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Use of a mitochondrial COI sequence to identify species of the subtribe Aphidina (Hemiptera, Aphididae)

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Abstract

Aphids of the subtribe Aphidina are found mainly in the North Temperate Zone. The relative lack of diagnostic morphological characteristics has hindered the identification of species in this group. However, DNA-based taxonomic methods can clarify species relationships within this group. Sequence variation in a partial segment of the mitochondrial *COI* gene was highly effective for identifying species within Aphidina. Thirty-six species of Aphidina were identified in a neighbor-joining tree. Mean intraspecific sequence divergence in Aphidina was 0.52%, with a range of 0.00% to 2.95%, and the divergences of most species were less than 1%. Mean interspecific divergence within previously recognized genera or morphologically similar species groups was 6.80%, with a range of 0.68% to 11.40%, with variation mainly in the range of 3.50% to 8.00%. Possible reasons for anomalous levels of mean nucleotide divergence within or between some taxa are discussed.

Keywords

Hemiptera, Aphidinae, Aphidina, mitochondrial COI gene, intraspecific divergenuce, interspecific divergence, identification

Introduction

Aphids are globally important invasive agricultural pests (Foottit et al. 2006; Messing et al. 2007). The aphid subtribe Aphidina (Hemiptera: Aphididae: Aphidinae) contains approximately 670 described species worldwide (Remaudière and Remaudière 1997). Several of them are on the list of the most important agricultural pests, including *Aphis gossypii* Glover, *Aphis glycines* Matsumura, *Schizaphis graminum* (Rondani) and *Toxoptera citricidus* (Kirkaldy) (Blackman and Eastop 2000). The largest aphid genus *Aphis* includes 550 species, approximately 10% of the total number of known aphid species; the nominal subgenus *Aphis* contains more than 90% of these species.

Resolving species relationships within Aphidina has been hindered by the lack of variation in morphological features. In particular, species of *Aphis* lack diagnostic morphological characteristics. Although some species can be easily distinguished by a single diagnostic morphological trait, many of them cannot be separated morphologically. Consequently, many species have been grouped according to their gross morphological similarities. The resultant entities, known as "groups of species", have no taxonomic validity because they simply contain species that are difficult to tell apart morphologically.

Three such "groups of species", the black-backed, black and *frangulae*-like groups, have been described in Europe (Heie 1986; Stroyan 1984). Each of these groups is based on its similarity to a single polyphagous or oligophagous species, *Aphis craccivora, Aphis fabae* and *Aphis frangulae/gossypii*, respectively. Within these groups, it is still difficult to accurately identify some taxa (Coeur d'acier et al. 2007). Zhang and Zhong (1981) dealt with Chinese members of the *A. craccivora* complex, and divided them into six species and subspecies, *Aphis sophoricola* Zhang, *Aphis atrata* Zhang, *Aphis craccivora craccivora* Koch, *Aphis craccivora usuana* Zhang, *Aphis robiniae robiniae* Macchiati and *Aphis robiniae canavaliae* Zhang; however, Remaudière and Remaudière (1997) merged these six taxa into a single species, *A. craccivora* Koch. Zhang et al. (2010) studied the subspecies differentiation of *Aphis fabae* Scopoli based on morphological and genetic data analysis.

Because the identification of aphid species is often based on presumed host plant specificity, polyphagous or oligophagous species, such as *A. craccivora*, *A. fabae* and *A. frangulae/gossypii*, can easily be misidentified (Coeur d'acier et al. 2007). These types of taxonomic problems are universal in Aphididae. Therefore, the development of an accurate and quick method to identify aphids is essential for the timely detection of new invasive species and the prevention of severe crop losses.

A standard region of the mitochondrial gene that encodes cytochrome c oxidase I (*COI*) was originally used to identify unknown aphid specimens (Hebert et al. 2003a). Although its taxonomic utility is limited by the requirement for a complete database of voucher specimens which individuals can be compared with (Moritz and Cicero 2004; Will and Rubinoff 2004), DNA barcoding has nonetheless proven a useful tool for

taxonomists (Schindel and Miller 2005). DNA taxonomy has successfully identified cryptic species in a diverse range of taxa (Brown et al. 2003; Ball and Hebert 2005; Barrett and Hebert 2005; Foster et al. 2004; Hogg and Hebert 2004; Monaghan et al. 2005; Cardoso and Vogler 2005; Ward et al. 2005; Vences et al. 2005; Clare et al. 2007) and has been especially useful for identifying aphid species (Foottit et al. 2008; Wang and Qiao 2009).

In this paper, we attempt to clarify some of the current taxonomic confusions and previously obscure species relationships within Aphidina. The variation in a short mitochondrial *COI* gene sequence that we found was used. Its utility was assessed as a method to accurately and quickly identify an assemblage of mainly Chinese aphids at the species level.

Materials and methods

Taxon sampling and data collection

We examined 198 *COI* sequences; 143 sequences were extracted from Chinese samples, and 55 sequences of European and North American samples were downloaded from GenBank. The ingroup included 176 Aphidina specimens from 36 species (subspecies) (34 species after revision) and 9 genera (subgenera). The outgroup was composed of 22 sequences from 5 species of 2 genera in the sister subtribe Rhopalosiphina (6 sequences), 7 species of 6 genera in Macrosiphini (12 sequences); and 4 species of 4 genera in Fordinae (4 sequences).

Three subgenera of the genus *Aphis* from the Palaearctic region were represented in our samples, namely *Aphis*, *Bursaphis* and *Protaphis*. Two recognized major "groups of species", the black-backed and *frangulae*-like aphids, and some morphologically distinct species (including *Aphis spiraecola*, *Aphis nerii* and *Aphis farinosa*) were also examined.

Collection information for all samples, including locations, host plants and collection dates, are shown in Appendix 1. Except for specimens for slide-mounting that were stored in 70% ethanol, all other specimens were stored in 95% or 100% ethanol. All samples and voucher specimens were deposited in the National Zoological Museum of China, Institute of Zoology, Chinese Academy of Sciences, Beijing, China.

About 143 samples including many individuals, one to three individuals per sample were isolated DNA for molecular studies, and three to five individuals per sample were made to slide-mounted specimens for morphological examination. Voucher specimens of all samples were identified from their main morphological diagnostic features, and compared with previously identified specimens. The species name of each sample has been provided in Appendix 1. *Aphis asclepiadis* Fitch was identified from the description of Zhang and Zhong (1983), and by comparison with their specimens.

DNA extraction, PCR and sequencing

Total DNA was isolated from one to three individuals per sample, followed by a standard phenol-chloroform-isoamylalcohol (PCI) extraction with some modifications (Sambrook et al. 1989). Polymerase chain reaction (PCR) was used to amplify a 1250–1300 base pair (bp) segment of the mitochondrial *COI* gene. There were two primer pairs, including two forward primers and one reverse primer. LCO1718 (Simon et al. 1994) was one of the forward primers. We designed the other forward primer (5'-TATATCTTTCCCACGATTAAATAA-3') and the reverse primer (5'-GCATATTAATTCTGCCATATTAG-3'). Each PCR contained 5 μL of 10× PCR buffer at pH 8.3 (10 mmol/L of Tris HCl at pH 8.3, 1.5 mmol/L of $MgCl_2$, 50 mmol/L of KCl, 0.01% NP-40), 1 μL of 10 pmol/L of each dNTP (C, G, A, T) (Takara Biotech, Dalian, China), 2 μL of 10 μmol/L of each primer, 1.0 U (1 U≈16.67 nkat) of Taq DNA polymerase (Sangon Biotech, Shanghai, China) and 2 μL of the DNA template. The reaction was performed using a GeneAmp PCR System 9700 (Applied Biosystems, USA) under the following conditions: 95°C for 5 min; 35 cycles at 94°C for 1 min, 48–54°C for 1 min, 72°C for 1 min; and a final extension step of 10 min at 72°C. These two primer pairs worked well for all species examined.

Sequencing reactions were performed with the corresponding amplifying primers from both directions using a BigDye Terminator Cycle Sequencing Kit v.2.0 (Applied Biosystems, USA) and run on an ABI 3730 automated sequencer (Applied Biosystems, USA).

Assembling and aligning sequences

To obtain single consensus sequences, chromatograms, including sense and antisense, were analyzed and assembled using the Seqman module of the DNAStar* 5.0 software package (DNASTAR, Inc.1996). We checked the accuracy of the nucleotide sequences by confirming that they could be translated into proteins by using Editseq (DNASTAR, Inc. 1996). Sequences were deposited in GenBank under Accession Nos. FJ965596–FJ965749.

Aphid species' *COI* profiles

COI profiles were obtained from a neighbor-joining (NJ) tree with Kimura-2-parameter (K2P) distances created using MEGA3.1 (available at http://www.megasoftware.net). The K2P model provides the best metric when genetic distances are low (Nei and Kumar 2000). We used a simple NJ algorithm to identify species based on sequence similarity rather than reconstruct deeper phylogenetic relationships using NJ analysis.

Data analysis

The sequences were manually aligned with the Bioedit sequence editor (Hall 1999), and the alignment was subsequently pruned to 1145 bp. To obtain a more comprehensive range of *COI* sequences, we combined the 591 bp *COI* sequences from Chinese specimens with the downloaded sequences. Nucleotide-sequence divergences were calculated using Kimura's two-parameter model (Kimura 1980). Based on K2P distances, we obtained intraspecific sequence divergences for all species sequences from more than two individuals. When a single species had sequences from several individuals, one sequence was randomly chosen to represent that species. K2P divergences for all congeneric species pairs were studied and plotted as a frequency histogram. The mean intra- and interspecific K2P divergences were calculated as the overall mean of all pairwise comparisons within each species and genus, respectively.

Results

Data analysis

Including outgroups, 52 species were identified among the 198 taxa examined. Of the 591 bp that were analyzed, 373 were conserved, 218 were variable and 191 were parsimony-informative; 404 sites were constant, 187 were variable and 164 were parsimony-informative for ingroups only. These sequences were heavily biased toward A and T nucleotides (means: T = 39.4%, C= 13.9%, A = 34.5%, G = 12.2%).

Taxonomic assignments and NJ tree structure

In the NJ tree (Fig.1a–d), most of the aphid species and subspecies included in our NJ profile possessed a distinct *COI* sequence. Although the *Cryptosiphum artemisiae* Buckton clustered with Macrosiphini and *Swirskiaphis bambuciepula* Zhang was embedded within Rhopalosiphina, all other Aphidina specimens formed a cohesive group. The Rhopalosiphina appear to be a monophyletic sister group to Aphidina, whereas the Macrosiphini and Fordinae are rooted and clustered, separately.

Within Aphidina, two subgenera (*Bursaphis* and *Protaphis*) and the three recognized "groups of species" within the subgenus *Aphis* all formed separate, cohesive clusters. However, the species from the subgenus *Aphis* did not cluster together but were divided into the following six main clades: 'black-backed species', 'black species' '*frangulae*-like species', '*spiraecola*-like species', *A. nerii* and *A. farinosa*. *A. nerii* and A. *asclepiadis* (=*Aphis nerii*) cluster together, and with lower nucleotide divergence (0.00%–0.17%).

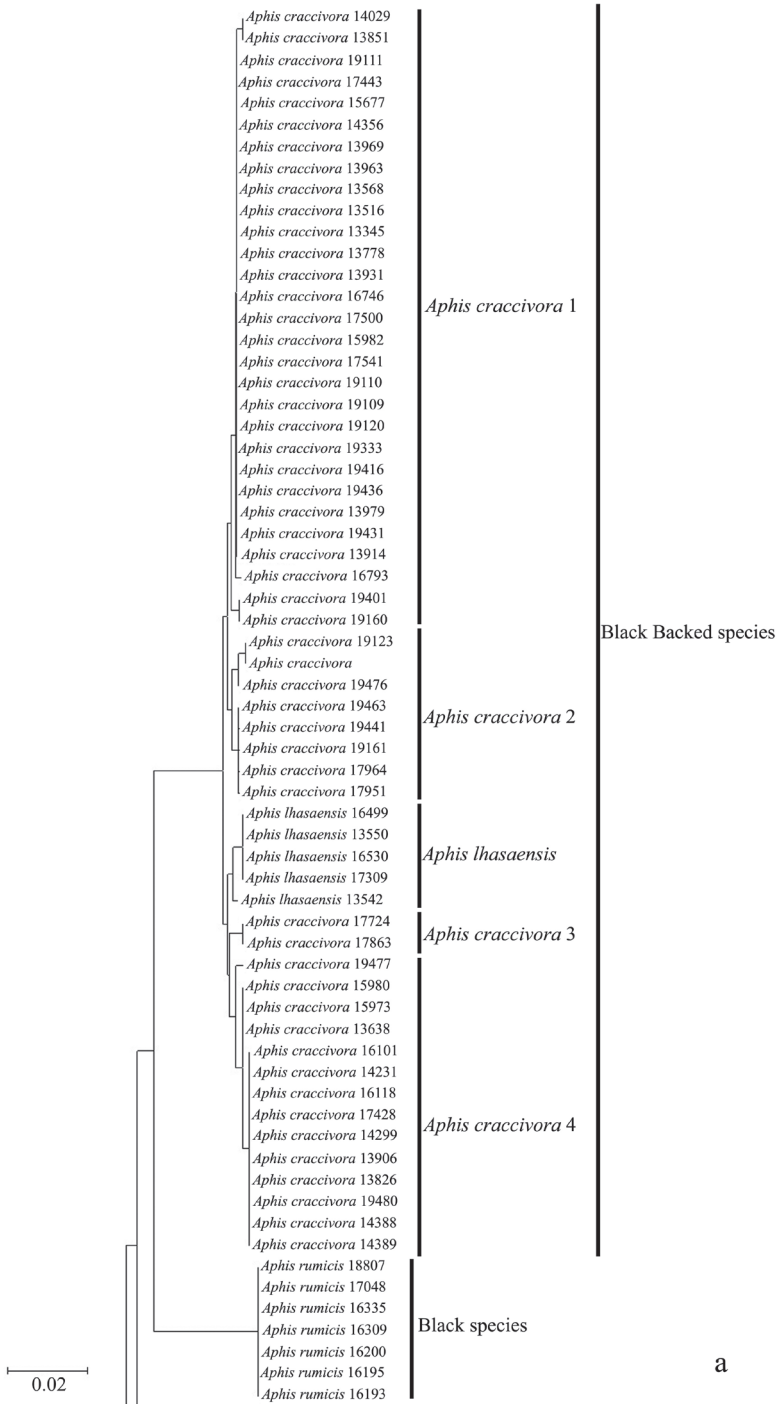

Figure 1a. Neighbor-joining analysis of 198 specimens. It was based on *COI* sequence divergence in 591 bp of the *COI* gene using Kimura's two parameter model.

