because



Figures 1–8. *Atheta* (*Microdota*) *subtilis* (Scriba): **1** habitus in dorsal view **2** male tergite VIII **3** male sternite VIII **4** median lobe of aedeagus in lateral view **5** median lobe of aedeagus in dorsal view **6** female tergite VIII **7** female sternite VIII **8** spermatheca. Scale bar for habitus = 1 mm; remaining scale bars = 0.2 mm.

of similarly shaped spermatheca and poorly preserved body, were misidentified as the latter species. We have compared European specimens of *A. subtilis* with those from Canada (LB, NB) and found no significant differences in external morphology and shape and structures of genitalia.

***Atheta* (*Microdota*) *pseudosubtilis* Klimaszewski & Langor**
Figs 9–16

(For diagnosis, see Klimaszewski et al. 2011)

Distribution. Recorded from NF and LB, NB (Klimaszewski et al. 2011, Webster et al. 2012).

Comments. The taxonomic position of *A. pseudosubtilis* is somewhat unclear. The shape of the spermatheca is very similar to those of *A. subtilis* and *C. antennalis*. Externally it is similar to *C. antennalis* but does not have a swollen basal antennal article. The median lobe of the aedeagus has internal sac structures very similar to those of *A. subtilis*. Externally, *A. pseudosubtilis* is readily distinguished from *A. subtilis* by the much shorter elytra (Figs 1, 9). DNA studies of all these species would be very useful in revealing their true relationships.

***Platonoffi* species group (new)**

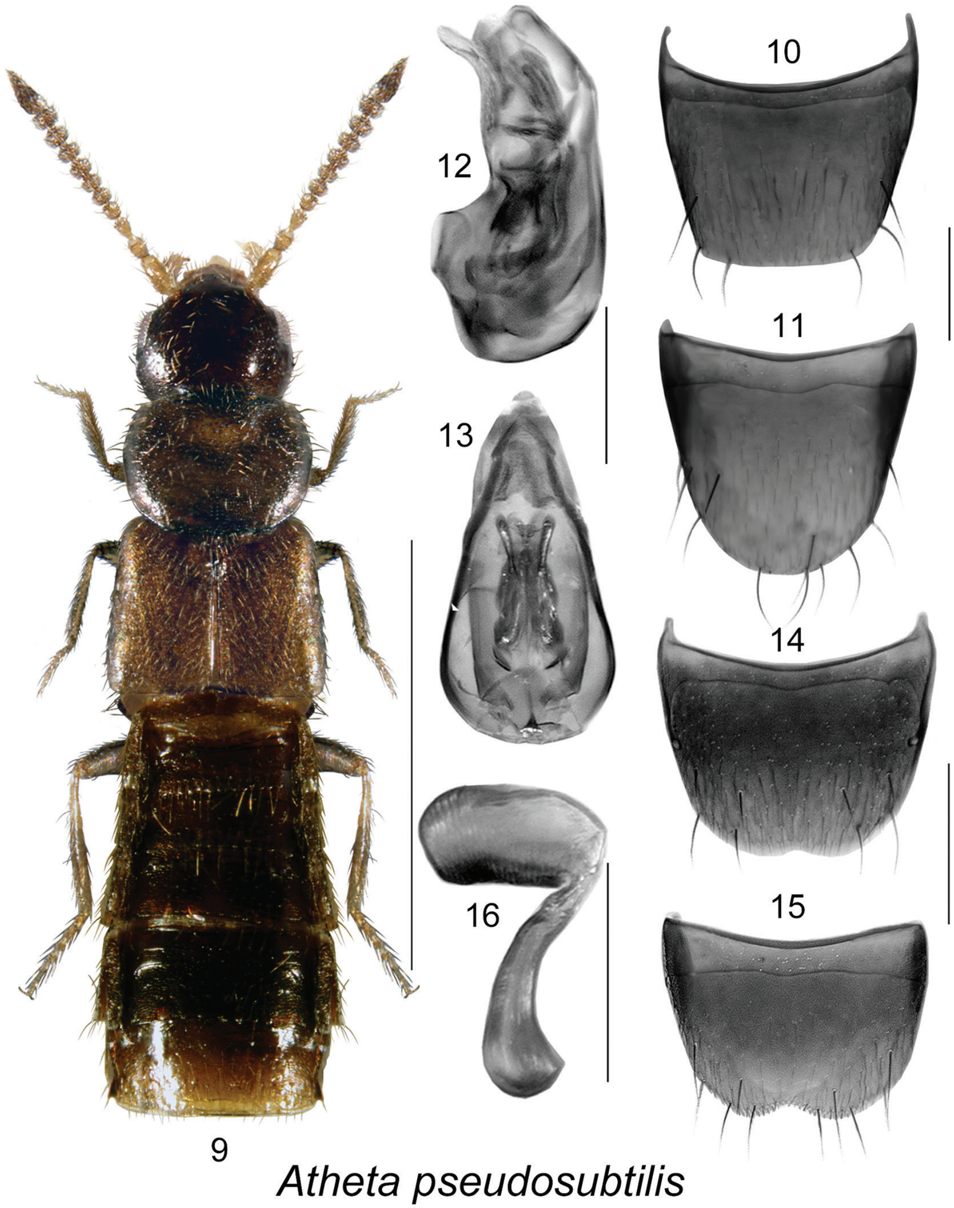
Species of this group are characterized by elytra at suture ranging from shorter to longer than pronotum (Figs 17, 25, 33, 41), male tergite VIII truncate and sometimes slightly emarginated medially or slightly crenulate apically (Figs 18, 26, 34, 42), median lobe of aedeagus with broadly oval bulbus clearly demarcated from triangular tubus in dorsal view (Figs 20, 29, 37, 45), and in lateral view, tubus straight mediobasally, arcuate or sinuate and moderately to strongly produced ventrally at apex (Figs 21, 28, 36, 44), internal sac structures complex (Figs 20, 21, 28, 29, 36, 37, 44, 45); spermatheca S-shaped with long, elongate club-shaped capsule bearing narrow and deep apical invagination and long sinuate stem (Figs 24, 32, 40, 48). Five species are known from Canada and Alaska.

***Atheta* (*Microdota*) *curtipenis* Klimaszewski & Webster, sp. n.**
http://zoobank.org/08F3959E-4933-471F-B4FB-7D29A49665F5
Figs 17–24

Holotype (male). Canada, New Brunswick, Saint John Co., ca 2 km NE of Maces Bay, 45.1168°N, 66.4552°W, 8.V.2006, R.P. Webster, coll. // eastern white cedar swamp, under moose dung (LFC). **Paratypes**: labelled as the holotype (RWC) 1 male, 1 female.

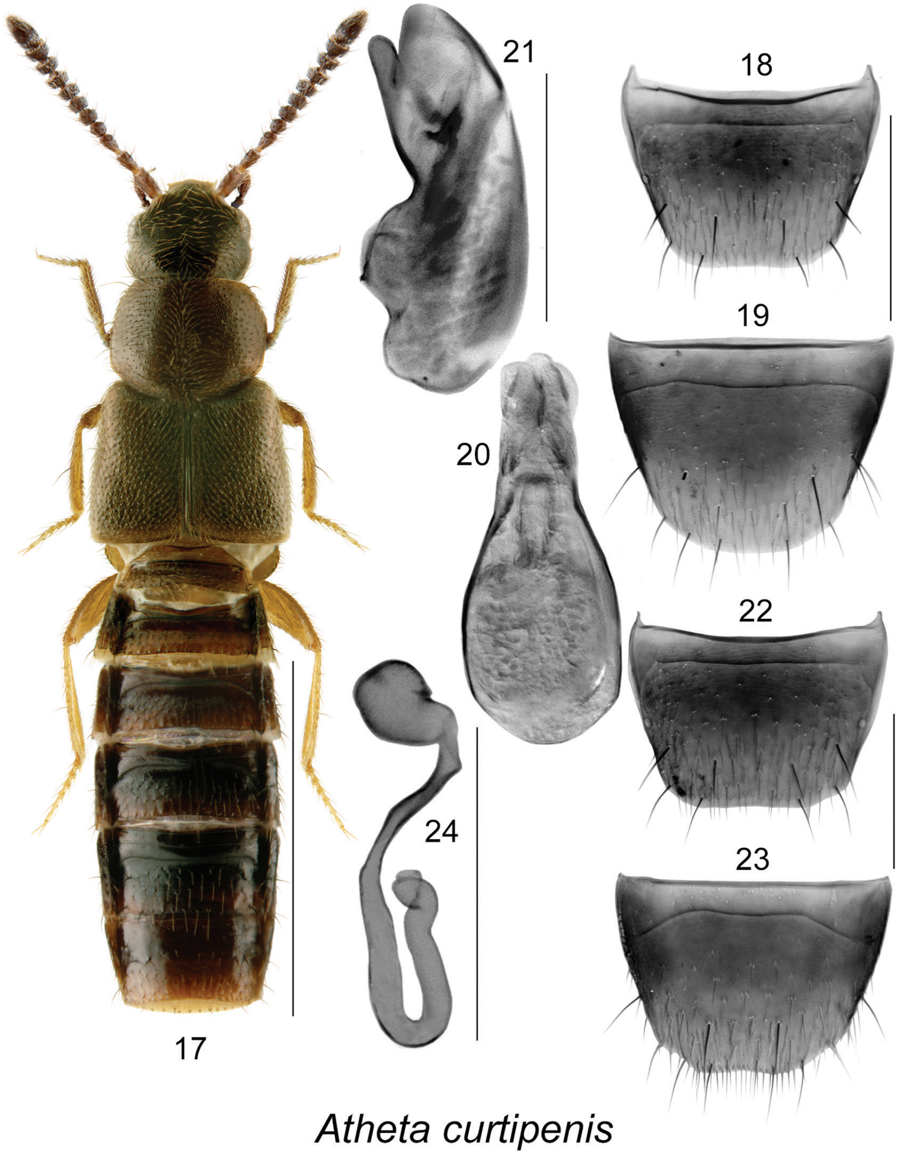
Etymology. The specific name *curtipenis* refers to a short median lobe of aedeagus of this species.

Diagnosis. Body length 2.0–2.3 mm, subparallel, moderately convex, dark brown, abdomen slightly darker than remainder of the body, legs yellowish brown (Fig. 17); integument glossy, densely punctate and densely pubescent on forebody and less so



Figures 9–16. *Atheta* (*Microdota*) *pseudosubtilis* Klimaszewski & Langor: **9** habitus in dorsal view **10** male tergite VIII **11** male sternite VIII **12** median lobe of aedeagus in lateral view **13** median lobe of aedeagus in dorsal view **14** female tergite VIII **15** female sternite VIII **16** spermatheca. Scale bar for habitus = 1 mm; remaining scale bars = 0.2 mm.

on head and abdomen, microsculpture of forebody fine; head slightly narrower than pronotum, strongly narrowed posteriad and slightly angular posteriorly, eyes large and slightly shorter than postocular area dorsally; pronotum transverse, narrower than



Figures 17–24. *Atheta* (*Microdota*) *curtipenis* Klimaszewski & Webster, sp. n.: **17** habitus in dorsal view **18** male tergite VIII **19** male sternite VIII **20** median lobe of aedeagus in dorsal view **21** median lobe of aedeagus in lateral view **22** female tergite VIII **23** female sternite VIII **24** spermatheca. Scale bar for habitus = 1 mm; remaining scale bars = 0.2 mm.

elytra; elytra wider and longer than pronotum; abdomen subparallel. MALE. Tergite VIII truncate apically (Fig. 18); sternite VIII broadly rounded apically (Fig. 19); median lobe of aedeagus narrowly oval in dorsal view (Fig. 20), tubus sinuate basally and then straight and rounded apically in lateral view (Fig. 21); internal sac structures as illustrated (Figs 20, 21). FEMALE. Tergite VIII truncate apically (Fig. 22); sternite VIII slightly emarginated apically (Fig. 23); spermatheca compressed S-shaped, capsule spherical with short and narrow apical invagination, stem narrow and U-formed posteriorly (Fig. 24).

Natural history. Adults were found in an eastern white cedar swamp under moose dung in May.

Distribution. Known only from NB, Canada.

Comments. This species is distinguished by the moderately transverse pronotum, and the shape of the median lobe of the aedeagus and spermatheca.

***Atheta* (*Microdota*) *microelytrata* Klimaszewski & Godin**

Figs 25–32

(For diagnosis, see Klimaszewski et al. 2012)

Distribution. Recorded only from YT (Klimaszewski et al. 2012).