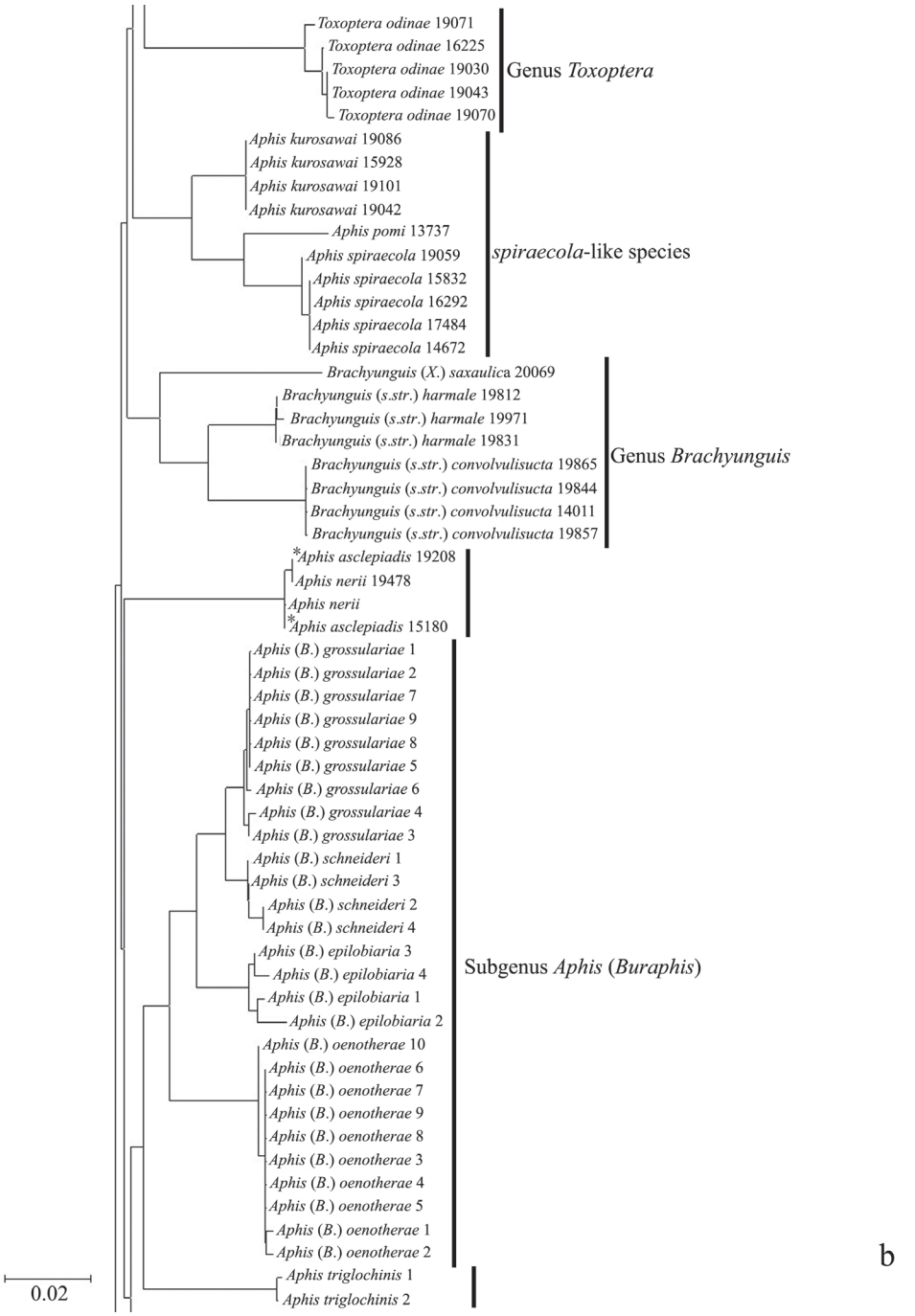

Figure 1b. Neighbor-joining analysis of 198 specimens. It was based on *COI* sequence divergence in 591 bp of the *COI* gene using Kimura's two parameter model. * They were originally misidentified as *Aphis asclepiadis* Fitch; actually, should be *A. nerii* Boyer de Fonscolombe.

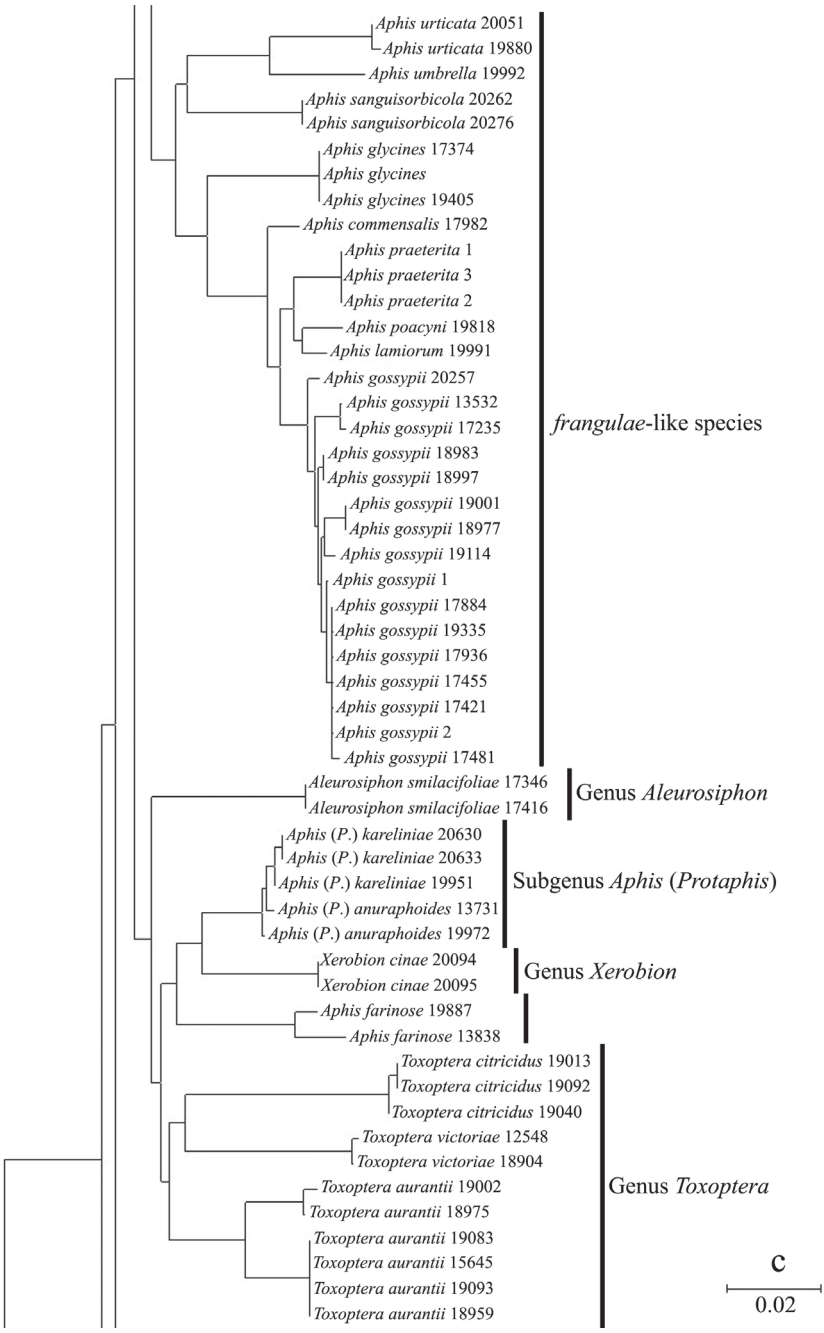

Figure 1c. Neighbor-joining analysis of 198 specimens. It was based on *COI* sequence divergence in 591 bp of the *COI* gene using Kimura's two parameter model.

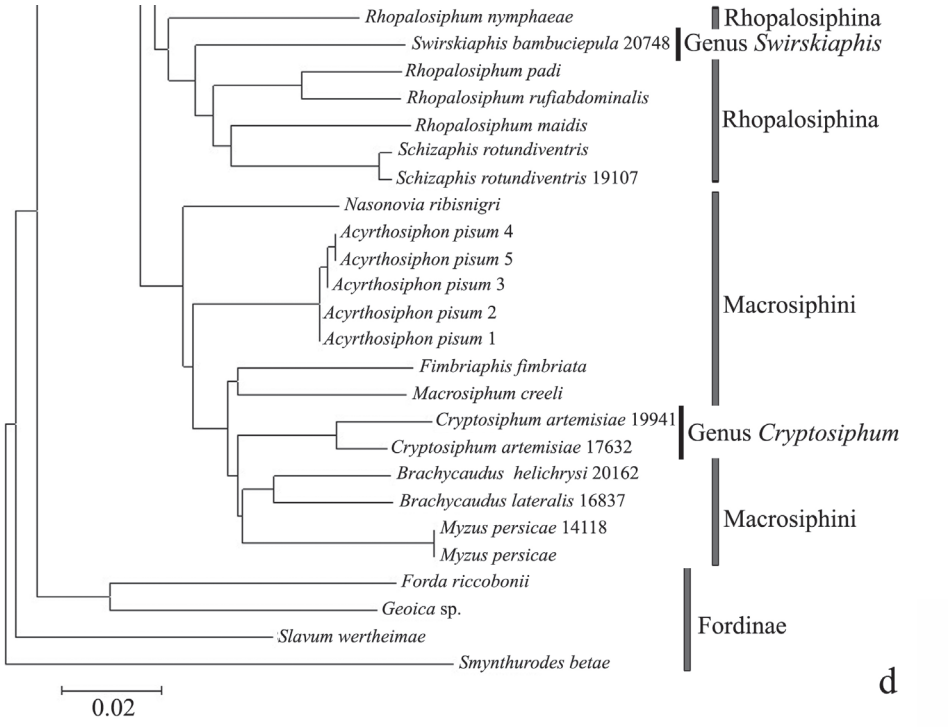

Figure 1d. Neighbor-joining analysis of 198 specimens. It was based on *COI* sequence divergence in 591 bp of the *COI* gene using Kimura's two parameter model.

The genus *Toxoptera*, represented in our sample by sixteen individuals from four species, did not cluster together but was separated into three clades. Although six individuals of *T. aurantii* formed a cohesive group, two subgroups were apparent.

Nucleotide diversity

Among 19,503 pairwise combinations in 198 specimens, the mean *COI* divergence was 6.99%, with a range of 0.00% to 17.56%, and most nucleotide divergence ranged from 0.00% to 1.75% and 3.75% to 13.00%.

Omitting *Cryptosiphum artemisiae* and *Swirskiaphis bambuciepula*, the mean *COI* divergence among the 14,878 species pairs placed within Aphidina by Remaudière and Remaudière (1997) was 6.10%, with a range of 0.00% to 11.40% (Fig. 2). These results indicate that the average intraspecific sequence divergence in Aphidina is 0.52%, with a range of 0.00% to 2.95% (Table 1), and the average interspecific divergence is 6.80%, with a range of 0.68% to 11.40% (Table 2).

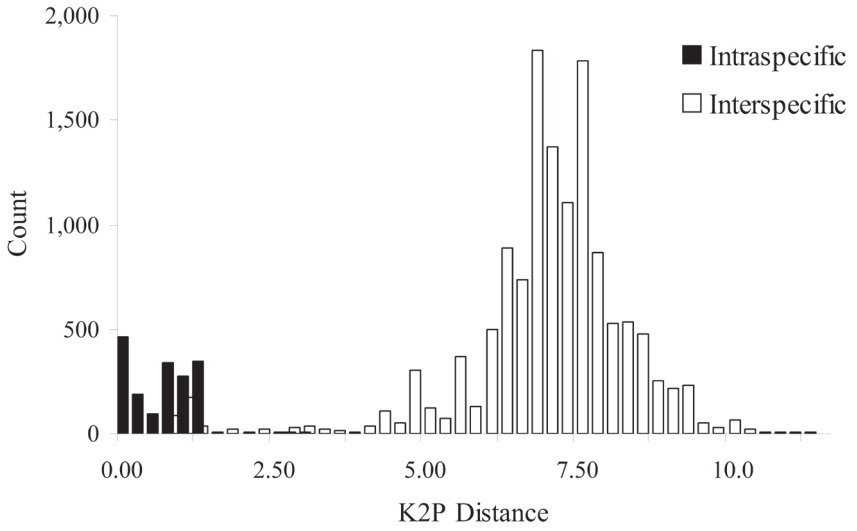

Figure 2. Histogram of intra- and interspecific nucleotide divergence in Aphidina. Divergences were calculated by using Kimura's two parameter (K2P) model.

Table 1. Mean and range of intraspecific nucleotide divergences for Aphidina species. Data were estimated by using Kimura's two parameter model.

Species	No. of individuals	Mean percent divergence %	Range %	SD %
Aphis craccivora	53	0.55	0.00–1.20	0.40
Aphis craccivora 1*	29	0.08	0.00–0.51	0.13
Aphis craccivora 2*	6	0.26	0.00–0.51	0.23
Aphis craccivora 3*	2	0.00	0.00	/
Aphis craccivora 4*	14	0.12	0.00–0.51	0.16
Aphis lhasaensis	5	0.14	0.00–0.34	0.18
Aphis farinosa	2	1.54	1.54	/
Aphis glycines	3	0.00	0.00	0.00
Aphis gossypii	16	0.53	0.00–1.37	0.39
Aphis kurosawai	4	0.11	0.00–0.17	0.00
Aphis asclepiadis	2**	0.17	0.17	/
Aphis nerii	2	0.17	0.17	/
Aphis praeterita	3	0.20	0.00–0.51	0.26
Aphis rumicis	7	0.00	0.00	0.00
Aphis sanguisorbicola	2	0.00	0.00	/
Aphis spiraecola	5	0.07	0.00–0.17	0.09
Aphis triglochinis	2	0.17	0.17	/
Aphis urticata	2	0.17	0.17	/
Aphis (*B.*) *epilobiaria*	4	0.82	0.34–1.19	0.33
Aphis (*B.*) *grossulariae*	9	0.14	0.00–0.51	0.14

Species	No. of individuals	Mean percent divergence %	Range %	SD %
Aphis (*B.*) *oenotherae*	10	0.10	0.00–0.34	0.11
Aphis (*B.*) *schneideri*	4	0.23	0.00–0.34	0.18
Aphis (*P.*) *anuraphoides*	2	0.17	0.17	/
Aphis (*P.*) *kareliniae*	3	0.11	0.00–0.17	0.10
Aleurosiphon smilacifoliae	2	0.00	0.00	/
Brachyunguis convolvulisucta	4	0.00	0.00	0.00
Brachyunguis harmalae	3	0.11	0.00–0.17	0.10
Cryptosiphum artemisiae	2	2.95	2.95	/
Toxoptera aurantii	6	1.50	0.00–2.95	1.41
Toxoptera citricidus	3	0.11	0.00–0.17	0.10
Toxoptera odinae	5	0.37	0.00–0.85	0.29
Toxoptera victoriae	2	0.17	0.17	/
Xerobion cinae	2	0.00	0.00	/
All	169	0.52	0.00–2.95	0.44

*intraspecific clades.