***Atheta* (*Microdota*) *platonoffi* Brundin**

Figs 33–40

(For diagnosis, see Klimaszewski et al. 2011)

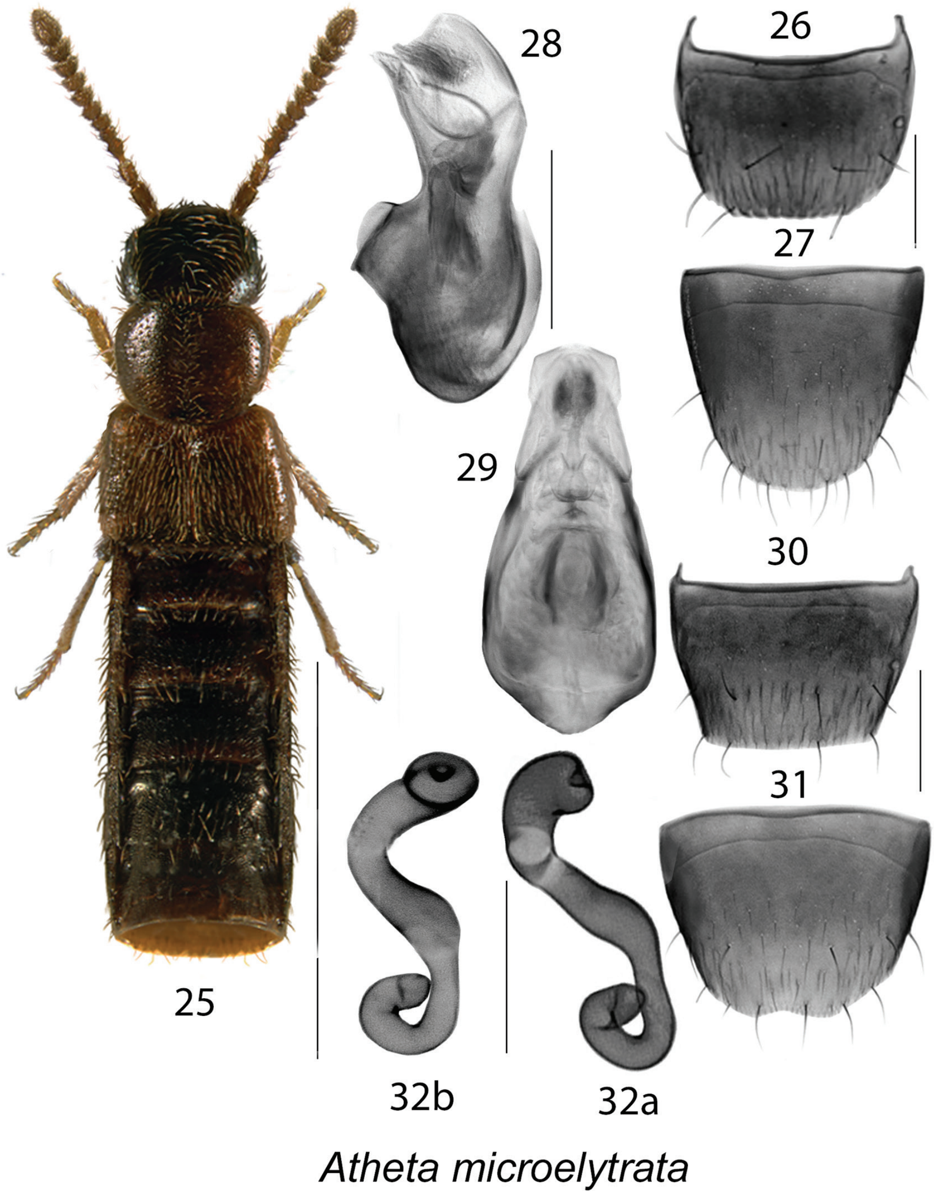
Distribution. In Canada, recorded from AB, BC, LB, NB, NF, NS, ON, SK, YT, and in USA from AK (Klimaszewski et al. 2011, 2015).

***Atheta* (*Microdota*) *pratensis* (Mäklin, 1852)**

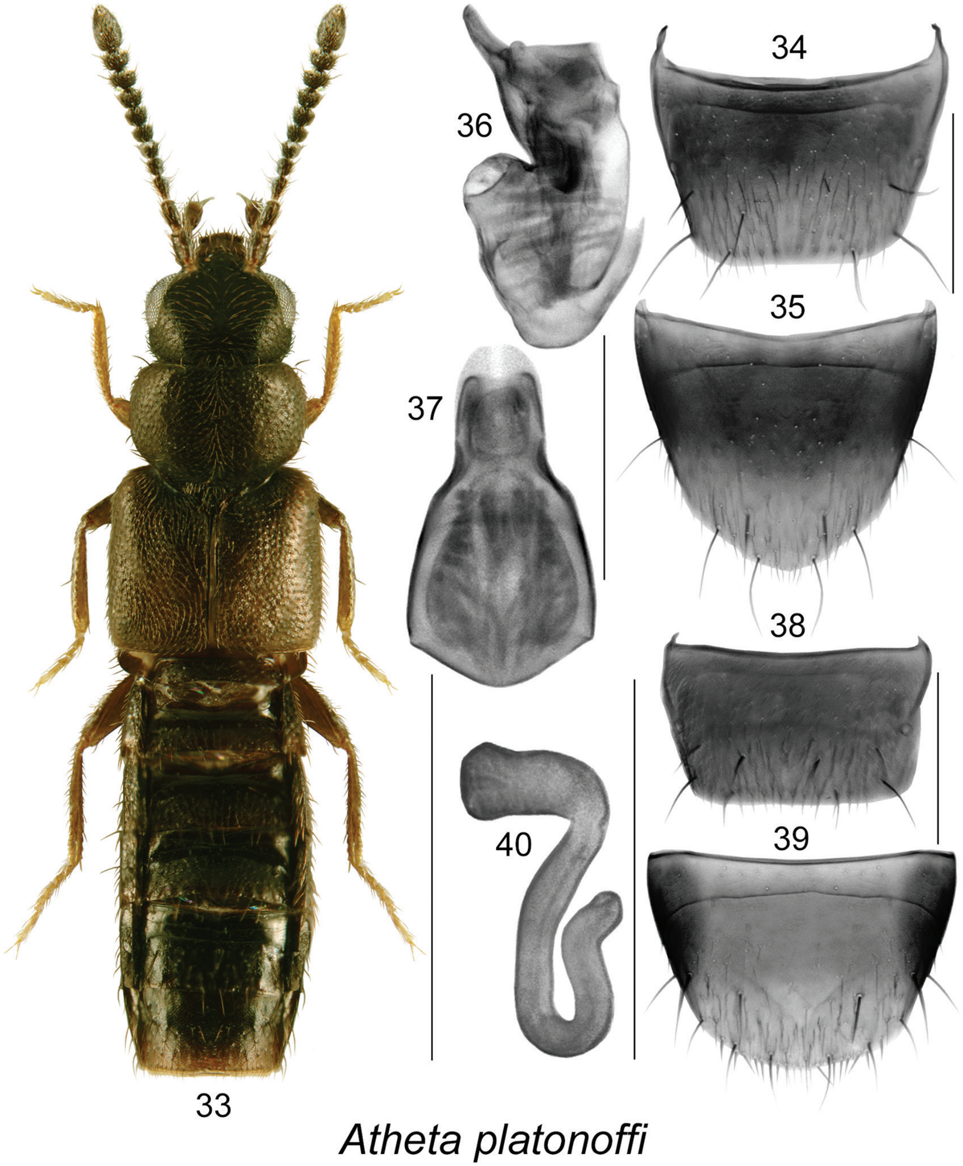
Homalota pratensis Mäklin, 1852: 308. As *Atheta* (*Microdota*): Moore and Legner 1975, Klimaszewski et al. 2011; Bousquet et al. 2013.

Syntypes. USA, Alaska: Kenai; Holmberg; *pratensis* Mäklin; Mus. Zool. Helsinki, No. 14517 (ZMH) 1 male; same labels except No. 17518 (ZMH) 1 female.

Diagnosis. This species may be readily separated from other Nearctic congeners by the following combination of characters: pronotum rounded and margined, as wide as head and at least 1.5 times narrower than elytra; elytra elongate about twice as long as pronotum with wavy pattern of pubescence posteriorly; male tergite VIII truncate apically; sternite VIII rounded apically; median lobe of aedeagus with large oval bulbus and small triangular tubus in dorsal view, apical part of tubus narrow and



Figures 25–32. *Atheta* (*Microdota*) *microelytrata* Klimaszewski & Godin: **25** habitus in dorsal view **26** male tergite VIII **27** male sternite VIII **28** median lobe of aedeagus in lateral view **29** median lobe of aedeagus in dorsal view **30** female tergite VIII **31** female sternite VIII **32a, b** spermatheca. Scale bar for habitus = 1 mm; remaining scale bars = 0.2 mm.



Figures 33–40. *Atheta* (*Microdota*) *platonoffi* Bernhauer: **33** habitus in dorsal view **34** male tergite VIII **35** male sternite VIII **36** median lobe of aedeagus in lateral view **37** median lobe of aedeagus in dorsal view **38** female tergite VIII **39** female sternite VIII **40** spermatheca. Scale bar for habitus = 1 mm; remaining scale bars = 0.2 mm.

produced ventrally in lateral view; female tergite VIII truncate apically, and sternite VIII rounded apically and with antecostal suture sinuate and pointed medially; spermatheca S-shaped with club-shaped capsule bearing deep invagination and sinuate stem looped posteriorly, similar to that of *A. platonoffi*.

Distribution. AK, WA (Mäklin 1852, Moore and Legner 1975).

Comments. This species is somewhat similar to *A. subtilis* but may readily be distinguished externally by having elytra about 1.5 times wider and almost twice longer than pronotum. We examined the type series but the specimens were in poor shape and therefore were not illustrated.

***Atheta* (*Microdota*) *riparia* Klimaszewski & Godin**

Figs 41–48

(For diagnosis, see Klimaszewski et al. 2012)
Atheta (*Microdota*) *riparia* Klimaszewski & Godin, 2012: 225.

Distribution. Recorded only from YT in Canada (Klimaszewski et al. 2012).

***Pennsylvanica* species group (new)**

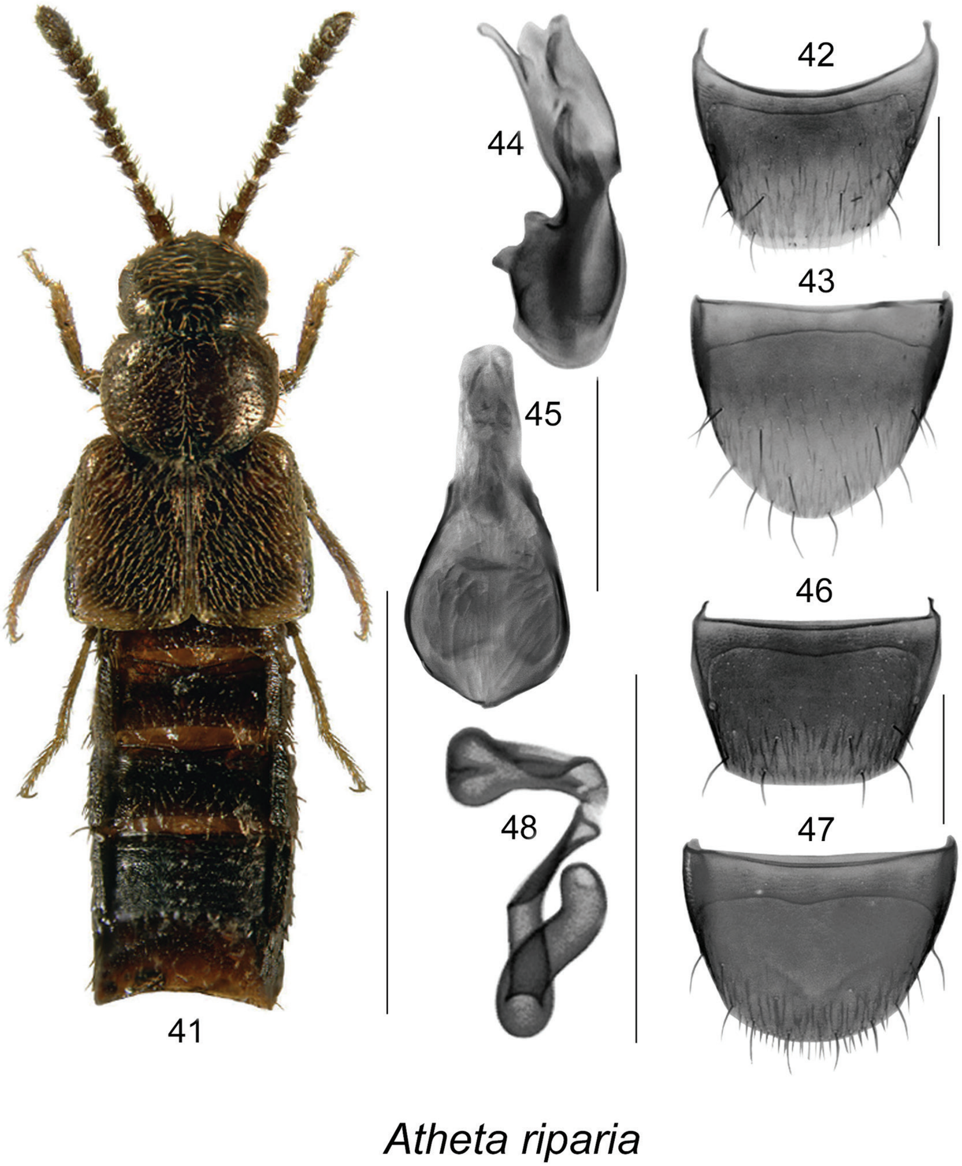
Species of this group are characterized by elytra at suture ranging from as long as or longer than pronotum (Figs 49, 56, 61, 69), male tergite VIII truncate or slightly emarginated medially and slightly crenulate apically (Figs 50, 70), median lobe of aedeagus with broadly oval bulbus streamlined with broad basally triangular tubus in dorsal view (Figs 52, 65, 74, 75), in lateral view tubus straight and slightly narrowly triangularly produced ventrally (Figs 51, 64, 72, 73), internal sac structures complex (Figs 51, 52, 64, 65, 72–75); spermatheca S-shaped with club-shaped capsule bearing narrow and shallow apical invagination and long, posteriorly looped stem (Figs 55, 59, 60, 68, 78, 79). Four species are known from Canada.