** The two samples were originally misidentified as *Aphis asclepiadis* Fitch; actually, they should be *A. nerii* Boyer de Fonscolombe.

Table 2. Interspecific nucleotide divergences for species in 9 genera or "groups of species" in Aphidina. Data were estimated by using Kimura's two parameter model.

Groups	No. of species (individuals)	Mean percent divergence %	Range %	SD %
Black backed species	5* (58)	0.83	0.51–1.20	0.18
Black backed species	2 (58)	0.80	0.68–1.20	0.09
spiraecola-like species	3 (10)	3.85	3.31–4.55	0.32
frangulae-like species	9 (30)	4.90	1.20–8.91	2.16
Aphis (*Protaphis*)	2(5)	0.54	0.34–0.68	0.13
Aphis (Buraphis)	4 (27)	3.40	0.85–4.41	1.05
Brachyunguis	3 (8)	5.01	3.84–6.97	1.49
Toxoptera	4 (11)	6.83	2.59	2.11
All (revised)	32* (173)	6.80	0.68–11.4	1.45

* No. of clades.

Discussion

As expected from previous DNA studies of aphids (Shufran et al. 2000, Anstead et al. 2002, Favret and Voegtlin 2004, von Dohlen 2000, von Dohlen et al. 2002, 2006, Zhang and Qiao 2007ab, Foottit et al. 2008, Kim and Lee 2008, Wang and Qiao 2009), the DNA sequences we used were heavily biased towards the nucleotides A and T. Nonetheless, we found that the variation in a partial segment of the mitochondrial *COI* gene can be used to identify species within Aphidina.

Sequence divergences within and among species

The magnitude of *COI* divergence varies among different animal groups. Hebert et al. (2003b) found that *COI* divergence among 13,320 species in 11 families ranged from 0.0% to 53.7%. Most pairs (79%) showed over 8% sequence divergence, and most species pairs (98%) had over 2% sequence divergence. Our data indicate that the mean *COI* divergence within Aphidina is 6.10%, with a range of 0.00% to 11.40%.

This degree of intraspecific divergence is similar to that found in other animal taxa. For example, treating the provisional species as separate taxa, the 0.52% intraspecific variation we found in Aphidina is comparable to values reported for other taxa, such as 0.27% in North American birds (Hebert et al. 2004b), 0.39% in marine fish (Ward et al. 2005), an average value of 0.60% in Guyanese bats (Clare et al. 2007), 0.46% in Lepidoptera (Hajibabaei et al. 2006), 0.11% in North American mayflies (Ball et al. 2005) and 0.14% in spiders (Barrett and Hebert 2005).

The six specimens assigned to the species *Toxoptera aurantii* (Boyer de Fonscolombe) were divided into two different clades, with divergences ranging from 2.59% to 2.95%, far higher than those between the other Aphidina species. This result indicated that *T. aurantii* probably contains cryptic species, but we did not find any distinct morphological differences after checking the specimens. These results were consistent with the conclusions of Wang and Qiao (2009).

Omitting *Cryptosiphum artemisiae*, which should be moved into the tribe Macrosiphini (Kim and Lee 2008), and *Swirskiaphis bambuciepula* (see below), the mean sequence divergence among Aphidina species was 6.80%. This divergence is similar to those reported in other animal groups, for example, 7.93% in North American birds (Hebert et al. 2004b), 9.93% in marine fish (Ward et al. 2005), an average value of 7.8%±4.78% in Guyanese bats (Clare et al. 2007) and 4.58%, 4.41% and 6.02% in Lepidoptera (Hajibabaei et al. 2006).

However, mean divergences among the black-backed "groups of species" and the two species of *Aphis* (*Protaphis*) ranged from 0.34% to 0.85%, far lower than that between the other Aphidina groups, and the divergence between *Aphis* (*Bursaphis*) *grossulariae* Kaltenbach and *Aphis* (*B.*) *schneideri* (Börner) was also unusually low (0.85%).

Systematic status of some taxa

Pairwise *COI* sequence divergence among congeneric animal species is generally over 2% (Hebert et al. 2003b). Lower interspecific divergences are unusual in other animal groups but are often found in Aphidina. For instance, some clearly distinct species in the genera *Aphis* and *Illinoia* exhibited divergences of less than 1% (Foottit et al. 2008).

Evidence for host races within *Aphis craccivora*

In our NJ tree, *A. craccivora* was divided into four clades and clustered together with *A. lhasaensis* Zhang. Pairs of clades in this group had *COI* sequence divergences ranging from 0.51% to 1.20% (mean=0.83%), lower than the interspecific divergences of the other aphids. *A. lhasaensis* was found in Tibet, infesting subterranean parts of *Astragalus sinicus* L. (Fabaceae). It is similar to *A. craccivora*, except that its abdominal segments II–IV have large marginal tubercles. Our results suggest that *A. lhasaensis* should be regarded as a Tibetan subspecies of *A. craccivora* rather than a separate species. Two of the four clades of *A. craccivora* showed some evidence of association with different host plants in the same family Fabaceae, indicating the presence of host-adapted races in Chinese populations of this species. In particular, 13 out of 14 samples collected from *Robinia pseudocacia* were of clade 1, and 12 out of 22 samples of *Sophora japonica* were of clade 4.

The Chinese record of *A. asclepiadis* Fitch should be referred to *A. nerii* Boyer de Fonscolombe

Zhang and Zhong (1983) recorded *A. asclepiadis* Fitch in China, and on the basis of their record and description, two samples were identified as this species. The *COI* sequence of these samples was found to be similar or identical to that of *Aphis nerii*; and on subsequent re-examination of slide-mounted specimens, they were identified as this species, which feeds on both Asclepiadaceae and Apocynaceae. The record of *A. asclepiadis* Fitch in China is therefore based on a misidentification of *A. nerii*.

***Swirskiaphis bambuciepula* Zhang and Zhang should be in Rhopalosiphina**

Swirskiaphis was erected by Hille Ris Lambers (1966) for a species on Umbelliferae in western Asia related to *Aphis* but with long thick dorsal hairs. Zhang and Zhang (2000) described a second species in this genus, *S. bambuciepula* on *Phyllostachys* sp. (Gramineae) from Gansu Province, China. In this study, this species was embedded within Rhopalosiphina based on *COI* sequences. By checking the type of the species, and comparing with original description and figures of the type species, *S. polychaeta* Hille Ris Lambers (1966), some morphological features indicated the species should not be in genus *Swirskiaphis*. The dorsal setae on abdominal tergites are distinctly fewer, about half as long as in the type species; the processus terminalis is more than twice as long as the base of the last antennal segment; the marginal tubercles on abdominal tergite VII are placed above the level of spiracular pore; and the host plant is in a different family. Two very important diagnostic features, the position of the marginal tubercles on abdominal tergite VII and the length of the processus terminalis indicate that the species should be in Rhopalosiphina, not in Aphidina; and it seems likely that this species belongs in *Melanaphis*. Further studies with more specimens are needed in order to decide the generic placement of this species within Rhopalosiphina.

Conclusion

Mean intraspecific sequence divergence in Aphidina was 0.52%, with a range of 0.00% to 2.95%, and the divergences of most species were less than 1%. The mean interspecific divergence with Aphidina was 6.80%, with a range of 0.68% to 11.40%, and most genera were in the range of 3.50% to 8.00%. A short *COI* sequence proved to be very useful for the identification of species within Aphidina. However, more specimens and DNA sequences are required to solve the remaining problems in classification and phylogeny.

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RESEARCH ARTICLE

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New species, new records and new morphological characters of the genus *Tillicera* Spinola from China (Coleoptera, Cleridae, Clerinae)

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Abstract

Two new species of the genus *Tillicera* Spinola, 1841 from China are described and illustrated: *Tillicera sensibilis* **sp. n.** from Yunnan (also from Myanmar, Thailand and Laos) and *Tillicera wenii* **sp. n.** from Taiwan. *Tillicera bibalteata* Gorham, 1892, *T. hirsuta* (Pic, 1926) and *T. michaeli* Gerstmeier & Bernhard, 2010 are newly recorded from China. *Tillicera auratofasciata* (Pic, 1927) is newly recorded in some provinces of China. A key to species of the genus from China is provided. Relationships between species are discussed with emphasis on characters of male phallus, female internal reproductive organs and pit-like sensilla in male terminal antennomere, which is discovered in *Tillicera* for the first time. The present generic definition of *Tillicera* is discussed as well. Photos of terminalia of the previously known species are also provided for comparison.

Keywords

Coleoptera, Cleridae, *Tillicera*, China, new species, sensillum

Introduction

Fifteen species of the oriental genus *Tillicera* Spinola, 1841 were recognized by Gerstmeier and Bernhard (2010) whose thorough generic revision, with the exception of *T. assamensis* Stebbing, 1907 from Assam, India, was based on first hand examination of primary types. Two species occur in China: *T. auratofasciata* (Pic, 1927) from Xizang and *T. cleroides* Gorham, 1892 from Yunnan. In the course of our studies of material from several major Chinese collections and additionally some European museums, two new species were discovered: *Tillicera sensibilis* sp. n. from Yunnan (also from Myanmar, Thailand and Laos) and *Tillicera wenii* sp. n. from Taiwan; both of which exhibiting a similar habitus to that of *T. auratofasciata* (Pic, 1927), *T. javana* Spinola, 1844 and *T. soror* Schenkling, 1902, but with significantly different aedeagi. Furthermore, new distribution records of some previously known species were found.

Gerstmeier and Bernhard (2010) did not separate the tegmen and phallus, and thus some systematically significant characters of the phallus were not quite clear. In the present study the tegmen and phallus are separated apart and fine structures of the phallus are carefully compared.

For the first time, high resolution color photographs of female internal reproductive organs of Cleridae are provided. The female internal reproductive organs of all the species from China are compared except for *T. wenii* due to a lack of specimens. And for the first time, pit-like sensilla on the male terminal antennomere in *Tillicera* is discovered (in dorsal view). Comparative photographs of this structure are presented for *T. auratofasciata* and the two new species described herein. The purpose of this paper is to describe two new species, present new distribution records for previously known species, discuss the relationships among species and the generic definition of the genus, and provide some new morphological characters which might better facilitate further systematic study of the genera related to *Tillicera* and *Clerus*.

Material and methods

Materials examined are deposited in the following collections; abbreviations as shown in the text:

CAU	China Agricultural University, Beijing, China
INCA	Insects collection of INCA Science Ltd., Chongqing, China
IZAS	Institute of Zoology, Chinese Academy of Sciences, Beijing, China
MCSN	Museo Civico di Storia Naturale, Genova, Italy
MHBU	Museum of Hebei University, Baoding, Hebei, China
MNHN	Muséum National d'Histoire Naturelle, Paris, France
NMNS	National Museum of Natural Science, Taiwan, China

NMPC National Museum, Prague, Czech Republic
RGCM Roland Gerstmeier Collection, Munich, Germany
SHNU Department of Biology, Shanghai Normal University, China
SWFU Southwest Forestry University, Kunming, China

Whole male abdomens were removed from the body with fine forceps, treated with 10% KOH solution at room temperature for 8–12 hours. Terminalia were prized apart, rinsed and examined in 70% ethanol, then photographed in glycerol and eventually stored within glycerol in genital vials which were pinned below specimens. Female internal organs were all dissected from dry specimens. The female specimens of *T. auratofasciata* and *T. sensibilis*, collected in 2009 and 2008 respectively, were killed by ethyl acetate then preserved in ethanol and pinned later. Whole female abdomens were removed from the body with fine forceps, treated with 10% KOH solution at room temperature for 12–16 hours. Female reproductive organs were prized apart, rinsed in 70% ethanol, stained with chlorazol black E saturated solution in 70% ethanol for 40 seconds, photographed in 70% ethanol then mounted on a plastic slide in euparal, which was pinned below specimens. Antennae were removed from the head (segments 3–11 of *T. auratofasciata* and *T. sensibilis*; 10–11 of *T. wenii*), treated with 10% KOH solution at room temperature for 48 hours and rinsed with water before being photographed.

Habitus images were captured using a Canon 450D digital camera with Canon Macro 100 mm lens; genitalia were captured by a Canon 450D digital camera fitted to a Nikon SMZ–1500 stereoscopic dissecting microscope; antennae were captured by a Nikon digital Sight DS–SM camera fitted to a Nikon SMZ–1500 stereoscopic dissecting microscope controlled by ACT–2U software. Series of partially focused photographs were taken and then combined using Helicon Focus software, and finally processed with Adobe Photoshop software. Line drawings of pronota were made from color photographs with the software Adobe Illustrator.

Measurements were made under a stereo microscope using an ocular micrometer. Body length is the linear distance from labrum to elytral apex. Body width is the maximum width across elytra. Lengths and widths of terminal antennomeres were measured as in Fig. 29.

Terminology mostly accorded with Ekis (1977). When describing the phallus, we do not consider the natural orientation, but define the dorsal face as the position where the median orifice (*sensu* Sharp and Muir 1912) opens, (and the opposite as the ventral face), and thus, each phallic plate has a dorsal margin and a ventral margin, and the membrane connecting the two ventral margin called phallic ventral membrane. The pulvillus of tarsomeres is abbreviated to P; for example 'P1' indicates pulvillus of the tarsomere 1, and 'pro-P1' indicates the pulvillus of the protarsomere 1 (clerids usually have pulvilli present on tarsomeres 1–4, while tarsomere 5 is slender and without a pulvillus).