***Atheta* (*Microdota*) *amicula* (Stephens)**

Figs 49–55

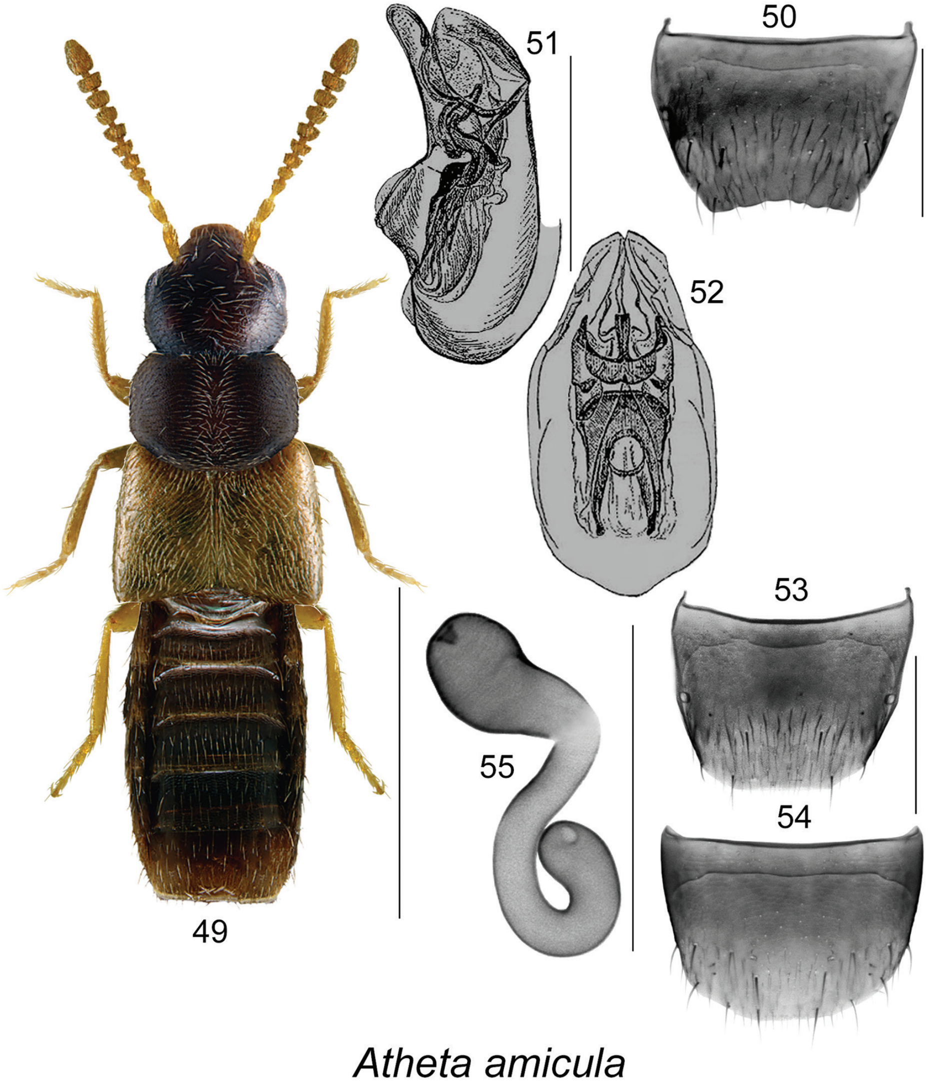
(For diagnosis, see Klimaszewski et al. 2011, Lee and Ahn 2015)
Aleochara amicula Stephens, 1832: 132. As *Atheta* (*Microdota*): Brundin 1948, Palm 1970, Benick and Lohse 1974, Smetana 2004, Lee and Ahn 2015.

Distribution. *Atheta* (*M.*) *amicula* is a Palaearctic species adventive in North America. It was reported in Canada based only on female specimens from NF and NS (Majka



Figures 41–48. *Atheta* (*Microdota*) *riparia* Klimaszewski & Godin: **41** habitus in dorsal view **42** male tergite VIII **43** male sternite VIII **44** median lobe of aedeagus in lateral view **45** median lobe of aedeagus in dorsal view **46** female tergite VIII **47** female sternite VIII **48** spermatheca. Scale bar for habitus = 1 mm; remaining scale bars = 0.2 mm.

and Klimaszewski 2008, Klimaszewski et al. 2011). In USA, it was recorded from WA (Moore and Legner 1975). For Palaearctic distribution and synonymy of this species, see Lee and Ahn (2015).



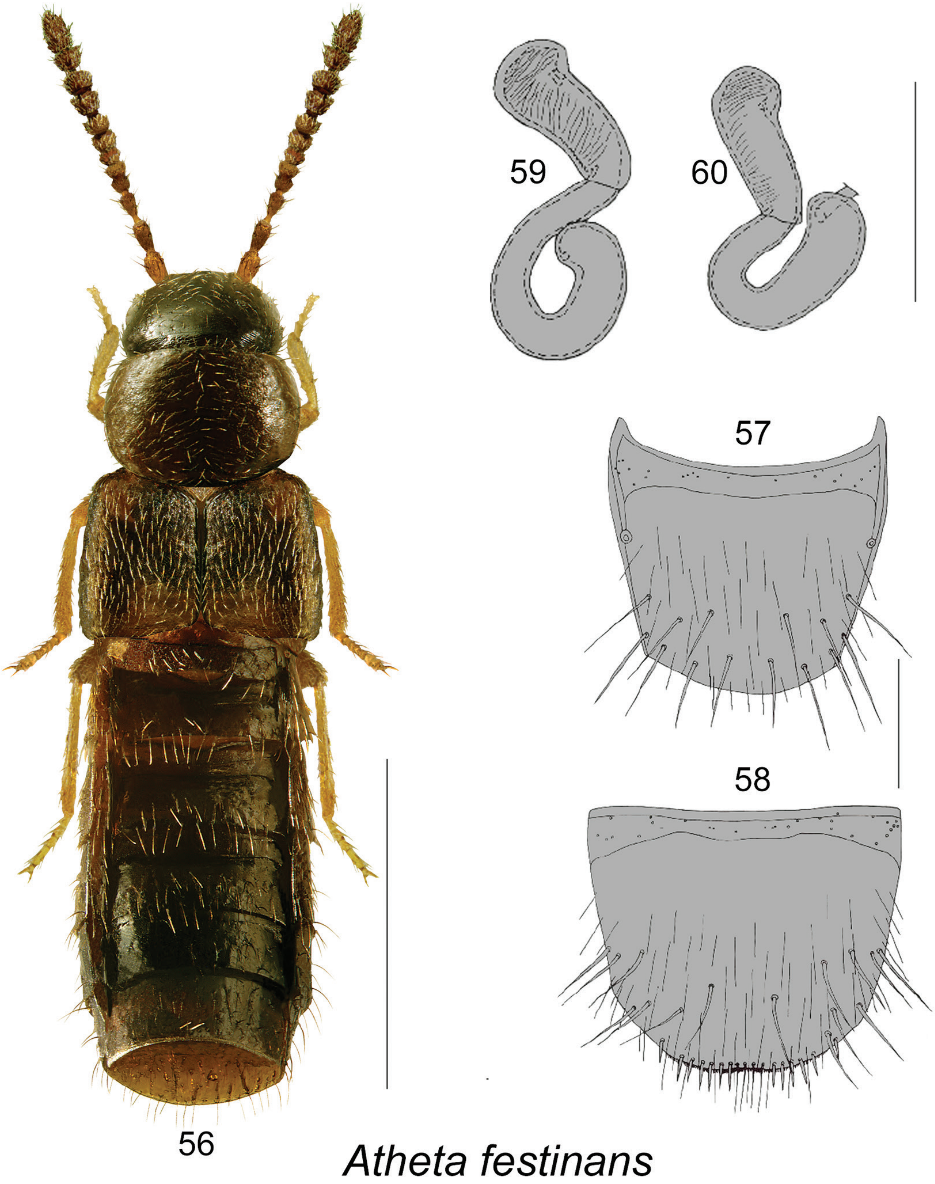
Figures 49–55. *Atheta* (*Microdota*) *amicula* (Stephens): **49** habitus in dorsal view **50** male tergite VIII (based on European specimen) **51** median lobe of aedeagus in lateral view (after Brundin 1948) **52** median lobe of aedeagus in dorsal view (after Brundin 1948) **53** female tergite VIII **54** female sternite VIII **55** spermatheca. Scale bar for habitus = 1 mm; remaining scale bars = 0.2 mm.

***Atheta* (*Microdota*) *festinans* (Erichson)**

Figs 56–60

(For diagnosis and synonymy, see Gusarov 2003b)

Homalota festinans Erichson, 1839: 112. As *Atheta* (*Microdota*): Gusarov 2003a, b, Brunke et al. 2012.



Figures 56–60. *Atheta* (*Microdota*) *festinans* (Erichson): **56** habitus in dorsal view **57** female tergite VIII **58** female sternite VIII **59, 60** spermatheca. Scale bar for habitus = 1 mm; remaining scale bars = 0.2 mm.

Material examined. Canada, Quebec, Berthier Co., Berthierville, 20.XI.2004, Michel Racine coll., sous débris de bois, dans sablière, avec Carabe *Dyschiriodes* sp. (LFC) 1 female.

Natural history. This is the first record with habitat data for this species. The QC specimen was captured from woody debris in a sandy pit in association with *Dyschirius* sp. (Carabidae).

Distribution. Erichson (1839) described this species from PA in USA. Gusarov (2003b) recorded it from AZ, CT, IA, IN, KY, NY, PA, and RI. Bernhauer (1907) reported *A. festinans* from ON, and Brunke et al. (2012) confirmed occurrence of this species in Waterloo Reg., ON. Here, we provide the first record of this species from QC.

Comments. All known Canadian specimens of *Atheta festinans* are females. Gusarov (2003b) remarked that all specimens seen of this species were females and suggested that this species may be parthenogenetic.

Atheta (*Microdota*) *formicaensis* Klimaszewski & Webster, sp. n.