Taxonomy

Key to species of *Tillicera* Spinola from China

1 Pronotum gradually narrowed after subapical depression, the widest part of the pronotum proper (*sensu* Ekis 1977) is in the extreme front (Fig. 3); anterior margin of pronotum with a band of dense, golden, decumbent setae ..... ***T. cleroides* Gorham**

– Pronotum swollen after subapical depression, the widest part of the pronotum proper (*sensu* Ekis 1977) is near the middle (Fig. 4); anterior margin of pronotum without a band of dense, golden, decumbent setae..... **2**

2 Elytra with two bands of golden decumbent setae, one just before middle, another near the apex, sometimes few additional sparse golden setae present at base; pro- and mesotibiae never with longitudinal carinae, metatibiae sometimes with indistinct rudiment of carinae..... **3**

– The middle golden or light yellow band on elytra split, forming a middle backward opened lunate band and two laterally transverse spots (Figs 1–2); the subapical band as in the previous species; all tibiae with distinct longitudinal carinae **5**

3 Elytral base with a distinct tuberosity, sometimes with some sparse golden setae around the tuberosity; integument from which the two bands of golden setae originate black..... ***T. michaeli* Gerstmeier & Bernhard**

– Elytral base without a distinct tuberosity, never with sparse golden setae either; integument from which the two bands of golden setae originates yellow..... **4**

4 Apex of elytra emarginate; elytral base with longitudinal rows of tubercles present on intervals..... ***T. hirsuta* (Pic)**

– Apex of elytra not emarginate; elytral base without such tubercles ..... ***T. bibalteata* Gorham**

5 The pattern-forming setae on elytra light yellow; meta-P1 evident but unlobed, meta-P2 distinctly bilobed in apex (Fig. 40); pit-like sensilla of male terminal antennomere smaller and deeper, indistinct in magnification 100× before treated with KOH solution (Fig. 31)..... ***T. wenii* sp. n.**

– The pattern-forming setae on elytra golden; Meta-P1 absent, meta-P2 just vestigeal and not clear (Fig. 39); pit-like sensilla of male terminal antennomere larger and shallower, clearly distinct in magnification 100× before treated with KOH solution (Figs 29–30, 32–33) **6**

6 Pubescence on metaepisternum and metasternum yellow, almost as thick as golden decumbent setae on elytra; metaepisternum black, at least the lateral part of metasternum black; length to width ratio of terminal antennomere of both sexes < 1.5 (Fig. 29)..... ***T. auratofasciata* (Pic)**

– Pubescence on metaepisternum and metasternum white, distinctly far thinner than light yellow decumbent setae on elytra; metasternum and metaepis-

ternum always earth-yellow; length to width ratio of terminal antennomere of both sexes > 1.5 (Fig. 30) ..... ***T. sensibilis* sp. n.**

***Tillicera auratofasciata* (Pic, 1927)**
http://species-id.net/wiki/Tillicera_auratofasciata
Figs 5–12, 29, 32, 34–37

Pseudoclerops auratofasciata Pic, 1927: 8 (Chapa, N Vietnam).
Tillicera auratofasciata: Pic, 1934: 133.

Diagnosis. Distinguishable from superficially similar specimens of *T. sensibilis* by body stouter (length to width ratio of elytra: male about 2.04, female 2.11), length to width ratio of terminal antennomere of both sexes evidently below 1.5, metaepisternum black, at least the lateral part of metasternum black, pubescence on metaepisternum and metasternum yellow and almost as thick as golden decumbent setae on elytra, dorsal sinus of tegmen triangular, ventral sinus digitiform, and dorsal margin of phallus with large denticles extending from anterior half to posterior sclerotized area; and distinguishable from *T. wenii* by pattern-forming setae on elytra more gold colored, metaepisternum black, at least the lateral part of metasternum black, pubescence on metaepisternum and metasternum yellow and almost as thick as golden decumbent setae on elytra, meta-P1 absent and meta-P2 just vestigeal, pit-like sensilla of male terminal antennomere larger and shallower (distinct in magnification 100× before treated with KOH solution) (Figs 29, 32), paramere not pointed, dorsal sinus triangular, ventral sinus digitiform.

Supplemental description. Elytra: Length to width ratio: male about 2.04, female about 2.11.

Terminal antennomere: Length to width ratio of both sexes below 1.5; male with a shallow pit-like sensillum present at basal third, diameter 0.08 mm (clearly distinct in magnification 100× before and after treated with KOH solution) (Figs 29, 32).

Male terminalia: Ratio of length of paramere to whole tegmen 0.17: 1, paramere thumb-like in dorsal view, dorsal sinus triangular, ventral sinus digitiform (Figs 5–6); phallic plate with large denticles along dorsal margin and fine granular structures on posterior sclerotized area (denticles extending from anterior half to posterior sclerotized area; number of denticles can vary between left and right phallic plate and between individuals but whole length of denticles is consistent) (Figs 7–8, 12); phallic ventral membrane with one line of file-like structures on each side (Fig. 7); spicular fork (Fig. 9); tergum VIII (Fig. 10), sternum VIII (Fig. 11).

Female reproductive organs: Vagina swollen, base of bursa copulatrix narrower than posterior end of vagina; swollen zone between vagina and spermathecal duct larger than that in *T. sensibilis*; length of bursa copulatrix three times as long as spermatheca; spermathecal gland attached to basal fourth of spermatheca (Figs 36, 37); both dorsal and ventral lamina of ovipositor undivided (Figs 34, 35).

Distribution. China: Yunnan (new record), Guangxi (new record), Hainan (new record), Xizhang; Thailand; Laos; Vietnam.

Material examined. Lectotype designated here: female, "Type [printed]/Type [handwritten by Pic]/Tonkin, Chapa, 27.VI.1918, Jeanvoine/*Pseudoclerops auratofasciatus* n. sp. [handwritten by Pic]/*Tillicera auratofasciatus* Pic/Museum Paris, Coll. M. Pic/HOLOTYPE *Tillicera auratofasciata* (Pic, 1927), Revision 2009, Gerstmeier & Bernhard" (MNHN).

Remarks. The name-bearing type was not fixed in the original publication and there was no imply how many type series was. For the purpose to fix the name-bearing type, the lectotype is designated here, which is the same specimen noted as "holotype" in Gerstmeier & Bernhard (2010).

Other material examined. China: 1 male, Yunnan, Xishuangbanna, Cheli, Shihuiyao, alt. 700m, 1957.IV.27, leg. WANG Shuyong (IZAS); 1 female, Yunnan, Xishuangbanna, Mengla, alt. 620–650m, 1959.V.20, leg. ZHANG Facai (IZAS); 1 female, Yunnan, Xishuangbanna, Mengla, Menglun, No. 55 area, 21.9650°N, 101.2099°E, ca 630m, 2009.VIII.2, leg. SHI Hongliang, by beating (IZAS); 1 female, Yunnan, Nabanhe N.R. Xiaonuoyouxiazhai, alt. 1700m, 2009.V.8, leg. HU Jiayao & YIN Ziwei (SHNU); 1 male, Guangxi, Luocheng, Yuxi station, alt. 400—700m, 2003.VII.29–31, leg. YANG Xiujuan (MHBU); 1 female, Hainan, Jianfengling Nature Reserve, 2007.V, leg. DING Liang (IZAS).

Vietnam: 1 female, Tonkin, Mt. Bavi, alt. 800–1000m, 1941.VII, leg. A. De Cooman (IZAS); 2 females, Tonkin, Hoa–Binh, leg. A. De Cooman (IZAS); 1 male, Tam Dao, 930m, Vinh Phu Prov., N. Vietnam, 1~8–V–1998, Y. Arita leg.(MNHN); 2 females, Tam Dao, Vinh Phu Pro., N. Vietnam, Apr. –7 May 1996, Native leg. (MNHN); 1 male, Cuc Phuong, Ninh Binh Prov., N. Vietnam, 5–VI–1997, Y. Okushima leg. (MNHN); 1 male, TamDao, N. Vietnam, VIII. 1999 (RGCM); 1 male, N-Vietnam, Tam Dao, V.90, Dembicky leg. (RGCM); 1 male, 1994.May.2—8, TamDao, (N. Vietnam), local-col. (RGCM); 1 female, Mt. Tam Dao, Vinh Phu, N. Vietnam, V. 1998 (RGCM).

Thailand: 1 male, N. Thailand, Meo Village, near Chiang Mai, V. 1988 (RGCM); 1 female, Mt. Doi Pui, 1400–1500m, Chiang Mai, N. Thailand, 22.V.1982, T. Shimomura leg. (MNHN); 1 female, Thailand, Chiangmai, Doi Pui, 26.V.1985 (RGCM); 1 female, N. Thailand, Doi Inthanon Nat. Res., 1250m, 22—31.V.2008, S. Murzin leg.

Laos: 1 male, Laos, Umg. Vientiane, III.—VI.1963 (RGCM);

***Tillicera sensibilis* G.Y. Yang & X.K. Yang, sp. n.**

urn:lsid:zoobank.org:act: B341B5D4-FDEE-4E60-B2BE-01A560A4F6C1

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

Figs 1, 4, 13–20, 30, 33, 38, 39

Holotype male. China, Yunnan, Yingjiang, Tongbiguan, Jianbian, Jingzhuzhai, 24.6119°N, 97.6153°E, ca 1420m, 2008.VI.4, leg. SHI Hongliang, by light trap.

Specimen pin mounted; locality label (original in Chinese); label with information on dissecting number (56#), dissector and date; holotype label; plastic vial with abdomen and aedeagus (IZAS). **Paratypes**. **China**: 2 males, 4 females, same locality data as holotype (1 male preserved in RGCM, others in IZAS); 1 male, Yunnan, Yingjiang, Xima, Menglai River second class hydroelectric power station, 24.7840°N, 97.6749°E, ca 1470m, 2008.VI.6, leg. SHI Hongliang, by light trap (IZAS); 1 female, same data but 2009.V.27–29, leg. ZHANG Weiwei (INCA); 1 male 1 female, Yunnan, Ruili, Dengga to Mafengshan, 23.9529°N, 97.5981°E–23.9449°N, 97.5565°E, alt. 927–1207m, 2009.VIII.10, leg. SHI Hongliang, by beating (IZAS); 1 female, Yunnan, Yongde, Daxueshan, Manlai, Huataoshu, 1520m, 2002.VI.17, leg. SONG Jinxin (SWFU); **Myanmar:** 1 male, Carin Chebà, 900—1000m, L. Fea V XII—88/Museum Paris, ex. Coll. R. Oberthur (MNHN; dissected); 1 male, Carin Chebà, 900—1100m, L. Fea V XII—88 (MCSN; dissected); **Thailand:** 1 male, Mt. Doi Pui, 1400—1500m, Chiang Mai, N. Thailand, 13–V–1982, T. Shimomura leg. (MNHN; dissected); 1 female, same data but 16–V–1982 (MNHN); 1 male, Thailand, Chiangmai, Doi Pui, 26.V.1985 (RGCM; dissected); 1 famale, same data but 14.V.1985 (RGCM); 1 female, Thailand, Soppong Pai, 1—8.V.1993, Pacholatko & Dembicky leg. (RGCM); Laos: 1 female, LAOS-NE, Houa Phan prov., 20°12-13.5'N, 103°59.5'-104°01'E, Ban Saluei→Phou Pane Mt., 1340—1870m, 15.iv.-15.v.2008, Lao collectors leg. (NMPC).

Diagnosis. Distinguishable from superficially similar specimens of *T. auratofasciata* by body slender (length to width of elytra: male about 2.37, female 2.16), length to width ratio of terminal antennomere of both sexes equal to or above 1.5, metaepisternum and metasternum earth-yellow, pubescence on metaepisternum and metasternum white and distinctly thinner than light yellow decumbent setae on elytra, yellow setal pattern on elytral apical third much narrowing towards suture, dorsal and ventral sinuses of tegmen oblong, and dorsal margin of phallus with large denticles extending from apical third towards apex; and distinguishable from *T. wenii* by pattern-forming setae on elytra more gold colored, meta-P1 absent and meta-P2 just vestigeal (Figs 39, 40), pit-like sensilla of male terminal antennomere larger and shallower [distinct in magnification 100x before treated with KOH solution] (Figs 30, 33), parameres parallel, with apex obtuse, dorsal and ventral sinuses oblong, and dorsal margin of phallus with large denticles extending from apical third towards apex.

Description. Size: male: length 6.8–8.2 mm; width 2.2–2.4 mm; female: length 8.4–9.5 mm; width 2.8–3.0 mm.

Head: Black; clypeus, labrum, labium, maxillae yellow-brown, apex of palpi darker; antennomeres 1–3 paler; cranium with slightly dense, fine punctation, each puncture bearing a yellow or black seta; terminal antennomere: length to width ratio of both sexes > 1.5, male with a shallow pit-like sensillum at basal third, diameter 0.06 mm (distinct in magnification 100× before and after treated with KOH solution) (Figs 30, 32).

Prothorax: Pronotum bicolored, anterior to subapical depression black, posteriorly orange; with dense punctation and anteriorly directed black and yellow setae; prosternum orange.

Mesothorax: Mesoscutelllum orange; mesosternum earth-yellow.

Metathorax: Metasternum and metaepisternum earth-yellow, pubescence on metaepisternum and metasternum white, distinctly far thinner than light yellow decumbent setae on elytra.

Elytra: Length to width ratio: male average about 2.37, female average about 2.16; integument tricolored, basal third orange, posterior two-thirds black; with a pair of lateral yellow maculae before middle, each distance from lateral margin to two-thirds way towards suture, matted with golden yellow, decumbent setae; behind two maculae, with a central backward opened lunate band formed of yellow decumbent setae (sometimes with a pale integumental spot in middle); apical third with another pair of yellow maculae, spanning from lateral margin to, or nearly to, suture, matted with golden yellow, decumbent setae, setal pattern narrowing towards suture; basal third regularly and deeply punctate in rows, diameter of punctures larger than intervals; inner two rows of elytral punctation fading away behind lunate band; basal third with erect, black setae (extreme base with some yellow setae), black part with posteriorly directed, black, decumbent pubescence (apical third mixed with some yellow setae).

Legs: Black, paler at base, paler part of profemora not longer than one tenth, of mesofemora not longer than one fourth, of metafemora not longer than half; with moderately dense, grayish yellow, erect setae; all tibiae with distinct longitudinal carinae; pro- and meso- P1–4 present, P1 evident but unlobed, P2 feebly lobed apically, P3–4 conspicuously lobed apically; meta-P1 absent, meta-P2 just vestigeal and not clear, meta- P3–4 conspicuously lobed apically (Fig. 39).

Abdomen: Black.

Male terminalia: Ratio of length of paramere to whole tegmen 0.26: 1, parameres parallel, apex obtuse, dorsal and ventral sinuses both oblong, latter broader and deeper (Figs 13–14); phallic plate with large denticles along dorsal margin and fine granular structures on posterior sclerotized area (denticles extending from anterior third to posterior sclerotized area; number of denticles may vary between left and right phallic plate and between individuals but whole length of denticles is consistent) (Figs 15–16, 20); phallic ventral membrane with one line of file-like structures on each side (Fig. 15); spicular fork (Fig. 17); tergum VIII (Fig. 18), sternum VIII (Fig. 19).

Female reproductive organs: Vagina swollen, base of bursa copulatrix narrower than posterior end of vagina; length of bursa copulatrix three times as long as spermatheca; swollen zone between vagina and spermathecal duct smaller than that in *T. sensibilis*; spermathecal gland attached to basal fourth of spermatheca (Fig. 38); both dorsal and ventral lamina of ovipositor divided.

Distribution. China: Yunnan; Myanmar; Thailand; Laos.

Etymology. The specific epithet *sensibilis* (= having the faculty of sensation) is a Latin adjective, referring to the presence of the pit-like sensillum in male terminal antennomere, which is first discovered in this species.