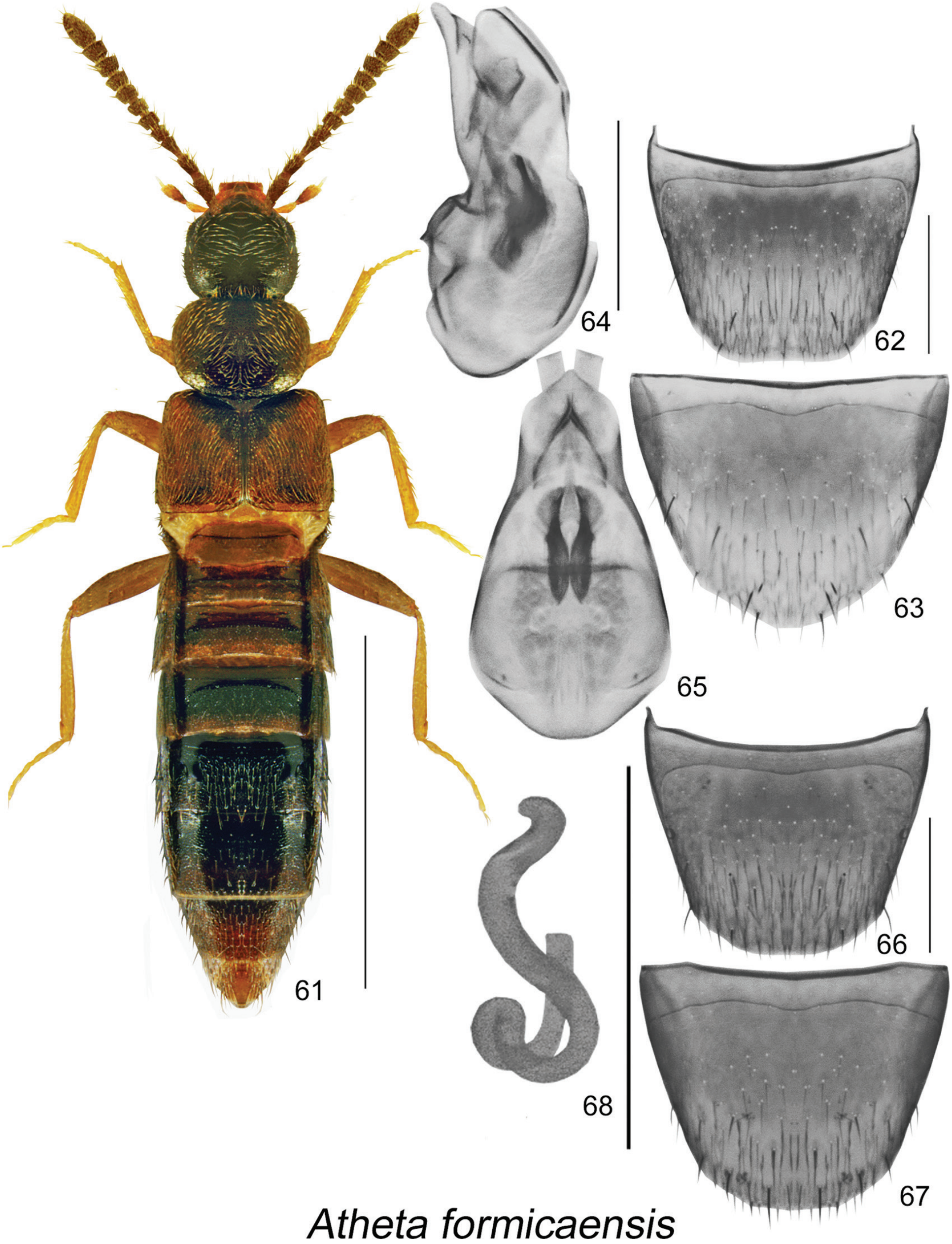
http://zoobank.org/A4C2D2A2-735F-4D0B-94B0-D46C3D2BDB8C
Figs 61–68

Holotype (male). Canada, New Brunswick, York Co., New Maryland, Charters Settlement, 45.8395°N, 66.7391°W, 19.V.2006, R.P. Webster coll. // mixed forest, on surface of nest of black *Formica* sp. (LFC) 1 male. **Paratypes**: labelled as holotype (RWC) 1 male, 1 female; Charters Settlement, 45.8395°N, 66.7391°W, 29.IV 2004, R.P. Webster coll. // mixed forest, on surface of nest of black *Formica* sp. (RWC) 3 sex undetermined; same data except: 30.IV.2005 // mixed forest in nest of black *Formica* sp., sifting nest material (RWC) 2 sex undetermined; Queens Co., Cranberry Lake P.N.A., 46.1125°N, 65.6075°W, 13.V.2011, R.P. Webster coll. // old red oak forest, in nest of black mound-building *Formica* species, near surface of mound (LFC, RWC) 1 female, 2 sex undetermined.

Etymology. The specific name *formicaensis* is a feminine adjective derived from the generic name *Formica*, an ant genus found in association with the type series.

Diagnosis. Body length 2.6–2.8 mm, subparallel, moderately convex, head and posterior part of abdomen dark brown, pronotum medium to dark brown, elytra with centre of disc yellowish brown and darker edges, base of abdomen light brown, legs yellowish brown (Fig. 61); integument glossy, sparsely punctate and sparsely pubescent, microsculpture distinct and stronger on pronotum and elytra; head slightly narrower than pronotum, rounded and slightly angular posteriorly, eyes small and shorter than postocular area dorsally; antennal articles V–X from subquadrate to slightly transverse; pronotum transverse, slightly narrower than elytra; elytra wider and as long as pronotum; abdomen subparallel. MALE. Tergite VIII truncate apically (Fig. 62); sternite VIII broadly rounded apically and slightly pointed medially (Fig. 63); median lobe of aedeagus narrowly oval in dorsal view with short and triangular tubus (Fig. 65), in lateral view tubus sinuate basally and then straight and rounded apically (Fig. 64); internal sac structures as illustrated (Figs 64, 65). FEMALE. Tergite VIII truncate apically (Fig. 66); sternite VIII broadly rounded apically (Fig. 67); spermatheca small, S-shaped, capsule spherical without apparent apical invagination, stem narrow and sinuate (Fig. 68).

Natural history. Adults were found in association with nests of black ants in the genus *Formica* in April and May.



Figures 61–68. *Atheta* (*Microdota*) *formicaensis* Klimaszewski & Webster, sp. n.: **61** habitus in dorsal view **62** male tergite VIII **63** male sternite VIII **64** median lobe of aedeagus in lateral view **65** median lobe of aedeagus in dorsal view **66** female tergite VIII **67** female sternite VIII **68** spermatheca. Scale bar for habitus = 1 mm; remaining scale bars = 0.2 mm.

Distribution. Known only from NB, Canada.

Comments. This species is probably closely associated with nests of the ant genus *Formica*. It is distinguished from all other Nearctic species of *Microdota* by the shape of the median lobe of the aedeagus and spermatheca. The shape of the spermatheca is similar to that of Palaearctic *A.* (*M.*) *glabricula* Thomson (Palm 1970).

***Atheta* (*Microdota*) *pennsylvanica* Bernhauer**

Figs 69–79

(For diagnosis, see Klimaszewski et al. 2011, and for synonymy, Gusarov 2003b)
Bernhauer 1907: 388. As *Atheta* (*Microdota*): Gusarov 2003b.

Distribution. This species was recorded in Canada from NB, NF, NS, ON, QC, and in the USA from MN, NY, PA, VT (Gusarov 2003b, Klimaszewski et al. 2011).

***Sculptisoma* species group (new)**

Species of this group are characterized by elytra at suture at least as long as pronotum (Fig. 80), male unknown; spermatheca pipe-shaped with hemispherical capsule narrowed basally and without apparent apical invagination, and with long stem that is looped posteriorly and twisted apically (Fig. 83). One species belongs to this group.

***Atheta* (*Microdota*) *sculptisoma* Klimaszewski & Langor**

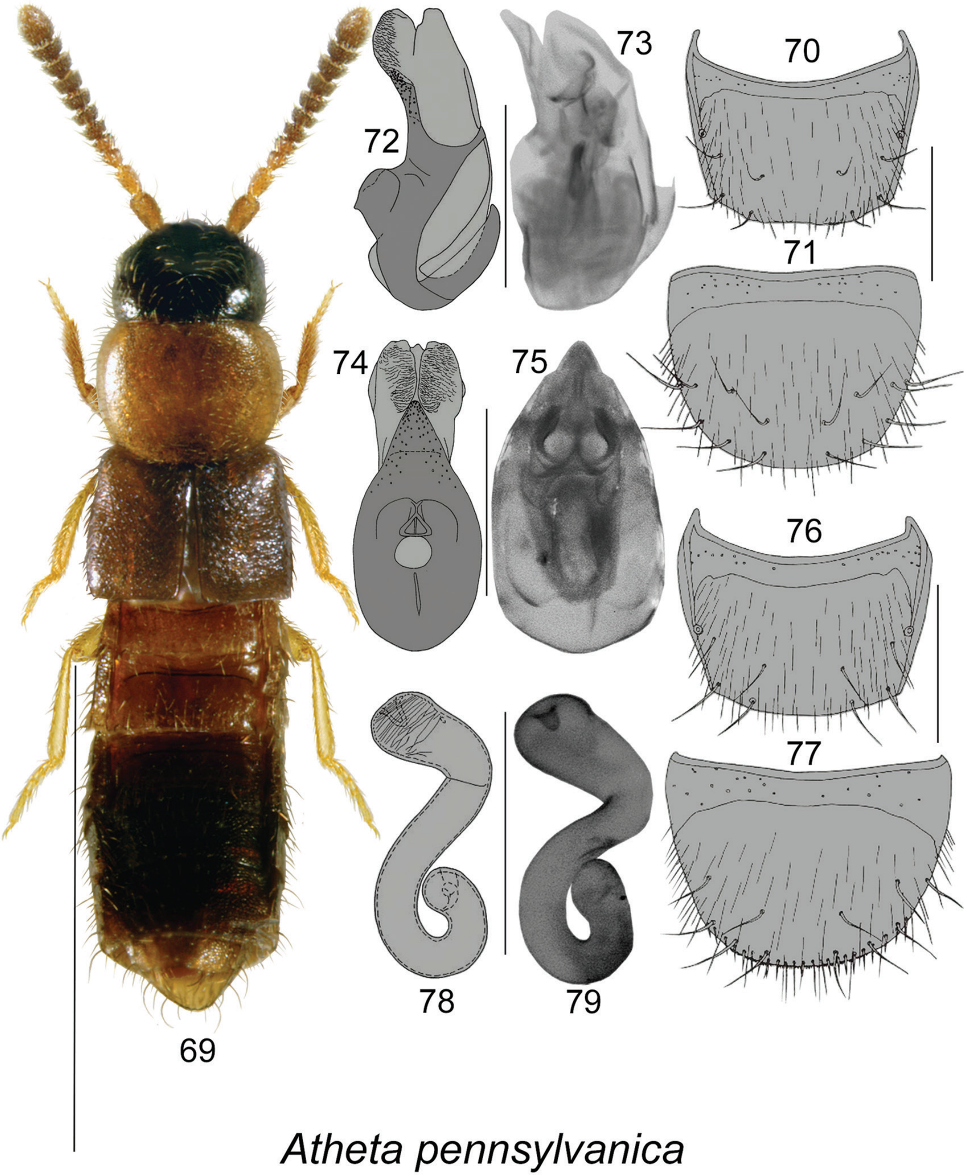
Figs 80–83

(For diagnosis, see Klimaszewski et al. 2011)
Klimaszewski et al. 2011: 148.

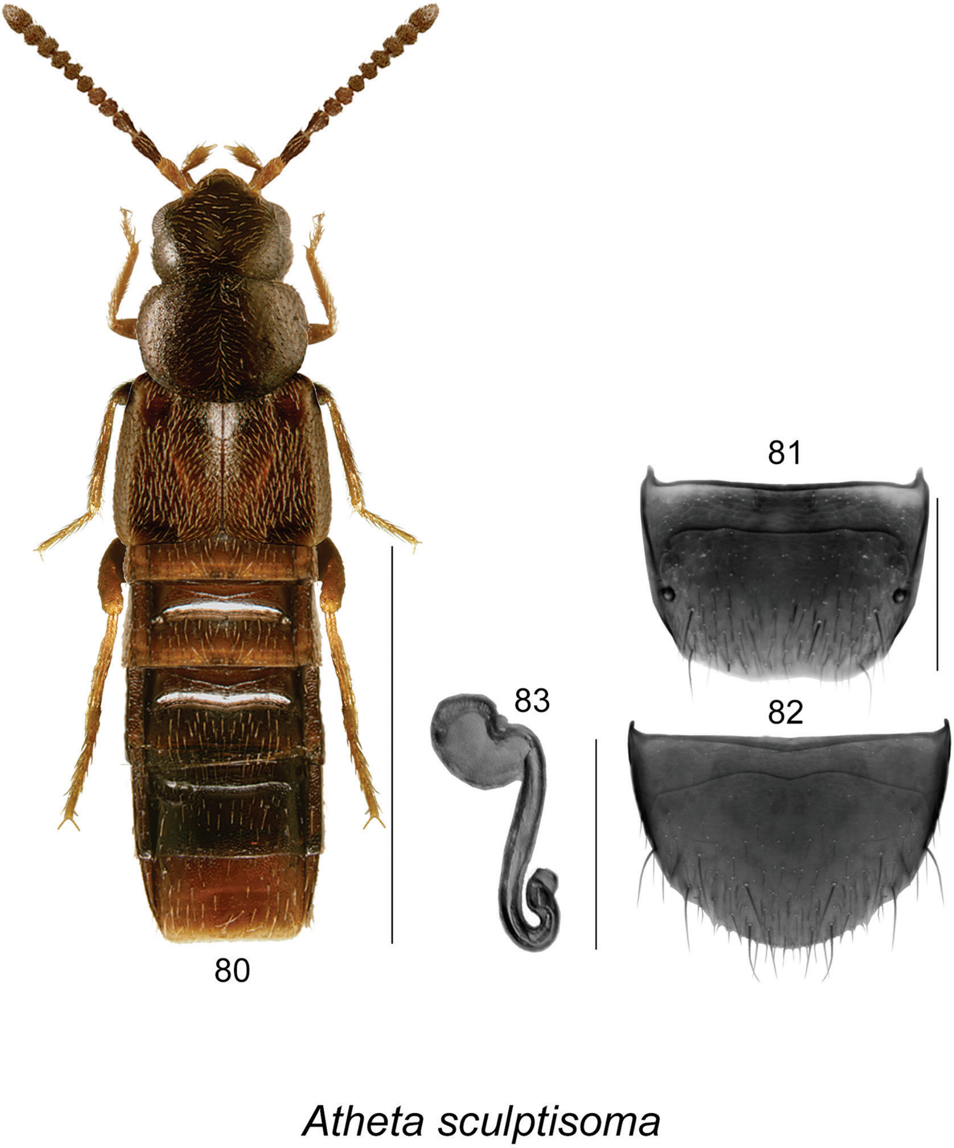
Distribution. This native Nearctic species was recorded only from the type locality in southeastern NF in Canada (Klimaszewski et al. 2011).