***Tillicera wenii* G.Y. Yang & X.K. Yang, sp. n.**
urn:lsid:zoobank.org:act:305CC980-F9AB-4949-A794-9C7808F2E992
http://species-id.net/wiki/Tillicera_wenii
Figs 2, 21–28, 31, 40

Holotype male. Taiwan, Taoyuen country, Mt. Lalashan, 1994.V.10, leg. CHOU Wen-I. Specimen adhibitted on rectangular board; locality label (original in Chinese); label with information on dissecting number (108 #), dissector and date; holotype label; plastic vial with abdomen and aedeagus (NMNS). **Paratype**. 1 male, Taiwan, Hualien County, Bilyu Divine Tree, 1995.VI.19, leg. CHOU Wen-I (IZAS).

Diagnosis. Distinguishable from superficially similar specimens of *T. auratofasciata* by pattern-forming setae on elytra paler, metasternum and metaepisternum earth-yellow, pubescence on metaepisternum and metasternum white and distinctly thinner than light yellow decumbent setae on elytra, meta-P1 evident and meta-P2 bilobed (Figs 39–40), pit-like sensilla of male terminal antennomere oblique, smaller and deeper (indistinct in magnification 100x before treated with KOH solution) (Figs 29, 31), paramere pointed; and distinguishable from *T. sensibilis* by pattern-forming setae on elytra paler, meta-P1 evident and meta-P2 bilobed (Figs 39–40), pit-like sensilla of male terminal antennomere oblique, smaller and deeper (indistinct in magnification 100x before treated with KOH solution) (Figs 30–31, 33), paramere pointed, dorsal and ventral sinuses both lanceolate, and dorsal margin of phallus with large denticles extending from basal half towards apex.

Description. Size: male: length 9.1–9.2 mm; width 2.5–2.6 mm; female: unknown.

Head: Black; clypeus, labrum, labium, maxillae yellow-brown, apex of palpi darker; antennomeres 1–4 paler; cranium with slightly dense, fine punctation, each puncture bearing a yellow or dark seta; terminal antennomere: length to width ratio > 1.5, males with an oblique and deep pit-like sensillum at basal third, diameter of opening 0.03 mm (indistinct in magnification 100x before treated with KOH solution) (Fig. 31).

Prothorax: Pronotum bicolored, anterior to subapical depression black, posteriorly orange, with some faint dark zones laterally; with dense punctation and anteriorly directed black and yellow setae; prosternum orange.

Mesothorax: Mesoscutelllum orange; mesosternum earth-yellow.

Metathorax: Metasternum and metaepisternum earth-yellow, pubescence on metaepisternum and metasternum white, distinctly far thinner than light yellow decumbent setae on elytra.

Elytra: Length to width ratio: male average about 2.30, female unknown; integument tricolored, basal two-fifths orange, posterior three-fifths black; with a pair of light yellow maculae before middle, each spanning from lateral margin to two-thirds way towards suture, matted with greyish yellow, decumbent setae; behind two maculae, with a central backward opened lunate band formed of yellow decumbent setae, more or less joining with anterior maculae; apical third with another pair of light yellow maculae,

spanning from lateral margin to, or nearly to, suture, matted with greyish yellow, decumbent setae, setal patterns broadly meeting at suture; basal two-fifths regularly and comparatively shallowly punctate in rows, diameter of punctures a little smaller than, or as wide as, intervals; inner four rows of elytral punctation fading away behind lunate band; basal two-fifths with erect, black setae (extreme base with some light yellow setae), black part with posteriorly directed, black, decumbent pubescence (apical third mixed with some light yellow setae as well).

Legs: Black, paler at base, paler part of profemora not longer than one tenth, of mesofemora not longer than one fourth, of metafemora not longer than half; with moderately dense, grayish yellow, erect setae; all tibiae with distinct longitudinal carinae; P1–4 of all legs present, P1 evident but unlobed, P2 feebly lobed apically, P3–4 conspicuously lobed apically (Fig. 40).

Abdomen: Black.

Male terminalia: Ratio of length of paramere to whole tegmen 0.37: 1, paramere pointed, dorsal and ventral sinuses both lanceolate, former broader and deeper (Figs 21–22); phallic plate with large denticles along dorsal margin and fine granular structures on posterior sclerotized area; spicular fork (denticles extending from anterior half to posterior sclerotized area; number of denticles may vary between left and right phallic plate and between individuals but whole length of denticles is consistent) (Fig. 23–24, 28); spicular fork (Fig. 25); tergum VIII (Fig. 26), sternum VIII (Fig. 27).

Female reproductive organs: Unknown.

Distribution. China: Taiwan.

Etymology. Dedicated to CHOU Wen-I, a specialist on Taiwan Cerambycidae and the collector of this species.

Tillicera bibalteata Gorham, 1892, new record from China

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

Figs 41, 45

Tillicera bibalteata Gorham, 1892: 732 (Carin Hills, Chebà).

Diagnosis. Differs from *T. hirsuta* by absence of tubercular rows on basal elytral intervals, elytral apex not emarginate; from *T. michaeli* by absence of tuberosity on elytral base (on third interval exactly) and absence of tubercular rows on basal elytral intervals, integument from which two bands of golden setae originate yellow, elytra apex not projecting nor acute, color of first three antennomeres light paler, legs black.

Distribution. China: Yunnan, Sichuan, Hainan; Bhutan; Myanmar; Thailand; Laos; Vietnam; Cambodia.

Material examined. Lectotype designated by Gerstmeier & Bernhard (2010)**:** female, "Tenasserim, Thagatà, Fea. Apr. 1887/Typus /*bibalteata*, Gorh./Syntypus, *Tillicera bibalteata*, Gorham, 1892 [handwritten by Raffaello Gestro]/Museo Civico di Genova/LECTOTYPE ♀, *Tillicera bibalteata*, Gorham, 1892, Revision 2009,

Gerstmeier & Bernhard" (MCSN); **Paralectotype:** Carin Chebà, 900—1100 m, L. Fea V XII—88, Museo Civico di Genova (MCSN).

Other material examined. 12 specimens: 1 male, Yunnan, Jingdong, alt. 1170m, 1956.VI. 30, leg. Kryzhanovskij (IZAS); 1 female, Yunnan, Jingdong, Dongjiafen, alt. 1250m, 1956.VI.19, leg. A. Shnitnikov (IZAS); 1 male, Yunnan, Jinping, Mengla, alt. 500m, 1956.V.2, leg. HUANG Keren (IZAS); 1 male, Yunnan, Xiaomengyang, alt. 850m, 1957.V.3, leg. ZANG Lingchao (IZAS); 1 male, same data but leg. WANG Shuyong (IZAS); 1 male, Yunnan, Xishuangbanna, Mengpeng, alt. 550m, 1959.VI.27, leg. LI Suofu (IZAS); 1 female, Yunnan, Xishuangbanna, Damenglong, alt. 650m, 1958.V.4, leg. HONG Chunpei (IZAS); 1 female, Yunnan, Xishuangbanna, Menghun, alt. 1200–1400m, 1958.V.21, leg. MENG Xuwu (IZAS); 1 male, Yunnan, Mengla, Yaoqu, alt. 850m, 2005.V.11, leg. CUI Jianxin (CAU); 1 male, Sichuan, Chengdu, 1955.V.28, leg. HUANG Keren & JIN Gentao (IZAS); 1 female, Hainan, Shuiman, alt. 640m, 1960.V.25, LI Changqing (IZAS); 1 female, Mt. Doi Pui, 1400–1500m, Chiang Mai, N. Thailand, 20–V–1982, T. Shimomura leg. (MNHN).

Tillicera hirsuta (Pic, 1926), new record from China

http://species-id.net/wiki/Tillicera_hirsuta
Figs 42, 46

Thanasimus hirsuta Pic, 1926: 22 (Tonkin).
Tillicera hirsuta: Gerstmeier & Bernhard, 2010: 18.

Diagnosis. Differs from *T. bibalteata* by having tubercular rows on basal elytral intervals, elytral apex emarginate; from *T. michaeli* by absence of tuberosity on elytral base (on third interval exactly), diameter of interstitial tubercules larger than diameter of punctures on elytra, integument from which two bands of golden setae originates yellow, elytral apex emarginate, first four antennomeres paler.

Distribution. China: Yunnan; Vietnam; Indonesia; Malaysia.

Material examined. Lectotype designated here: female, "Type [handwritten by Pic]/Lac Thô, Tonkin / *Thanasimus hirsutus*, n. sp. [handwritten by Pic]/Museum Paris, Coll. M. Pic/HOLOTYPE ♀ *Thanasimus hirsutus* Pic, 1926 = *Tillicera hirsuta*, Revision 2009, Gerstmeier & Bernhard" (MNHN).

Remarks. The name-bearing type was not fixed in the original publication and there was no imply how many type series was. For the purpose to fix the name-bearing type, the lectotype is designated here, which is the same specimen noted as "holotype" in Gerstmeier & Bernhard (2010).

Other material examined. 5 specimens: 1 female, Lac Thô, Tonkin (MNHN); 1 male, Phuyen binh, 1907 (MNHN); 1 female, Yunnan, Xishuangbanna, Menglun, Lvshilin, 21°54.61'N, 101°16.87'E, ca 630m, 2009.XI.14, leg. TANG Guo & YAO Zhiyuan, by fogging (IZAS); 1 male 1 female, Tonkin, Hoa-Binh, leg. A de Cooman (IZAS).

***Tillicera michaeli* Gerstmeier & Bernhard, 2010, new record from China**
http://species-id.net/wiki/Tillicera_michaeli
Figs 43, 47

Tillicera michaeli Gerstmeier & Bernhard, 2010: 23 (Laos).

Diagnosis. Differs from *T. bibalteata* by having a tuberosity on elytral base (on third interval exactly), each basal elytral interval with a row of tubercules, integument from which two bands of golden setae originate black, elytra apex slightly projecting and acute, color of first three antennomeres black, legs reddish brown; from *T. hirsuta* by having a tuberosity in basediscal elytra (on third interval exactly), diameter of interstitial tubercules smaller than diameter of punctures on elytra, integument from which two bands of golden setae originate black, elytral apex slightly projecting and acute, first four antennomeres black.

Distribution. China: Guangxi, Guangdong, Hainan; Vietnam; Laos.

Material examined. Holotype: male, "Laos, Phongsaly Prov., Phongsaly env., Phu Fa, h: 1450–1600 m/27.VII.2006, leg. M. Geiser, Bergregenwald, Umgestürzter Baum/HOLOTYPE male, *Tillicera michaeli* sp. n., Gerstmeier & Bernhard, 2009 Revision, Gerstmeier & Bernhard" (RGCM); **Paratype:** 2 specimens, same locality data as Holotype; 1 specimen, same data but 28.VII.2006 (RGCM).

Other material examined. 16 specimens: 1 male, Guangxi, Napo, Defu, alt. 1350m, 2000.VI.18, leg. LI Wenzhu (IZAS); 3 males, Guangdong, Nanling Nature Reserve, 2009.IV–VIII, leg. GAO Lei, by Malaise trap; 1 male, same data but by window trap; 1 male, same data but on soil; 3 males 2 females; same data but collecting methods unknown (IZAS). 1 male, Hainan, Yinggeling Nature Reserve, Hongxin village, 19.0805°N, 109.5210°E, alt. 415m, 2007.XII.3, leg. YANG Ganyan, by searching on dead rubber branches on wayside (IZAS); 1 male, same data but leg. WANG Zhiliang (IZAS); 1 female, Hainan, Jianfengling Nature Reserve, 1983.V.27, leg. Gu Maobin, by hand (IZAS); 1 male 1 female, Tonkin, Mt. Bavi, 800–1000m, 1941.VII, leg. A. De Cooman (IZAS).

Discussion

The placement of the species *T. wenii* sp. n. into the genus *Tillicera* might receive some controversy, because currently the most important character of the genus *Tillicera* is tarsal pulvillar formula 4–4–2 (Gerstmeier 2002, 2006; Gerstmeier and Bernhard 2010; Opitz 2010), while the tarsal pulvillar formula of *T. wenii* is 4–4–4. But note that none of other species of genera related to *Clerus* and *Tillicera* (*sensu* Gerstmeier 2010) shows 4–4–4 tarsal pulvillar formula, and the general appearance, male phallus (phallic plate with large denticles along dorsal margin and fine granular structures on posterior sclerotized area) and presence of pit-like sensilla on male terminal antennomere suggest a close relationship among *T. wenii* and *T. auratofasciata* and *T. sensibilis*,

and its recent relatives might as well include *T. soror* (from Bhutan) and *T. javana* (from Java) based on their aedeagi illustrated by Gerstmeier and Bernhard (2010). "It is the genus that pronounces the characters, and not the characters that pronounces the genus" (Linnaeus 1737; Mayr 1969; Opitz 2010). *T. wenii* might be a special and advanced species in the lineage of that includes *T. auratofasciata*, *T. sensibilis*, *T. soror* and *T. javana*.

The extreme close relationship between *T. auratofasciata* and *T. sensibilis* can be additionally inferred from the characters below (unfortunately the female of *T. wenii* is unknown): female vagina swollen, base of bursa copulatrix narrower than posterior end of vagina, length of bursa copulatrix three times as long as spermatheca, spermathecal gland attached to basal fourth of spermatheca; the male phallic posterior scleroitzed area of both sharply reduced in size, both have the ventral membrane with one line of file-like structures on each side, the pit-like sensillum on each terminal antennomere of males larger, shallower and straight.

T. bibalteata and *T. hirsuta* appear to be closely related; the evidence being that they have the same type of male phallus and female internal reproductive organs (phallic plate with small denticles on both dorsal and ventral margins; base of bursa copulatrix as wide as posterior end of vagina; length of bursa copulatrix is at least four times as long as spermatheca) (Figs 41–42, 45–46).

The positions of *T. cleroides* and *T. michaeli* are uncertain. Phallus and female internal reproductive organs of *T. cleroides* do not provide evidence of its relationship to other species (the phallic plate with small denticles along dorsal ventral margin and larger denticles on the ventral margin, base of bursa copulatrix as wide as posterior end of vagina, and spermathecal gland attached to the middle of spermatheca) (Figs 44, 48), but its pronotum indeed gives a very different look among this genus (Fig. 3). As for *T. michaeli*, its phallic plate is uniformly sclerotized near the apex and without marginal denticles (Fig. 43), and the integument from which the two bands of golden setae originate is not yellow but black, which might indicate a close relationship to some species of *Clerus* than to other species of *Tillicera*.