***Macesi* species group (new)**

Species of this group are characterized by the strongly glossy body, elytra at suture slightly longer than pronotum (Fig. 84), male tergite VIII truncate apically and with two small lateral teeth (Fig. 85), median lobe of aedeagus with small bulbus and elongate tubus, in lateral view tubus straight, apex narrowly triangular and slightly pointed (Fig. 87), internal sac structures pronounced (Fig. 87); female unknown. One species belongs to this group.



Figures 69–79. *Atheta* (*Microdota*) *pennsylvanica* Bernhauer: **69** habitus in dorsal view **70** male tergite VIII (after Gusarov 2003b) **71** male sternite VIII (after Gusarov 2003b) **72** median lobe of aedeagus in lateral view (after Gusarov 2003b), and **73** based on Canadian specimen **74** median lobe of aedeagus in ventral view (after Gusarov 2003b), and **75** in dorsal view (based on Canadian specimen) **76** female tergite VIII (after Gusarov 2003b) **77** female sternite VIII (after Gusarov 2003b) **78** spermatheca (after Gusarov 2003b), and **79** based on Canadian specimen. Scale bar for habitus = 1 mm; remaining scale bars = 0.2 mm.



Figures 80–83. *Atheta* (*Microdota*) *sculptisoma* Klimaszewski & Langor: **80** habitus in dorsal view **81** female tergite VIII **82** female sternite VIII **83** spermatheca. Scale bar for habitus = 1 mm; remaining scale bars = 0.2 mm.

***Atheta* (*Microdota*) *macesi* Klimaszewski & Webster, sp. n.**

http://zoobank.org/A4599D2A-246D-4AD1-A2F4-214C4585DED9
Figs 84–87

Holotype (male). Canada, New Brunswick, Saint John Co., ca 2 km NE of Maces Bay, 45.1161 N, 66.4560 W, 8.V.2006, R.P. Webster, coll. // Eastern white cedar swamp, in sphagnum and litter near brook (LFC).

Etymology. The specific name *macesi* is an adjective derived from Maces Bay in NB, where the holotype specimen was found.

Diagnosis. Body length 2.7 mm, subparallel, flattened, brownish-black, tibiae and tarsi brown (Fig. 84); integument glossy and more so on abdomen, sparsely punctate and pubescent, except for pronotum and elytra; microsculpture of forebody dense and strong, meshed with hexagonal sculpticells; head about as wide as pronotum, slightly angular posteriorly, eyes large and as long as postocular area dorsally; antennae with articles V–X moderately to strongly transverse; pronotum broadest in apical third and narrowest at base, rounded laterally and basally, transverse, narrower than elytra; elytra wider and slightly longer than pronotum; abdomen subparallel. MALE. Tergite VIII truncate apically and with two large lateral teeth (Fig. 85); sternite VIII rounded apically (Fig. 86); median lobe of aedeagus with small bulbus and long tubus, in lateral view tubus straight and apex slightly produced ventrally, apex narrowly triangular and slightly pointed (Fig. 87), internal sac structures well defined (Fig. 87). FEMALE. Unknown.

Natural history. A single male was found in eastern white cedar in sphagnum and litter near a brook, in May.

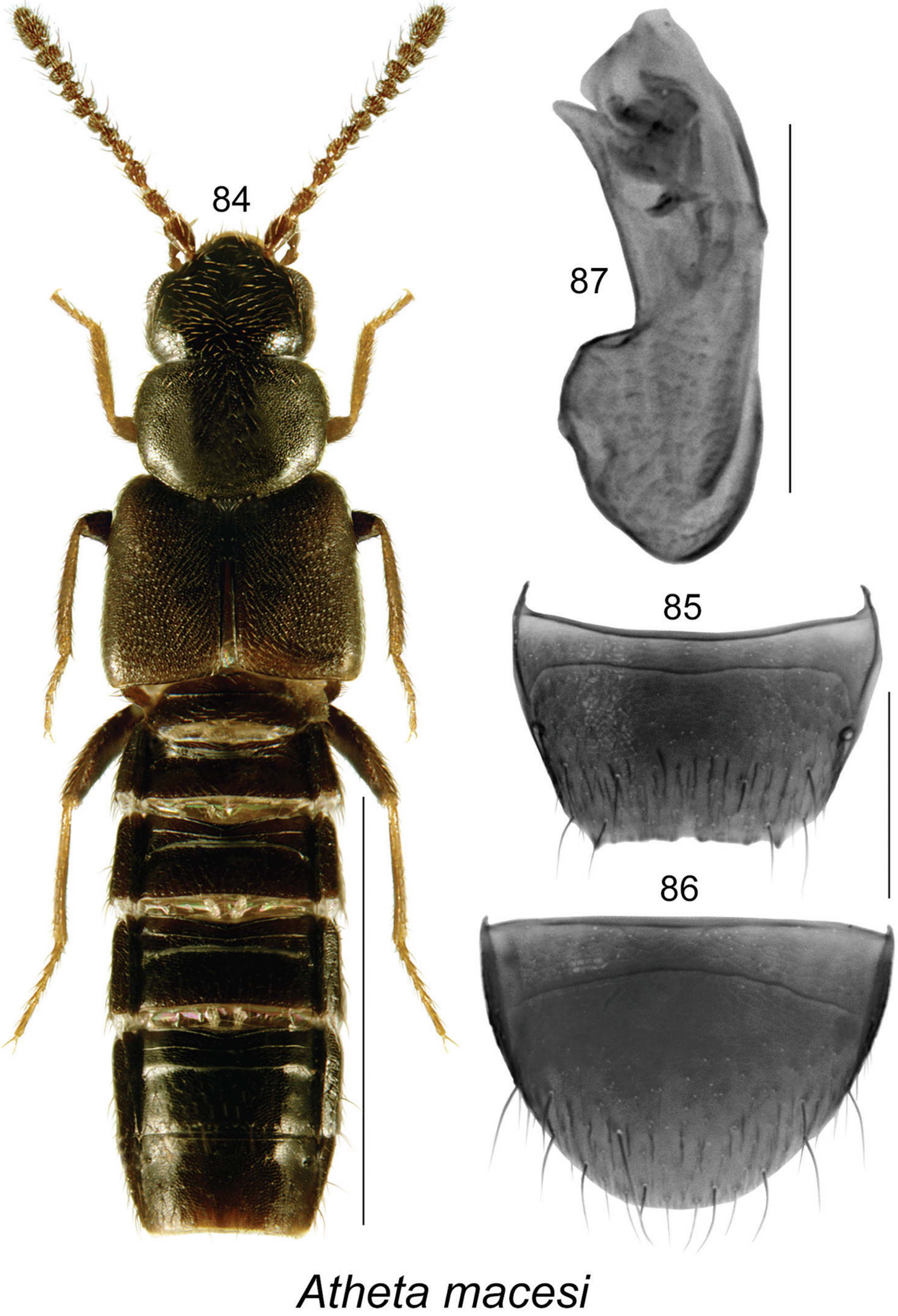
Distribution. Known only from NB, Canada.

Comments. This species is known only from a single male collected in sphagnum and litter.

Genus *Clusiota* Casey

Clusiota Casey, 1910: 119; Moore and Legner 1975: 347.

Diagnosis. The following combination of characters is distinctive for *Clusiota*: small and subparallel body (Figs 96, 88, 104), length 1.5–2.5 mm, antennomere I swollen (Figs 96, 88) except for *C. grandipenis* (Fig. 104), and longer than II, V–X strongly transverse (Figs 96, 88, 104); labial palps with 3 articles; glossae narrow, deeply split forming V-shaped structure; maxillary palpus with 3 articles, last one narrowly elongate; pronotum transverse, about 1.2 times as wide as long, pubescence at midline directed apically in most specimens anteriorly and laterad elsewhere (Figs 96, 88, 104); pronotal hypomeron fully visible medially in lateral view; elytra with pubescence directed obliquely postero-laterad from midline of disc (Figs 96, 88, 104); abdomen slightly swollen posteriorly; male tergite VIII emarginate medially (Figs 89, 97, 105);



Figures 84–87. *Atheta* (*Microdota*) *macesi* Klimaszewski & Webster, sp. n.: **84** habitus in dorsal view **85** male tergite VIII **86** male sternite VIII **87** median lobe of aedeagus in lateral view. Scale bar for habitus = 1 mm; remaining scale bars = 0.2 mm.

median lobe of aedeagus with large bulbus and moderately narrow, and triangularly shaped apically tubus in dorsal view (Figs 91, 99, 107), crista apicalis of bulbus large (Figs 92, 100, 108); spermatheca L-shaped or S-shaped with club-shaped tubular capsule, and short sinuate stem (Figs 95, 103, 111).

Comments. Species of this genus may be confused with *Microdota* species, from which they may be readily distinguished by the swollen first basal antennal articles (except for *C. grandipenis*), and shape of genitalia, with median lobe bearing large crista apicalis of bulbus. Casey (1910) believed this genus was related to the subgenus *Datomicra* of *Atheta*.

Key to Nearctic species of *Clusiota*

1. Elytra longer than pronotum and at least 1.3 times broader than pronotum (Figs 88, 104) **2**

– Elytra at most as long as pronotum and about 1.1 times broader than pronotum (Fig. 96); median lobe of aedeagus with tubus straight medially and apical part broad in lateral view (Fig. 100), bulbus without distinct large sclerites in dorsal view (Fig. 99); male tergite VIII with shallowly emarginated apical margin (Fig. 97); spermatheca consisting of club-shaped and elongate capsule and sinuate, short and broad stem (Fig. 103) .... ***Clusiota antennalis* Klimaszewski & Godin**

2. Body reddish-brown (Fig. 88); median lobe of aedeagus with tubus sinuate medially and apical part narrow in lateral view (Fig. 92), bulbus with two strong elongate sclerites in dorsal view (Fig. 91); male tergite VIII with deeply emarginated apical margin (Fig. 89); spermatheca sinuate (Fig. 95) .... ***Clusiota impressicollis* (Bernhauer)**

– Body dark brown (Fig. 104), median lobe of aedeagus with tubus scarcely sinuate medially and apical part broad in lateral view (Fig. 108), bulbus with differently shaped structures (Fig. 107); spermatheca S-shaped (Fig. 111) .... ***Clusiota grandipenis* Klimaszewski & Webster, sp. n.**

Clusiota impressicollis (Bernhauer)

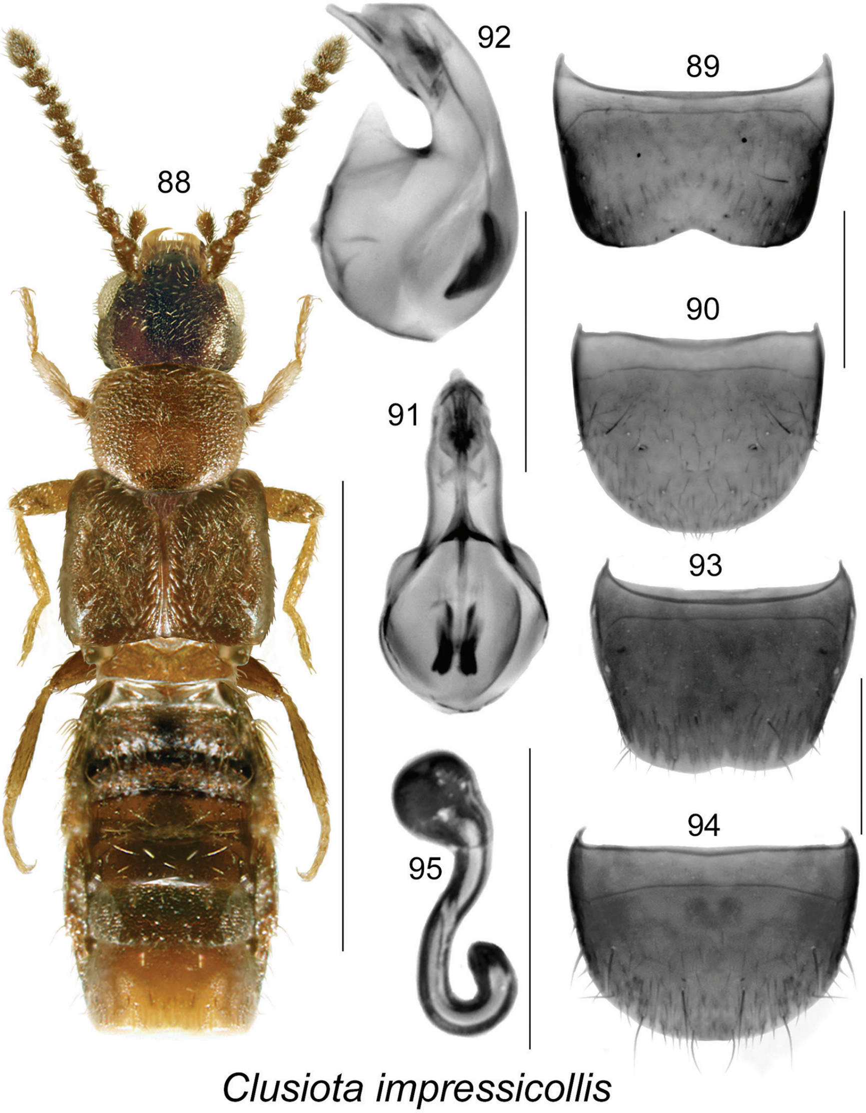
Figs 88–95

(For diagnosis, see Casey 1910, Klimaszewski et al. 2011)

Atheta impressicollis Bernhauer 1907: 389. As *Clusiota*: Klimaszewski et al. 2011, Brunke et al. 2012, Bousquet et al. 2013.