Whether the current genus *Tillicera* is a monophyly might need further examination, because firstly the characters to support this genus currently (antennomeres triangularly dilated from the fifth and tarsal pulvillar formula 4–4–2) are not adequate; some species currently placed in *Tillicera* do not exhibit the typical triangularly dilated antennomeres and some Chinese related species not placed in *Tillicera* at present show 4–4–2 pulvillar formula as well. Secondly, as discussed in the above paragraph, some species currently placed in *Tillicera* might be closer to some species of *Clerus* than to other species of *Tillicera*. Actually, this is a problem of the generic definition of *Clerus-Tillicera* group, rather a problem of merely *Tillicera*. It is clear that a sound definition of the *Clerus-Tillicera* group, based on a greater range of characters (especially external and internal reproductive organs) is required, though this may not be accomplishable before all the representative species of this group are taxonomically revised. Conversely, the systematic importance of the pulvillar formula in *Clerus-Tillicera* group (especially for those with 4–3–2, 4–4–2 tarsal pulvillar formula) might require further test and

the true systematic value of the pulvillar formula, however, may be better realized if these structures were more carefully considered in terms of the degree of development of each pulvillus rather than just a formula (eg. distinctly or feebly lobed apically, or present but unlobed or vestigeal).

The pit-like sensillum of the male terminal antennomere was discovered during the course of the present study, and we found this structure in some undetermined Chinese Cleridae as well. Whether this sexually correlated character can provide additional evidence to infer a close relationship between species-groups might require further investigation.

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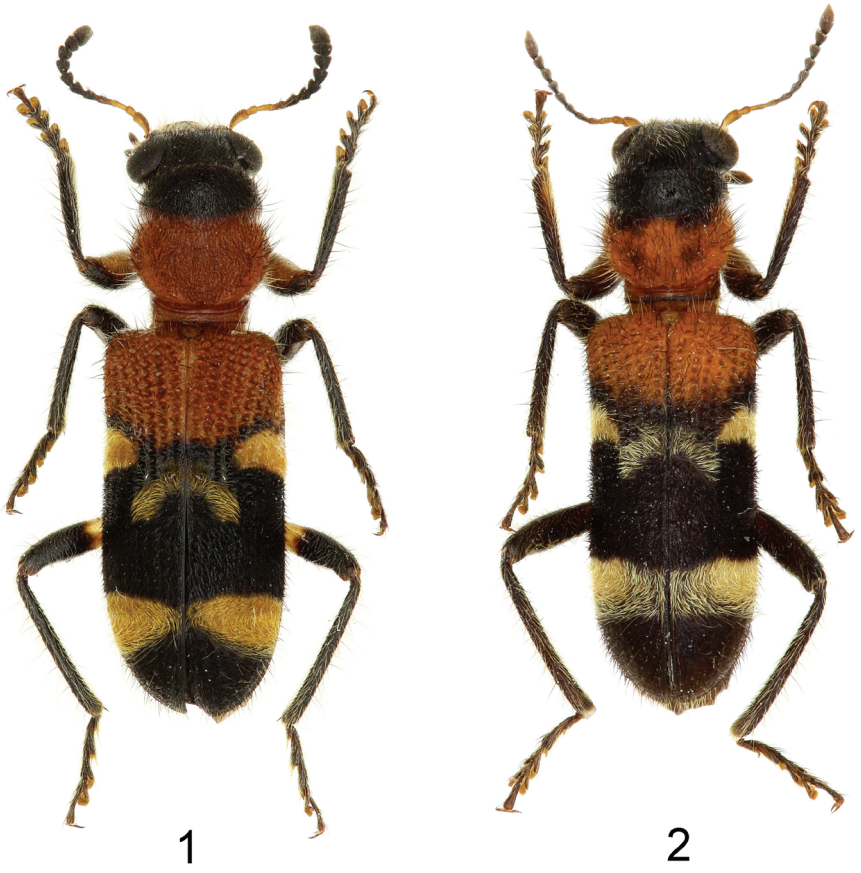
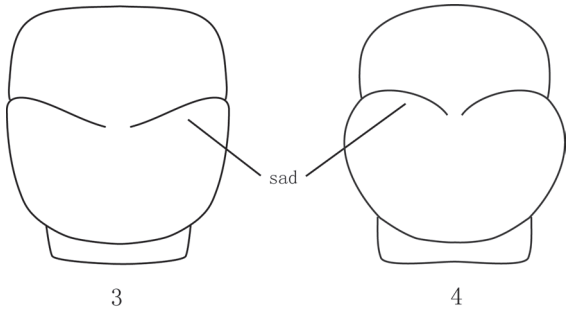
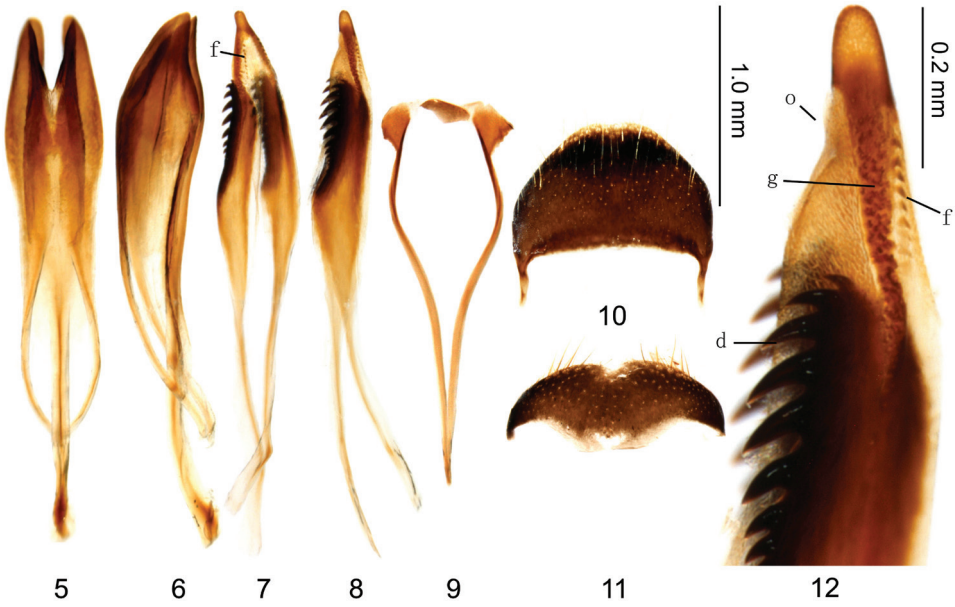
Plates



Figures 1–2. Habitus **1** *T. sensibilis* sp. n., paratype, from Yingjiang, Yunnan **2** *T. wenii* sp. n., holotype, from Lalashan, Taiwan.



Figures 3–4. Pronotum **3** *T. cleroides*, showing pronotum gradually narrowed after subapical depression **4** *T. sensibilis* sp. n., showing pronotum swollen after subapical depression **sad** = subapical depression.

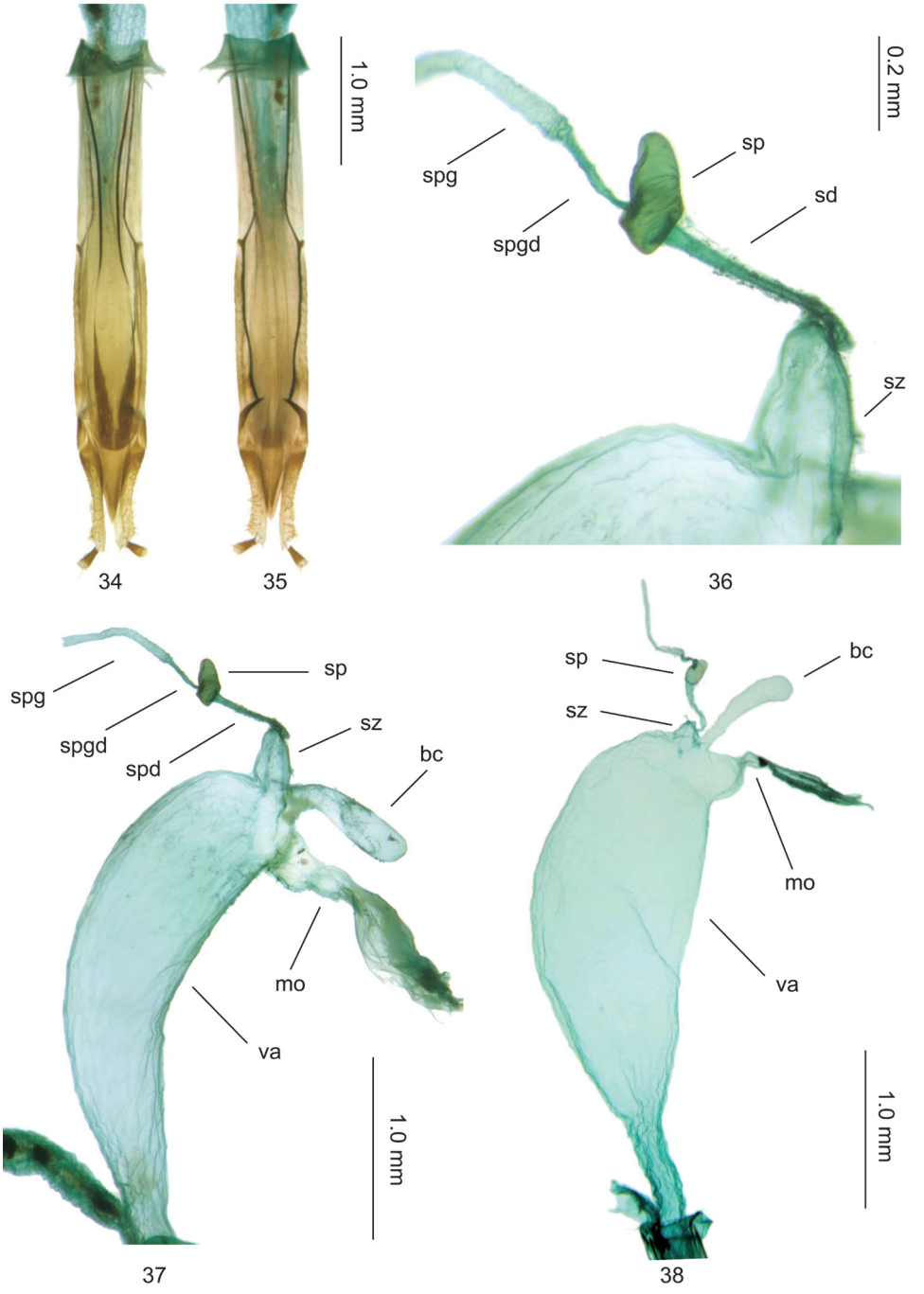


Figures 5–12. Male terminalia of *T. auratofasciata*, from Tonkin **5–6** tegmen (**5** dorsal view **6** lateral view) **7–8** phallus (**7** ventral view **8** lateral view) **9** spicular fork **10** tergum VIII **11** sternum VIII **12** phallus, lateral view. Abbreviations: **d** = dorsal denticles **f** = file-like structures on phallic ventral membrane **g** = granular structures; **o** = median orifice.

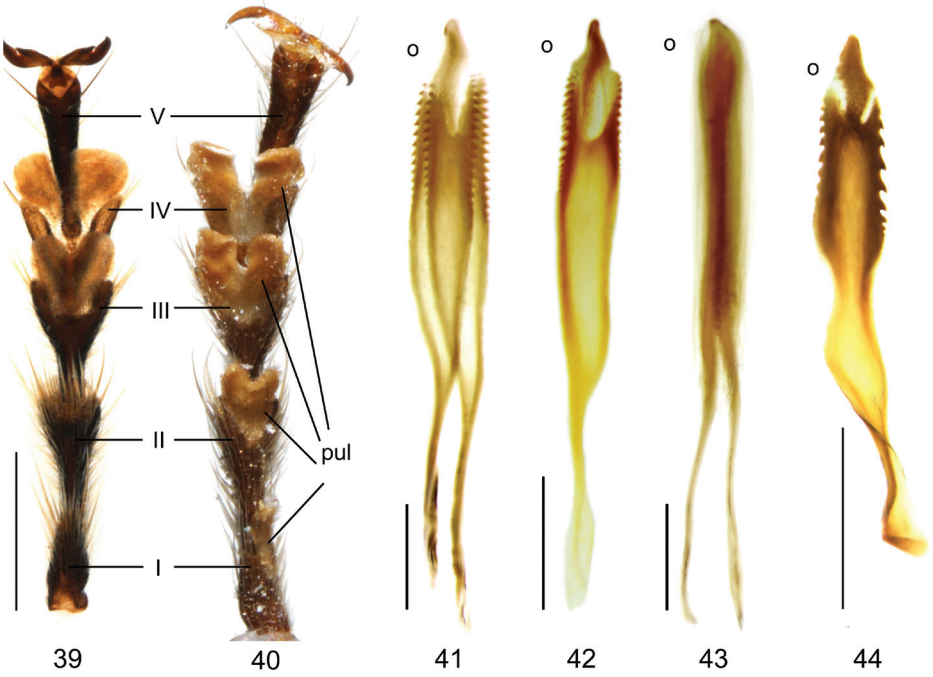
Figures 13–20. Male terminalia of *T. sensibilis* sp. n., holotype **13–14** tegmen (**13** dorsal view **14** lateral view) **15–16** phallus (**15** ventral view **16** lateral view) **17** spicular fork **18** tergum VIII **19** sternum VIII **20** phallus, lateral view. Abbreviations: **d** = dorsal denticles **f** = file-like structures on phallic ventral membrane **g** = granular structures; **o** = median orifice.

Figures 21–28. Male terminalia of *T. wenii* sp. n., holotype **21–22** tegmen (**21** dorsal view **22** lateral view) **23–24** phallus (**23** ventral view **24** lateral view) **25** spicular fork **26** tergum VIII **27** sternum VIII **28** phallus, lateral view. Abbreviations: **d** = dorsal denticles **f** = file-like structures on phallic ventral membrane **g** = granular structures; **o** = median orifice.

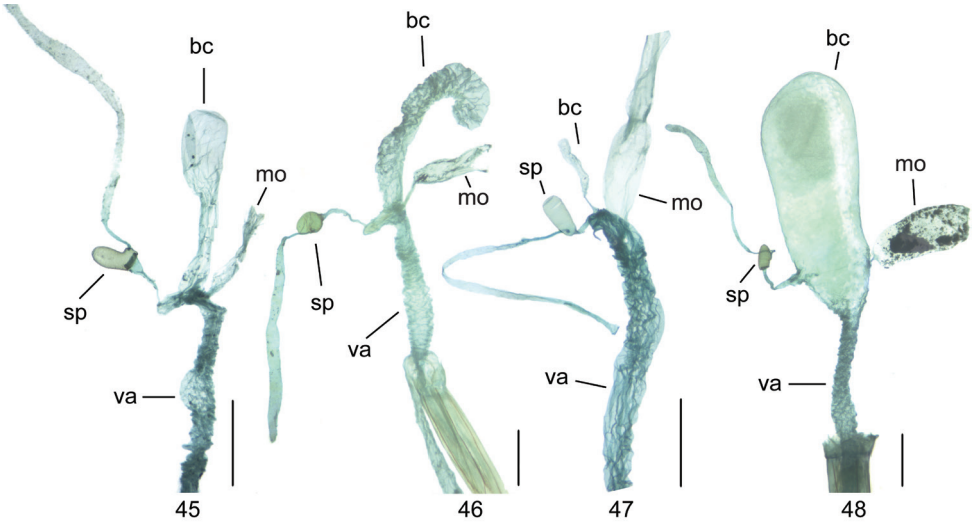
Figures 29–33. Male antennae in dorsal view, showing pit-like sensilla on terminal antennomere **29–31** terminal antennomere **29** *T. auratofasciata*, from Guangxi **30** *T. sensibilis*, sp. n., paratype **31** *T. wenii*, sp. n., paratype **32–33** antennomere **3–11 32** *T. auratofasciata*, from Guangxi **33** *T. sensibilis*, sp. n., paratype.



Figures 34–38. Female reproductive organs. **34–37** *T. auratofasciata* from Yunnan **34** ovipositor, dorsal view **35** ovipositor, ventral view **36** spermatheca **37** internal organs in lateral view **38** *T. sensibilis* from Yunnan. Abbreviations: **bc** = bursa copulatrix; **mo** = median oviduct; **sp** = spermatheca; **sz** = swollen zone; **spd** = spermathecal duct; **spg** = spermathecal gland; **spgd**= spermathecal gland duct; **va** = vagina.



Figures 39–44. Metatarsus **39** *T. sensibilis*, paratype, separated from body and treated with KOH **40** *T. wenii*, holotype, left leg in natural condition. The Roman numerals indicate the segment of the tarsus. **pul** = pulvillus. Scale = 0.5mm **41–44** Phallus **41** *T. bibalteata*, from Yunnan **42** *T. hirsuta*, from Tonkin **43** *T. michaeli*, from Hainan **44** *T. cleroides*, from Hainan. **o** = median orifice. Scale = 0.5mm



Figures 45–48. Female internal reproductive organs **45** *T. bibalteata*, from Yunnan **46** *T. hirsuta*, from Yunnan **47** *T. michaeli*, from Guangdong **48** *T. cleroides*, from Hainan. Abbreviations: **bc** = bursa copulatrix; **mo** = median oviduct; **sp** = spermatheca; **sz** = swollen zone; **spd** = spermathecal duct; **spg** = spermathecal gland; **spgd**= spermathecal gland duct; **va** = vagina.

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RESEARCH ARTICLE

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New species of *Prepseudatrichia* Kelsey from Thailand (Diptera, Scenopinidae)

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urn:lsid:zoobank.org:author:37F5AC48-EC3A-47ED-902B-2BD1467CCA72

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Abstract

A new species of *Prepseudatrichia* Kelsey, 1969 (*Prepseudatrichia tiger* **sp. n.**) is described from Thailand, the first record of the genus from the Oriental region. A key to world species of *Prepseudatrichia* is given.

Keywords

Therevoid clade, Asiloidea, Scenopinidae

Introduction

Window flies (Diptera: Scenopinidae) are a small family (*ca.* 420 species in 24 extant genera) of cosmopolitan asiloid flies with an adult body size rarely exceeding 5.0 mm. Scenopinids are distributed throughout all major biogeographical regions, but with significant continental endemism at the genus level, and most genera confined to one or two biogeographical regions (Kelsey, 1973).

The genus *Prepseudatrichia* Kelsey, 1969 contains four described species from Africa (*P. mateui* Kelsey, 1969, *P. stenogaster* (Séguy, 1931) and *P. violacea* Kelsey, 1969) and central Asia (Turkmenistan) (*P. kelseyi* Krivosheina, 1980). These rare flies are notable for their elongate, glossy black body habitus, similar to members of the genera *Pseudatricha* Osten Sacken, 1877 and *Neopseudatrichia* Kelsey, 1969. The elongate body shape and lack of pile in adults of these genera is presumed to be a morphological adaptation for escaping the narrow confines of wood boring beetle galleries, where species in these genera appear as specialist predators of wood boring beetle larvae. The larval and pupal stages of *P. kelseyi* were described by Krivosheina (1980). *Prepseudatrichia* is differentiated from all other window fly genera based on the wing vein M_1 being fused to the wing margin, separate from R_5, an elongate glossy black body, the male genitalia with a well developed hypandrium, an aedeagus extending anteriorly into the body cavity and lateral aedeagal lobes well developed, and the female lacking acanthophorite spines. As mentioned by Kelsey (1969), while *Prepseudatrichia* has a body shape similar to *Pseudatrichia* and *Neopseudatrichia*, the male genitalic morphology and wing venation more closely resemble members of *Scenopinus* Latreille, 1802. This may indicate a closer relationship to *Scenopinus* and the elongate, glabrous adult morphology representing convergence associated with larval feeding in wood boring beetle galleries. This question remains to be tested in a quantitative phylogenetic context.

A distinctive new species of *Prepseudatrichia* (*P. tiger* sp. n.) is described herein from Thailand based on a single male specimen. This is a new geographical record for this genus, previously known only from the Afrotropical and Palaearctic regions. A key to species of *Prepseudatrichia* is presented.

Materials and methods

Genitalia were macerated in 10% KOH at room temperature for one day to remove soft tissue, then rinsed in distilled water and dilute acetic acid, and dissected in 80% ethanol. Preparations were then placed into glycerine, with images made with the aid of a digital camera mounted on a stereomicroscope. Genitalia preparations were placed in glycerine in a genitalia vial mounted on the pin beneath the specimen. Terminology follows McAlpine (1981) and modified following Winterton (2005) and Winterton and Woodley (2009). In contrast to the scenopinid subfamilies Proratinae and Caenotinae, the male terminalia of Scenopininae are rotated 180°. To avoid confusion with terminology and comparative homology, structures are described and labeled as they are in related flies with terminalia not rotated; therefore the ventral apodeme of the aedeagus described herein is physically located dorsally. Type material is deposited in the Queen Sirikit Botanic Garden – Entomology collection, Chiang Mai, Thailand (QSBG). Specimen images were taken using a digital camera with a series of images montaged using Helicon Focus (©HeliconSoft).

Taxonomy

Key to *Prepseudatrichia* species

(modified after Kelsey 1969; males are unknown for *P. violacea* and *P. stenogaster*; females are unknown for *P. tiger* sp. n.)

1	Male **2**
–	Female **4**
2	Abdominal segments 3 and 4 with white bands; hypandrial lobes extended posteriorly as narrow triangular processes **3**
–	Abdomen without white bands; hypandrial lobes truncated, not extended as triangular processes (Turkmenistan) ..... ***P. kelseyi* Krivosheina**
3	Femora brown; hypoproct narrow, extending posteriorly well beyond epandrial lobes (Thailand) ..... ***P. tiger* sp. n**
–	Femora dark yellow; hypoproct truncated, not extending beyond epandrial lobes (North Africa) ..... ***P. mateui* Kelsey**
4	Thorax black, often with metallic luster **5**
–	Thorax with green and purple metallic suffusion (Chad) .... ***P. violacea* Kelsey**
5	Femora black ..... ***P. kelseyi* Krivosheina**
–	Femora with red or yellow suffusion **6**
6	Femora reddish; flagellum orange ..... ***P. stenogaster* (Séguy)**
–	Femora yellowish; flagellum black-brown..... ***P. mateui* Kelsey**

***Prepseudatrichia tiger* sp. n.**
urn:lsid:zoobank.org:act:FC2E1669-10A7-487F-8C15-1A1E7577FD2D
http://species-id.net/wiki/Prepseudatrichia_tiger
Figs 1–2

Type material. Holotype. male, THAILAND: Loei Phu Ruea National Park, Nern Wibaak ditch, 17°29.907'N, 101°20.483'E, 1196m, Malaise trap 26.ii-2.iii.2007, Patikhom Tumtip leg. T1714 (QSBG).

Diagnosis. Male abdomen with white bands on segments 3–4; antenna yellow-brown; thorax glossy black with metallic iridescence; femora brown; hypandrial lobes with triangular processes extending posteriorly to apex on epandrial lobes; hypoproct narrow, extending beyond epandrial lobes.

Description. Male. Body length: 4.1 mm (female unknown). *Head*. Glossy brown-black (Fig. 1); frons not protruding anteriorly beyond eye in profile (Fig. 2a), eyes almost contiguous at narrowest point; face brown-black, parafacia narrow, glabrous; mouthparts brown; antenna yellow-brown, overlain with greyish pubescence,

Figure 1. *Prepseudatrichia tiger* sp. n.: Male holotype habitus. Body length= 4.1 mm.

admixed with few short setae on outer surface of scape and pedicel, style subterminal; ocellar tubercle raised, broad; postocular ridge very narrow, with few minute setae laterally; occiput relatively flat to concave, pale pubescent medially; gena sparsely covered with fine yellowish setae. *Thorax*. Glossy brown-black with metallic iridescence, scutum finely rugose to scrobiculate posteromedially, very sparsely overlain with short pale setae; postpronotal lobe and postalar ridge pale tan; pleuron smooth and polished, except for a few sparse fine setae; coxae and femora brown; tibia brown basally, dark-yellow apically; sparse, short setae on legs; haltere dark brown; wing hyaline; venation typical for genus, dark yellow. *Abdomen*. Glossy brown, cylindrical, glabrous; dorsal surface flattened with dark, alveolate texture resembling elongate honeycomb; intersegmental membranes and posterior margins of tergites 3–4 bright white; tergite 2 sensory setal region as two circular patches. *Male genitalia* (Fig. 2B–C). Epandrial lobes scoop-like, not enclosing gonocoxites, elongate setae apically, microtrichia posteromedially; cerci narrow; hypoproct relatively large, narrow, extending beyond cerci posteriorly; gonocoxite triangular in shape; gonostylus well developed with spinose ridge posteriorly, articulated on gonocoxite basally; gonocoxal apodeme relatively narrow; hypandrial lobes membranous, elongate with irregular posteromedial margin, lobes articulated ventrally on gonocoxites; aedeagus extended anteriorly well beyond genitalic capsule; distiphallus trifid, curved, not extending beyond genitalic capsule; lateral aedeagal bulbs well developed either side of basiphallus; ventral apodeme of parameral sheath greatly enlarged, arms flanking aedeagus anteriorly with brace-like flanges; dorsal apodeme small, dark sclerotized as brace between gonocoxal apodemes; ejaculatory apodeme relatively large spatulate, directed ventrally from bulbous basiphallus.

Etymology. The species epithet is derived from the acronym for the Thailand Inventory Group for Entomological Research (TIGER) project, from which this species was discovered.

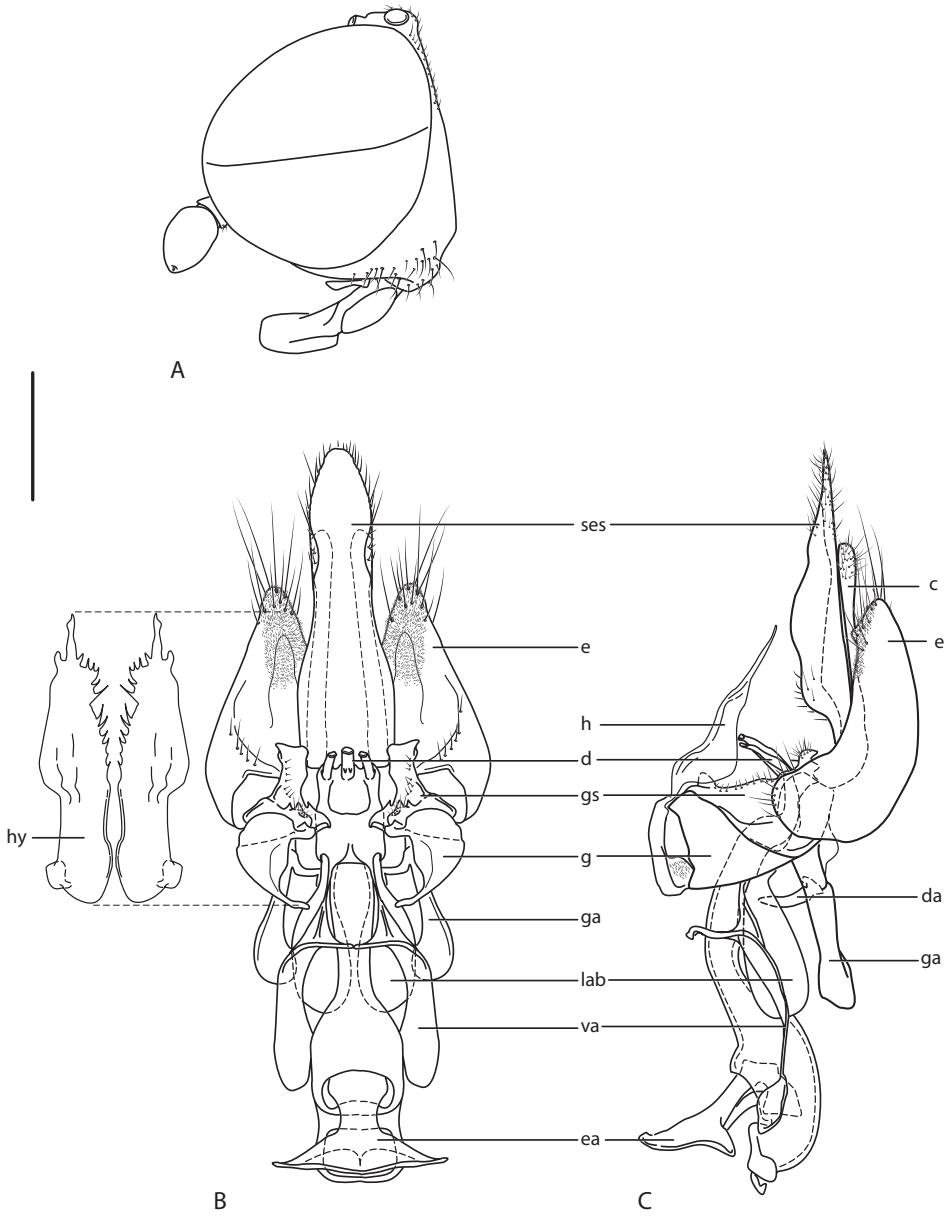

Figure 2. *Prepseudatrichia tiger* sp. n. **A** Male head, lateral view. Male genitalia **B** dorsal view (physically dorsal), hypandrium removed to show internal structures **C** same lateral view with hypandrium in place. Scale line = 0.25 mm. Abbreviations: *c*, cercus; *d*, distiphallus; *da*, dorsal apodeme of parameral sheath; *e*, epandrium; *ea*, ejaculatory apodeme; *g*, gonocoxite; *ga*, gonocoxal apodeme; *gs*, gonostylus; *h*, hypandrium; *ses*, subepandrial sclerite; *lab*, lateral aedeagal bulb; *va*, ventral apodeme of parameral sheath.

Comments. This species is known only from a single male specimen collected in Thailand. This represents a considerable range extension for the genus, into the Oriental Region, as *Prepseudatrichia* was previously only known from few species in the Palaearctic and Afrotropical regions. This distinctive species is differentiated from other species in the genus by the shape of the male genitalia, the white bands on the abdomen and dark femora color.