Clusiota claviventris Casey 1910: 119. Synonymized by Gusarov 2003a.

Material examined (additional locality data). Canada, Ontario, Sudbury Co., Mattagami, 25.VIII.1980, R. Baranowski (ZML) 2 males, 1 female; Nipissing Co., Algonquin Provincial Park, near Brent, 21.VIII.1980, R. Baranowski (ZML) 1 male.



Figures 88–95. *Clusiota impressicollis* (Bernhauer): **88** habitus in dorsal view **89** male tergite VIII **90** male sternite VIII **91** median lobe of aedeagus in dorsal view **92** median lobe of aedeagus in lateral view **93** female tergite VIII **94** female sternite VIII **95** spermatheca. Scale bar for habitus = 1 mm; remaining scale bars = 0.2 mm.

Distribution. BC, NB, NF, ON (Casey 1910, Klimaszewski et al. 2011, Bousquet et al. 2013).

Natural history. The specimens from ON were collected in August. The NF specimens were captured in a light flight intercept trap in fir-deciduous forest in July/August (Klimaszewski et al. 2011). These records indicate that adults occur late in the season.

Comments. This species was originally reported by Bernhauer (1907) from Baring, WA and Pasadena, CA. The previously unknown female is illustrated here for the first time from a specimen from Mattagami, ON.

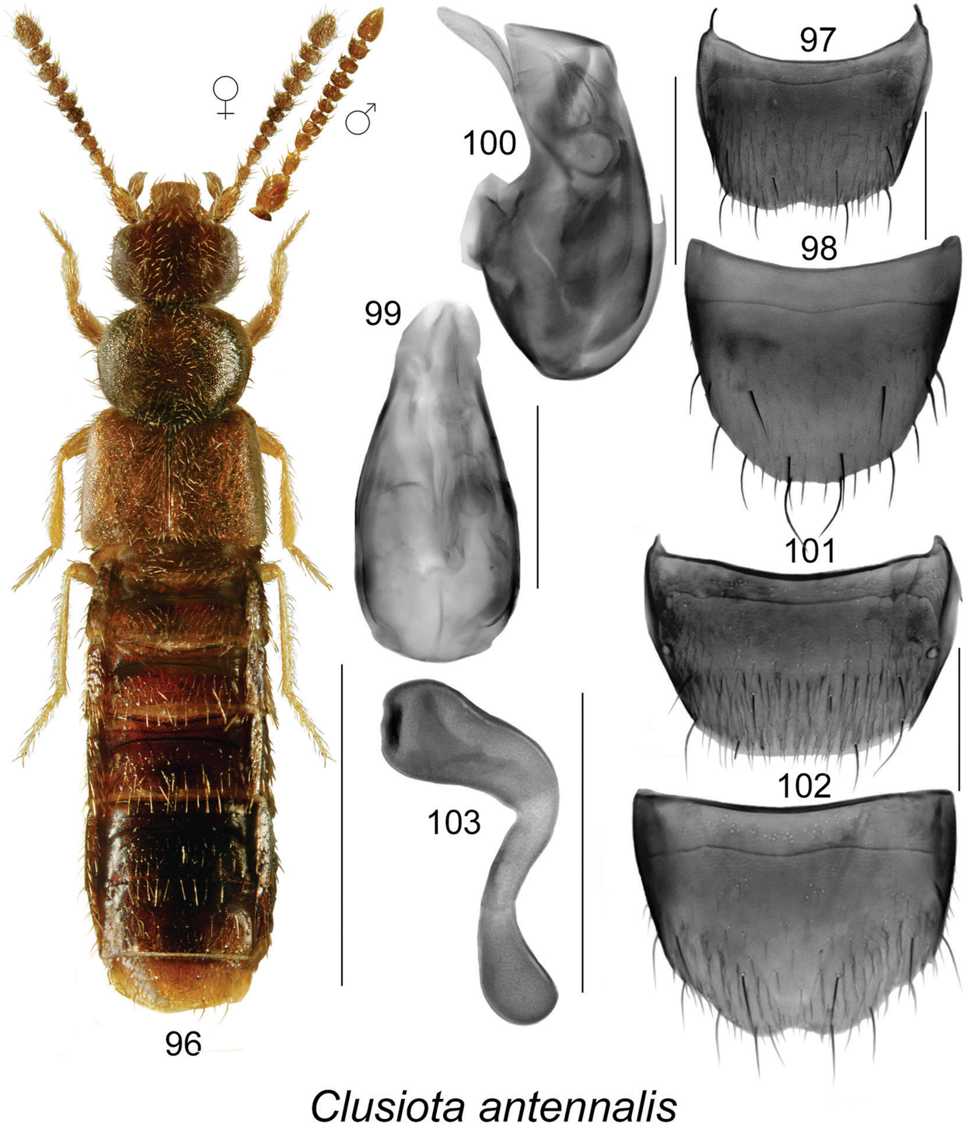
Clusiota antennalis Klimaszewski & Godin

Figs 96–103

(For diagnosis, see Klimaszewski et al. 2008)
Clusiota antennalis Klimaszewski & Godin in Klimaszewski et al. 2008.

Material examined. Canada, **British Columbia**, Cooper River Valley, A31698/F4-1-1, 4.VII–7.VIII.1996, +/- 20 m. pitfall trap, J. Lemieux (LFC) 1 female, 1 sex? same data except: A37541/P2-1-5, 6.VI–4.VII (LFC) 2 females; A36435/04-1-1, 7.VI–6.VII.1996 (LFC) 2 males; Vancouver Island, Mt. Cain: 50.14°N, 126.21°W, 5.VI–27.VI.1996, 16.6 PIT2, N. Winchester (ZML) 2 females; 50.14°N, 126.21°W, 27,VI–13.VII.1966, 16.6.PIT 3, N. Winchester (ZML) 3 females; 50.13°N, 126.21°W, 23.VI–7.VII.1997, 16.6 PIT2, N. Winchester (ZML) 18 females; 50.13°N, 126.21°W, 7.VII–20.VII.1997, 16.6 PIT8, N. Winchester (ZML) 7 females; 50.13°N, 126.21°W, 20.VII–5.VIII.1997, 16.6 PIT 6, N. Winchester (ZML) 1 female; 50.13°N, 126.21°W, +/- 20 m, 1.IX–19.IX.1997, 16.6 PIT8, N. Winchester (ZML) 5 males; same data except: 15.IX–28.IX.1996, 17.4 PAN 3 (ZML) 1 female; 28.IX–12.X.1996, 16.6 PAN 1 (ZML) 3 females; 12.X–1.XI.1996, 16.6 PAN3 (ZML) 1 male; 50.15°N, 126.25°W, 19.IX–4.X.1997, 17.4 PIT 7 (ZML) 1 male, 1 female. **U.S.A.**, **Alaska**, Prince of Wales Is.: Staney Ck., 41–45 m el., 55.79901°N, 133.11782°W, old growth, pitfall 2, 25.VI–9.VII.2012, J. Stockbridge et al. UAM100340147 (UAM) 1 female; same data except: 11–25.VI.2012, UAM100338700 (UAM) 1 female;14–28.V.2012 UAM100338413, UAM100338412, UAM100338414 (UAM) 3 females; Luck Lk. 2 Rd., old growth, 105 m el., 55.96855°N, 132.79615°W, +/- 10 m pitfall 3, 29.VI-8.VII.2010, J. Stockbridge UAM100278064 (UAM) 1 female; Luck Lk. 1 Rd., old growth, 101 m el., 55.97805°N, 132.75456°W, +/- 10 m. pitfall, 8-30.VII.2010, J. Stockbridge, C. Bickford UAM100279634, UAM100279635 (UAM) 2 females; same data except: 27.VI–11.VII.2012 UAM100343219, UAM100343218, UAM100343246 (UAM) 3 females; pitfall 1, 13-27.VI.2012, J. Stockbridge et al. UAM100339932 (UAM) 1 female; Hatchery Ck. 1, 2nd growth, 49 m el., 55.92654°N, 132.95645°N, +/- 10 m pitfall 3, 18.V–4.VI.2010, J. Stockbridge, C. Bickford UAM100262426 (UAM) 1 female; Dall Is., p. 12 el. 688 m., 54.99342°N, 133.01688°N, +/-4 m krummholtz, *Tsuga mertensiana, Vaccinium ovalifolium*, pitfall, 15–16.VII.2011, D.S. Sikes UAM100329960, UAM100329969 (UAM) 2 females. UAM data can be downloaded at http://arctos.database.museum/saved/Clusiota_antennalis.

Distribution. Originally described from Dyea, AK (Klimaszewski et al. 2008). It is here newly reported in Canada from BC, and from new localities in AK. *Clusiota antennalis* is a western Nearctic species known only from western BC and AK.



Figures 96–103. *Clusiota antennalis* (Klimaszewski & Langor): **96** habitus in dorsal view **97** male tergite VIII **98** male sternite VIII **99** median lobe of aedeagus in dorsal view **100** median lobe of aedeagus in lateral view **101** female tergite VIII **102** female sternite VIII **103** spermatheca. Scale bar for habitus = 1 mm; remaining scale bars = 0.2 mm.

Natural history. In AK, the holotype was captured in alder litter, and the recent AK specimens were collected primarily in pitfall traps from old-growth Pacific rain forests at low elevations although two specimens were collected in an alpine habitat above 650 m elevation. In BC, specimens from Vancouver Island were captured continuously from June to November in pitfall and pan traps.

Comments. Females of this species have a spermatheca extremely similar to those of *Atheta* (*M.*) *subtilis* and *A.* (*M.*) *pseudosubtilis*. *Clusiota antennalis* is easily separated from the two species by the swollen basal antennal article (Fig. 96), and from *A. subtilis* by much shorter elytra (Fig. 96). It differs from all Nearctic *Clusiota* and *Microdota* species by the shape of the genitalia.

Clusiota grandipenis Klimaszewski & Webster, sp. n.

http://zoobank.org/0424783F-C865-4166-A976-1D60D3AA10AF

Figs 104–111

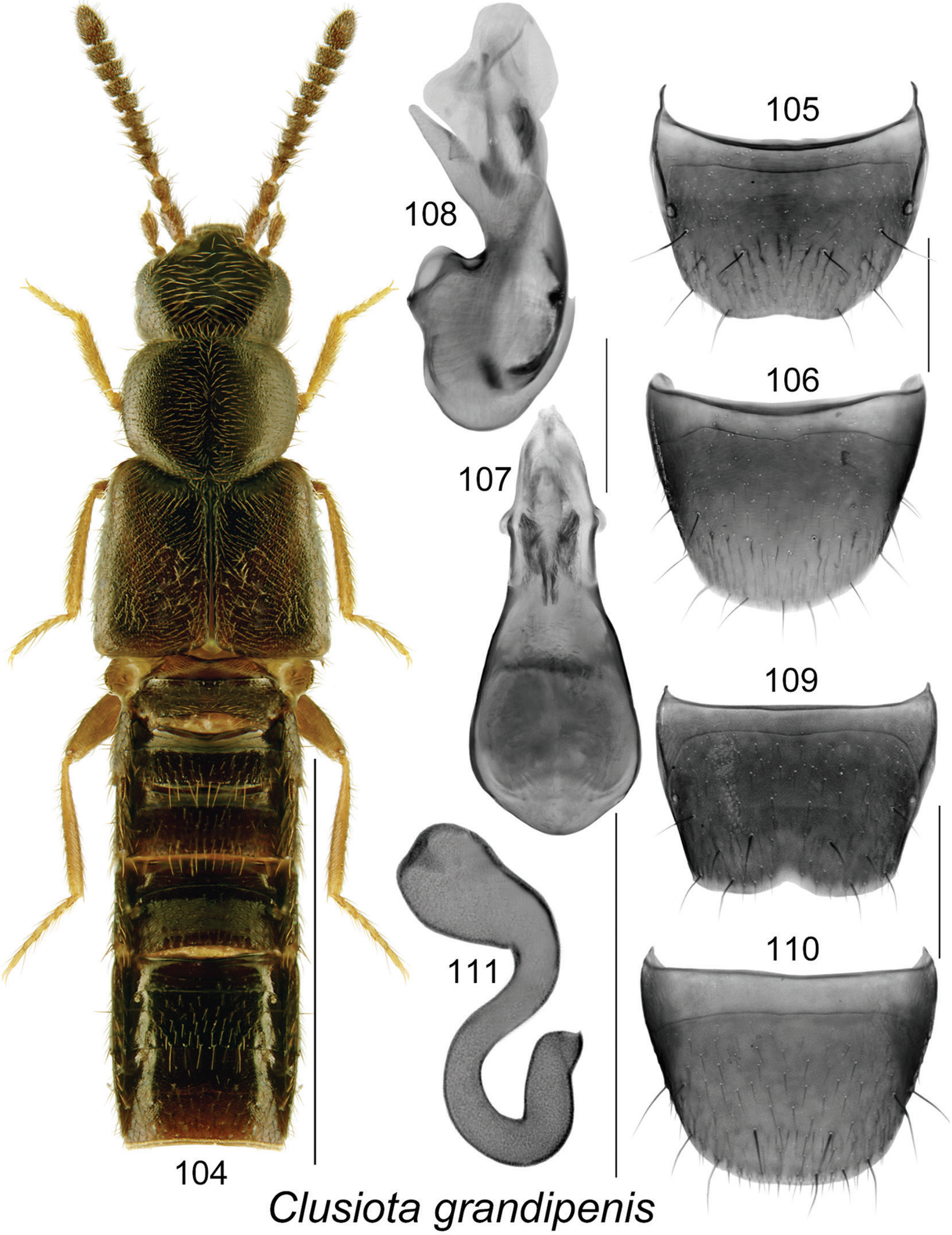
Holotype (male). Canada, New Brunswick, **Westmorland Co.**, Sackville near Ogden Mill, 45.92155°N, 64.38925°W, 12.V.2006, Scott Makepeace coll. // Black spruce forest, in nest contents of Great Horned Owl – *Bubo virginensis* (LFC). **Paratype**: **Canada, New Brunswick**, **Northumberland Co.**, ca. 2.5 km W of Sevogle, 47.0876N, 65.8613W, 27.VIII.2013, old jack pine forest, in decaying gilled mushroom, R.P. Webster (RWC) 1 female.

Etymology. The specific name *grandipenis*, meaning large penis, refers to the large tubus of the median lobe of the aedeagus of this species.

Diagnosis. Body length 2.2 mm, subparallel, flattened, dark brown, abdomen slightly darker than remainder of the body, legs yellowish brown (Fig. 104); integument glossy, densely punctate and densely pubescent on forebody and less so on head and particularly on abdomen, microsculpture of forebody fine, meshed with hexagonal sculpticells; head about as wide as pronotum, slightly angular posteriorly, eyes large and as long as postocular area dorsally; pronotum rounded laterally and basally, transverse, narrower than elytra; elytra wider and longer than pronotum; abdomen subparallel. MALE. Tergite VIII slightly emarginate apically (Fig. 105); sternite VIII broadly rounded apically (Fig. 106); median lobe of aedeagus with broadly oval bulbus streamlined with apically narrowly triangular tubus in dorsal view (Fig. 107), in lateral view tubus strongly produced ventrally, apex narrowly triangular and slightly pointed (Fig. 108), internal sac structures pronounced (Figs 107, 108). FEMALE. Tergite VIII with shallow apical median emargination (Fig. 109); sternite VIII rounded apically (Fig. 110); spermatheca S-shaped, capsule broadly club-shaped with deep median invagination, stem sinuate with posterior loop (Fig. 111).

Natural history. One adult was found in the nest contents of a Great Horned Owl, – *Bubo virginensis* in a black spruce forest in May and another from a decaying gilled mushroom in a jack pine forest during August.

Distribution. Known only from NB, Canada.



Figures 104–111. *Clusiota grandipenis* Klimaszewski & Webster, sp. n.: **104** habitus in dorsal view **105** male tergite VIII **106** male sternite VIII **107** median lobe of aedeagus in dorsal view **108** median lobe of aedeagus in lateral view **109** female tergite VIII **110** female sternite VIII **111** spermatheca. Scale bar for habitus = 1 mm; remaining scale bars = 0.2 mm.

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DATA PAPER

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The Register of Antarctic Marine Species (RAMS): a ten-year appraisal

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Abstract

The Register of Antarctic Marine Species (RAMS) is a marine species database that manages an authoritative taxonomic list of species occurring in the Southern Ocean. RAMS links with several other initiatives managing biogeographic or genomics information. The current paper aims to briefly present RAMS and provides an updated snapshot of its contents, in the form of a DarwinCore checklist (available through http://ipt.biodiversity.aq/resource.do?r=rams) and illustrative barplots. Moreover, this article presents a ten year appraisal (since the creation of RAMS). This appraisal first focuses on RAMS bibliometrics. We observed that RAMS was cited (Google Scholar) in 50 distinct publications among which 32 were peer-reviewed in 18 different journals. Three journals (Antarctic Science, Polar Biology, ZooKeys) represent almost 40% of these peer-review publications. The second appraisal focuses on the evolution of new RAMS records. We observed an important decrease in data additions since 2011. As a case study, we focused on an original dataset for a specific group (Asteroidea, Echinodermata). It appears that around one hundred species of asteroids are lacking in RAMS despite the relatively high availability of these data. This suggests that the users' community (or collaborative projects such as AquaRES) could be helpful in order to maintain the RAMS database over the long term.

Keywords

Register of Antarctic Marine Species, Biodiversity, Southern Ocean, Antarctic, Bibliometrics, Asteroidea

Rationale

The Register of Antarctic Marine Species (RAMS) is one of the regional species databases within the World Register of Marine Species (WoRMS, http://marinespecies.org) (Costello et al. 2013). RAMS compiles and manages an authoritative taxonomic list of species occurring in the Southern Ocean, establishing a dynamic benchmark for marine biodiversity research, conservation and sustainable management (De Broyer and Danis 2011). RAMS serves as a taxonomic reference for biogeographic information systems such as biodiversity.aq (Van de Putte et al. 2015) and iOBIS (Ocean Biogeographic Information System, IOC 2015). It also links with several other initiatives, including GenBank (http://www.ncbi.nlm.nih.gov/genbank/) and Barcode of Life (http://www.barcodeoflife.org/, see also De Broyer and Danis 2011 for additional information on RAMS concept and primary goals).

RAMS is managed by an Editorial Board which includes an Executive Committee and a team of Taxonomic Editors. The RAMS Executive Committee has an advising role in the development of RAMS and proposes Taxonomic Editors to take up responsibility for the maintenance of the database content. These editors are taxonomic experts and are in charge of the content and data quality control of their specific taxon. In March 2015, RAMS was administered by 59 taxonomic experts from 18 countries and 43 universities, museums or institutes.

Since its creation in 2005, the “Register of Antarctic Marine Species” was cited (Google Scholar, https://scholar.google.com) in 50 distinct publications (Fig. 1) that were themselves cited 492 times. Among these 50 publications, 32 were peer-reviewed in 18 different journals (mean impact factor: 2.25±1.25). Three journals (Antarctic Science, Polar Biology, ZooKeys) represent almost 40% of these peer-review publications and this percentage even exceeds 60% if the journals “Deep-sea Research Part I & II” and “Plos One” are added (Fig. 2).

Taxonomic coverage

General taxonomic coverage description: RAMS checklist (DarwinCore) is available through the GBIF Integrated Publishing Toolkit (http://ipt.biodiversity.aq/resource.do?r=rams).

The taxonomic scope of RAMS covers Antarctic and sub-Antarctic species from three realms (see operational limits in the Spatial coverage section): the sea floor (meio-, macro- and megazoobenthos; micro- and macrophytobenthos), the water column (phytoplankton, zooplankton, nekton) and the sea-ice.

As of March 2015, RAMS includes data on 18,470 taxa and 10,294 species, out of which 81% are taxonomically accepted (see last stats: http://marinespecies.org/rams/aphia.php?p=stats). The percentages of checked taxa (scientific names which have been checked by a taxonomic editor) have a huge variability among phyla (0–100%). Several causes could explain these differences such as editor activity levels or literature accessibility being unequal between groups (e.g. recent literature review vs scattered old

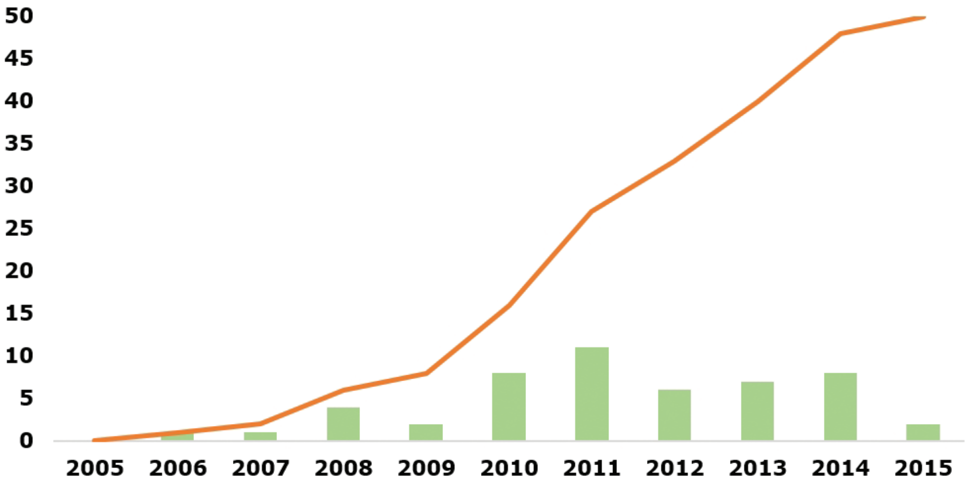

Figure 1. Cumulative number of publications citing "Register of Antarctic Marine Species" since 2005 (orange curve) and number of publications per year citing "Register of Antarctic Marine Species" (green barplot).

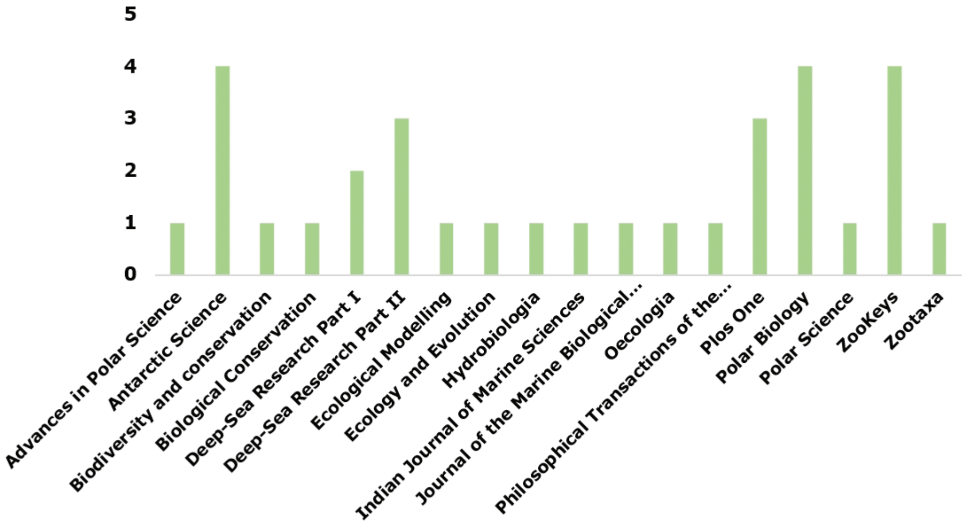

Figure 2. Number of distinct publications citing "Register of Antarctic Marine Species" per peer-reviewed journal.

publications). Moreover, the uncertain taxonomic status of some groups (e.g. due to new genetic analyses) could also explain some update gaps. Finally, the number of species in a group also greatly influences this percentage (a small group should never reach the highest percentages, even if only one species was not checked).The 8,354 accepted species (8,297 marine vs 57 non-marine) are unequally represented among kingdoms and phyla (Fig. 3). Among kingdoms, Animalia is by far the most represented (7,582)

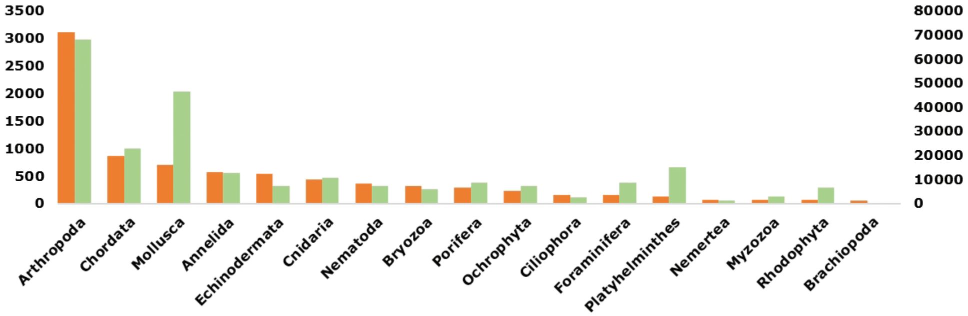

Figure 3. Number of accepted species (marine + non marine) per phylum in RAMS (orange plots, left axis) and in WoRMS (green plots, right axis). Phyla with less than 50 occurrences in RAMS were not represented.

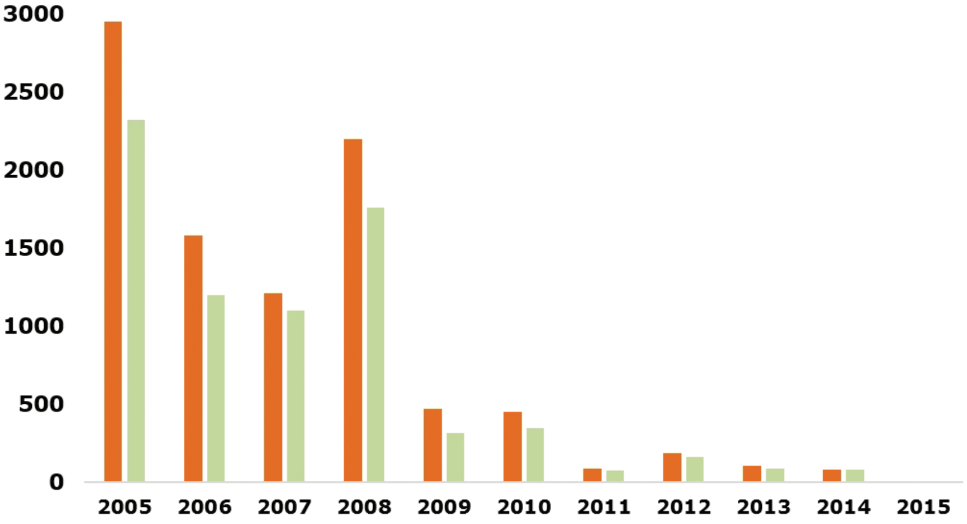

Figure 4. Number of species (left bars in orange) and accepted species (right bars in green) added to RAMS since 2004.

before Chromista (643), Plantae (89), Protozoa (39), Bacteria (1), while Archaea is absent. Regarding phyla, the most abundant, with 3120 accepted species, is Arthropoda followed by Chordata (867), Mollusca (705), Annelida (573) and Echinodermata (537). Interestingly, these five most abundant phyla are the same in WoRMS except for Echinodermata, a fact that highlights again their high specific diversity in the Southern Ocean compared to other oceans (De Broyer et al. 2014).

Since 2005, a total of 18,602 taxa (10,547 species) and 15,834 accepted taxa (8,519 accepted species) were added to RAMS, while the great majority of species (87%) and accepted species (88%) were added before 2009 (Fig. 4).

Moreover, for each of the last four years (2011–2014), the numbers of new species and accepted species were always below 200. This suggests that the great majority of available data was already implemented in RAMS and that the last new species are mainly associated to newly-discovered/described taxa.

A case study: the Asteroidea

To illustrate this prediction ("available data are already uploaded in RAMS"), as well as the quality of the RAMS database, we focused on a particular taxonomic group, the Asteroidea Class (Echinodermata), to check for potential mistakes or gaps. The choice of this class is justified by the fact that the Asteroidea are known to be highly diversified in the Southern Ocean (Danis et al. 2014). We built an original database, mining data from iOBIS (2015), the Biogeographic Atlas of the Southern Ocean (Danis et al. 2014) but also in early and recent literature. In this new dataset, around 289 species (13,308 occurrences) were found and only two spelling mistakes in RAMS species names were reported. However, RAMS lacks 98 species (1,160 occurrences) including data on 191 species (12,148 occurrences) (Fig. 5).

Conclusion

These gaps in Asteroidea data have probably three main causes. First, some recent papers (e.g. Janosik and Halanych 2010), describing new species, have not been taken into account in RAMS since their publication. Secondly, some other species are absent due to a lack of distribution information. Some species are indeed not reported within the RAMS area of interest despite their presence in it. This is especially true for species from New-Zealand where the Campbell Plateau extends far South within the Sub-Antarctic area. However, these species are often reported as New-Zealand species but not Southern Ocean species (e.g. McKnight 2006). Thirdly, other species not referenced in RAMS are linked to early publications (e.g. end of 19th century) that were not digitalized and can be difficult to access.

The case-study of Asteroidea highlights the fact that, despite the great work and expertise of taxonomic editors, some issues can arise even ten years after the creation of RAMS. Indeed, by checking only one class, we found more new entries than those added for the whole RAMS in 2014. Therefore, the user community is encouraged to help the network of taxonomic editors by contacting them (http://marinespecies.org/rams/aphia.php?p=editors) when they detect any mistake or gap during their RAMS utilization. In addition to gathering experts at specific workshops, several initiatives to address existing gaps in RAMS were/are planned. The development of the Biogeographic Atlas of the Southern Ocean (De Broyer et al. 2014) as well as the SCAR Expert Group on Antarctic Biodiversity Informatics (http://www.scar.org/ssg/life-sciences/eg-abi) both illustrate the interest of incorporating

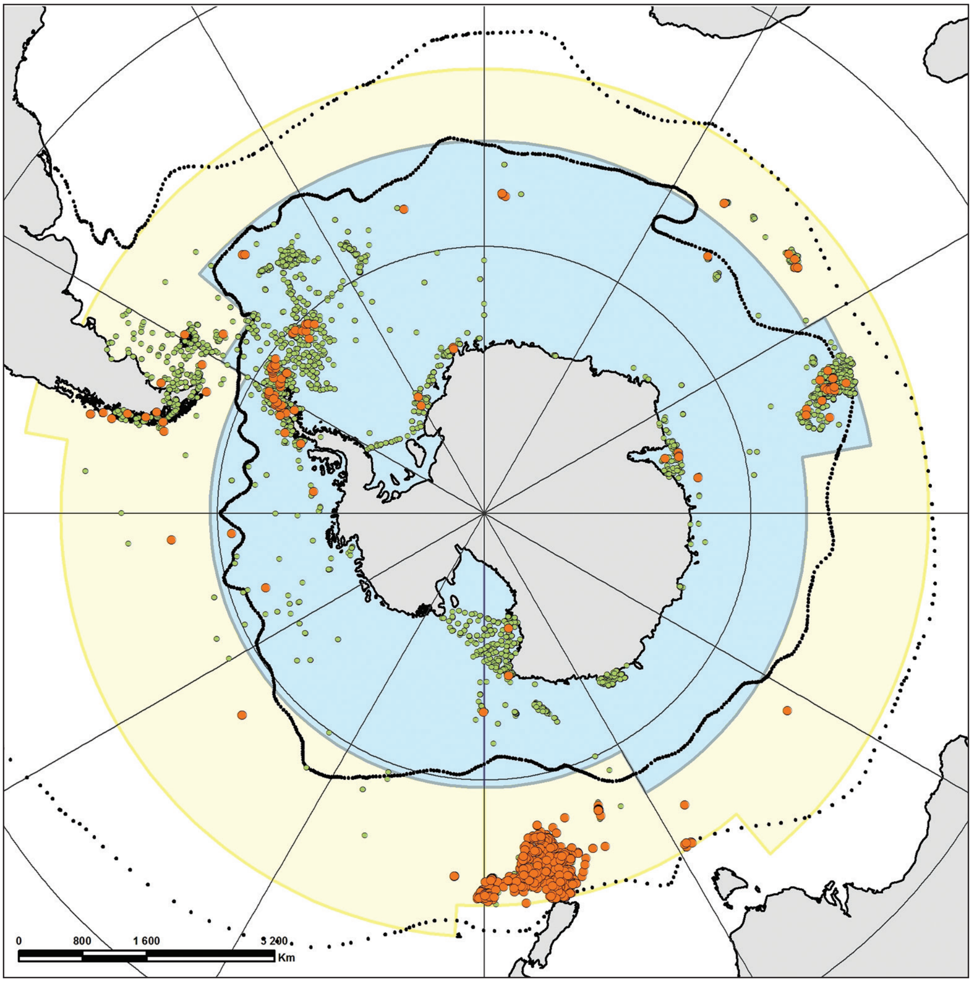

Figure 5. Asteroidea occurrences of RAMS species (green circles) and non-RAMS species (orange circles) within the RAMS area of interest, Antarctic area (light blue) and Sub-Antarctic area (light yellow). Black continuous line is the Polar front and the black dashed line is the Subtropical front.

taxonomical works into a broader and more stimulating context. Moreover, LifeWatch grants exist specifically to support editors in addressing gaps in their taxonomic group. Finally, RAMS is currently being enhanced with new data-cleaning tools in the framework of the AquaRES project (Aquatic Species Register Exchange and Services: http://odnature.naturalsciences.be/aquares). The main objective of this project is to improve the quality, interoperability and public availability of three major Global Species Directories, namely RAMS, WoRMS and FADA (Freshwater Animal Diversity Assessment, fada.biodiversity.be, Balian et al. 2007) as well as their data exchange with international initiatives (e.g. Encyclopedia of Life – http://eol.org, Ocean Biogeographic Information System – OBIS – http://iobis.org, Global Biodiversity Information Facility – GBIF – http://gbif.org, LifeWatch – http://lifewatch.be). It is expected that these will provide benefits to RAMS in late 2015 – early 2016.

Spatial coverage

General spatial coverage: The RAMS area of primary interest is the Antarctic area corresponding to the water masses south of the Polar Front extending to the coasts of the Antarctic continent (Fig. 5). It also includes coverage oft he Sub-Antarctic area (waters from the Polar Front to the Subtropical Front , Fig. 5).

Below are the operational limits for RAMS data as presented on the SCAR-MarBIN website (see Fig. 5; more information can be found on the following doc file: http://scarmarbin.be/documents/RAMS_GeoScope.doc)

ANTARCTIC AREA:

- True northern limit: Antarctic Polar Front (or Antarctic Convergence, 48°S to 63°S, convenient average limit: 55°S).
- Operational northern limits:

South Atlantic:

- Between 60°W and 50°W: 57°S
- Between 50°W and 30°E: 50°S

Indian Ocean:

- Between 30°E and 80°E: 50°S
- Between 80°E and 150°E: 55°S

South Pacific:

- Between 150°E and 60°W: 60°S

SUB-ANTARCTIC AREA:

- True southern limit: the Antarctic Polar Front (48°S to 63°S, convenient average limit: 55°S)
- True northern limit: the northernmost limit of the Southern Ocean s.l., i.e. the northern limit of the extension of the Sub-Antarctic water masses, which corresponds to the (nearly) circumpolar Subtropical Front (30°S to 47°S, convenient average limit: 43°S).
- Operational northern limits for data:

South Atlantic and Indian Ocean:	- Between 60°W and 140°E: 43°S
Pacific Ocean:	- Between 140°E and 176°W: 48°S
	- Between 176°W and 80°W: 45°S
	- Between 80°W and 72°W: 41°S

Shapefiles for the RAMS Area of Interest can be downloaded at http://share.biodiversity.aq/Atlas/Resources/Geographic_Scope/Shapefiles/

Dataset description

Object name: The Register of Antarctic Marine Species
Character encoding: UTF-8
Format name: Darwin Core Archive format
Format version: 1.1
Distribution: http://ipt.biodiversity.aq/resource.do?r=rams
Publication date of data: 27/11/2014
Language: English
Metadata language: English
Date of metadata creation: 27/11/2014
Hierarchy level: Dataset

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