Acknowledgements

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RESEARCH ARTICLE

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Cossidae of the Socotra Archipelago (Yemen)

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Abstract

The faunistic composition of the family Cossidae (Lepidoptera) of the Socotra Archipelago is revised. Five species are recognized, including two new species (*Mormogystia brandstetteri* and *Meharia hackeri*), and dubious identifications and records are discussed. Adults and genitalia are illustrated and bionomic details, DNA barcodes and a synonymic checklist for Socotran cossids are provided. A review of their distribution reveals that at least 80 percent of Socotra's cossids are unique to the archipelago, which is renowned for its endemism. A checklist listing all the species from generas *Meharia, Mormogystia*, *Aethalopteryx, Azygophleps*, as well as the synonymy and distribution is provided.

Keywords

Lepidoptera, Cossidae, *Meharia, Mormogystia*, *Aethalopteryx, Azygophleps,* new species, Socotra, Yemen

Introduction

This paper results from a collaborative project "The Lepidoptera of Socotra Islands/ Yemen – an integrative study of the fauna for reconstruction of evolutionary scenarios and for determination of conservation needs", between the Zoologische Staatssammlung, (München, Germany), the Nature Research Centre (Vilnius, Lithuania) and Museum of Socotra Archipelago Conservation & Development Programme (Hadibo, Socotra, Yemen).

Socotra, which lies 240 km east of the Horn of Africa and 380 km south of the Arabian Peninsula, is a well-known source of material for biogeography and evolution studies – a living laboratory with a high degree of endemism. It was explored by both English (described by Hampson 1899) and Austrian (described by Rebel 1907) natural history expeditions just before the turn of the 20th century, but it remained effectively inaccessible during the 1900s due to its geographic isolation, extreme natural conditions and military concerns. Wranik's 1999 summary of existing natural history knowledge addressed Lepidoptera conservation issues of the Socotra Archipelago, but was based primarily on information gained during those earlier expeditions. Collaboration of one of us (AS) with the SCDP, collecting from late February to early March and November 2008, March 2009 and January provided new data contributing to the understanding of Socotra's Cossidae fauna.

The Socotra Archipelago consists of four islands with Socotra (130 kilometres in length and 30–40 kilometres in width) accounting for 95% of the archipelago's land mass. Socotra, regarded as one of the most alien looking places on earth, has three main geographical features: (1) narrow coastal plains, (2) a limestone plateau extending across most of the island with karst caves, deep valleys and steep escarpments from 300 to 700 m, and (3) the Haghier Mountains in the centre of the island, which rise to 1,519 m (Miller and Cope 1996)

Socotra is a tropical desert with average highs between 27°C and 34°C and annual rainfall of only 130–170 mm. Rain is more intense in the higher mountains, which form the most important watershed and where many periodical watercourses run to the north and south. Permanent springs can also be found there, especially on the northern side. Otherwise, springs and streams are sporadic relying on rainfall. Climate conditions, rainfalls and major wind systems are dominated by seasonal monsoons of the Indian Ocean with most rain occurring during the Northern Hemisphere winter. The monsoon season causes strong winds and high seas, which cut off the island completely during the time of the southwest monsoon from May to September (Miller and Cope 1996, Wranik 1999).

The Socotra Archipelago is thought to have been part of the Gondwana supercontinent before it detached during the Miocene. In Tertiary times, Socotra was separated as part of a fault block from the African-Arabic tectonic plate and was formed coincident with the Gulf of Aden. As a result of its extremely long isolation, Socotra is of major biogeographical interest and more than one third of all its plants and possibly

animals are found nowhere else. Botanists rank Socotra's flora, including the extraordinary dragon´s blood tree *Dracaena cinnabari*, to be among the most important and endangered island floras of the world. It is generally suggested that the endemic plants and animals are relicts and descendants of ancient flora and fauna, which have survived since the Mesozoic era (Miller and Cope 1996, Wranik 1999).

Socotra Archipelago fauna is composed of tropical-subtropical arboreal and eremic elements derived from African, Asian or south-Arabian and endemic origins (Wranik 1999). No comprehensive investigations of the insular fauna of Socotra are available and ambiguous taxonomic definitions have repressed faunistic analysis and development of species checklists. Wranik (1999) examined a limited number of groups including Odonata in which only one of 20 species is endemic and Saltatoria where over half of about 50 species are endemic. Wranik found Tenebrionidae to have the highest level of endemism: most of about 30 species are endemic, indicating a Somalarabic relationship, while others are may be relicts from a more ancient fauna already extinct on the mainland.

About 250 species of Lepidoptera are currently reported from Socotra in the literature including 30 species of Rhopalocera (Hacker 1999), 89 Noctuidae (Hacker and Saldaitis 2010), over 40 Pyralidae (Hacker 1999), 28 Geometridae (Hausmann 2009) and others from less studied groups. Rebel (1907) suggested that 1/3 of the Lepidoptera fauna of the Socotra Archipelago was endemic, with a dominance of Afrotropical relationships.

We present five Cossidae species from Socotra, excluding *Eremocossus proleuca* (Hampson, 1896) and *Azygophleps inclusa* (Walker, 1856) which were mistakenly attributed to Socotra by Hampson (1903), Rebel (1907) and Hacker (1999). *E. proleuca* which was erroneously synonymized by Wiltshire (1980) as *E. reibellii* (Oberthür, 1876) does not occur on Socotra but was probably confused with one of the two new Cossidae species described in this paper. *Azygophleps inclusa* is distributed only in tropical Africa and differs from the similar *Azygophleps larseni* which is distributed in the Arabian peninsula and Socotra island.

Materials and methods

Material was collected in February through early March and November 2008, March 2009 and January 2010 using artificial light.

DNA barcodes (658 base pairs of Cytochrome Oxidase Subunit I 5' region, (COI-5P) were sequenced by Paul Hebert's laboratory at the University of Guelph for 15 Cossidae specimens.

Abbreviations

LT locus typus (type locality)

Abbreviations of depositories

ASV	private collection of Aidas Saldaitis (Vilnius, Lithuania)
BMNH	Natural History Museum (London, UK)
JBW	private collection of Johann Brandstetter (Winhöring/Kronberg, Germany)
LLE	private collection of Lutz Lehmann (Eisenhüttenstadt, Germany)
MNHN	Muséum National d'Histoire Naturelle (Paris, France)
MWM/ZSM	Museum Thomas Witt (Munich, Germany)/Zoologische Staatssammlung, München (Germany)
NRCV	Nature Research Centre (Vilnius, Lithuania)
RYB	private collection of Roman Yakovlev (Barnaul, Russia)
SCDP	Museum of Socotra Archipelago Conservation & Development Programme

Systematic accounts

Genus *Mormogystia* Schoorl, 1990
http://species-id.net/wiki/Mormogystia

Mormogystia Schoorl, 1990, Zool. Verhandelingen 263: 75–78. Type species – *Cossus reibellii* Oberthür, 1876.

Diagnosis. *Mormogystia* is distinguished from all other Cossidae genus by having large silvery areas on the forewing.

Description. Medium sized, brightly coloured moths. Male antennae bipectinate with very short processes; female antennal pecten much reduced. Large silvery areas on the forewing forming fasciae make this the only Cossidae genus to have such a high contrast pattern. Hindwings are uniform.

Male genitalia. Uncus elongate, with tapering or rounded broad apex; arms of gnathos short, fused to form a medium-size gnathos densely covered with small spines; valvae shovel-shaped, with pronounced sacculus and a large triangular costal projection; transtilla projections short, thick and uncinate; juxta saddle-shaped, with long lateral projections directed upwards; saccus massive, semicircular; aedeagus short, straight, thick; vesica opening located dorsoapically, its edges with short, spiny processes; vesica without cornutus.

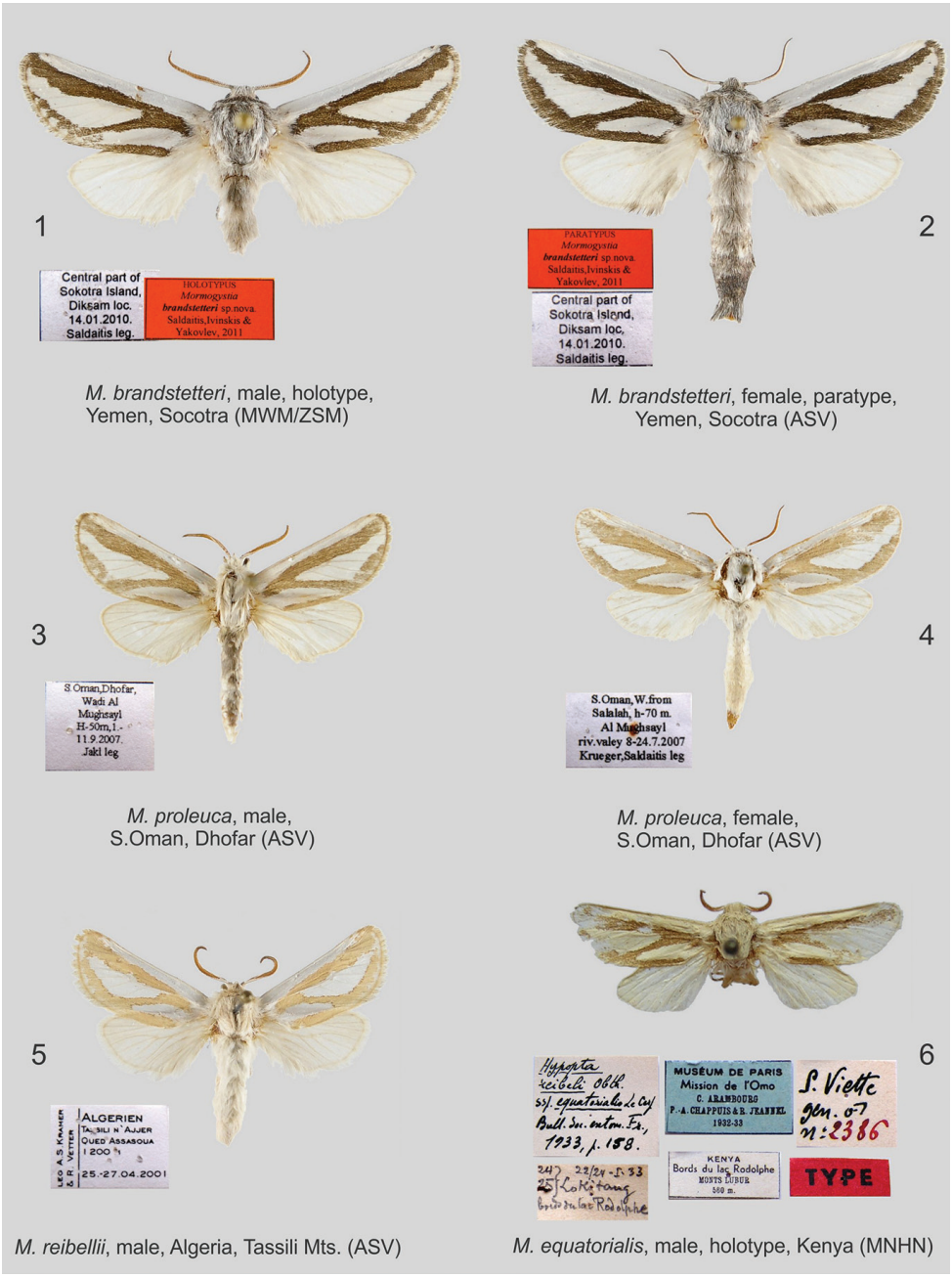
Female genitalia. Short oviductus; papillae anales wide, elliptic; apophyses posteriores ⅓ longer than apophyses anteriores; ostium broad, covered with falciform postvaginal plate; ductus wide, sclerotised; bursa membranous, sack-shaped, without signa.

Remarks. This small genus includes four species distributed in north Africa, Levante, Arabian peninsula and Kenya (Yakovlev 2011).

***Mormogystia brandstetteri* Saldaitis, Ivinskis & Yakovlev sp. n.**
urn:lsid:zoobank.org:act:48E8D1AE-EAD6-4DBD-AA0A-AC40BB375524
http://species-id.net/wiki/Mormogystia_brandstetteri
Figs 1, 2, 21, 27

Type material. Holotype ♂ (Fig. 1), central part of Socotra Island, Diksam loc., 14 January 2010, leg. A. Saldaitis (deposited in MWM/ZSM; slide No. BJ 1524). **Paratypes**: 77 ♂ and ♀ (Fig. 2), with same labels as holotype; Socotra Archipelago, Samha Island W., N 12°09', E 052°59', 23–24 February 2008, leg. A. Saldaitis; Socotra Archipelago, Abd al Kuri Island, Towanie vill. env., N 12°10', E 052°13', 25–27 February 2008, leg. A. Saldaitis; Socotra Island, Di Hamri loc., 1 March 2008, leg. Saldaitis; Socotra Island, Di Hamri loc., 20–21 November 2008, leg. Saldaitiene & Saldaitis; Socotra Island, hills near Hadibu, 21 March 2009, leg. A. Saldaitis; Socotra Island, Diksam canyon, 23 March 2009, leg. A. Saldaitis; W Socotra, Shuab, coast line, mangroves, 24 March 2009, leg. A. Saldaitis; N Socotra Island, Ayhft valley, 22 November 2008, leg. A. Saldaitis; S Socotra Island, Wadi Difarroha South side, 15 January 2010, leg. A. Saldaitis; N Socotra Island, Ayhft valley, 12 January 2010, leg. A. Saldaitis; N Socotra Island, Wadi Kam, 13 January 2010, leg. A. Saldaitis; N Socotra Island, top of Ayhft valley, 17 January 2010, leg. A. Saldaitis; E Socotra Island, sand dunes near Irisseyl loc., 18 January 2010, leg. A. Saldaitis; NE Socotra Island, Wadi Difarroha, North side, 19 January 2010, leg. A. Saldaitis (coll. ASV; JBW; LLE; MWM/ZSM; NRCV; RYB). Slide No. BJ 1532 (female).

Diagnosis. The new species differs from the related species *Mormogystia reibellii* (Oberthür, 1876) (Fig. 5), *M. proleuca* (Hampson in Walsingham et Hampson, 1896) (Figs 3, 4) and *M. equatorialis* (Le Cerf 1933) (Fig. 6) in external appearance, genitalia, DNA and distribution. The new species has a larger wingspan than its congeners: *M. brandstetteri* sp. n. 33–35 mm, *M. reibellii* 27–31 mm, *M. proleuca* 25–29 mm, *M. equatorialis* 26 mm. All species of the genus *Mormogystia* have a similar forewing pattern, but the ground colour of the new species is black as opposed to light ochre, light brown and brown, respectively, for *M. reibellii, M. proleuca* and *M. equatorialis.* The head, thorax and abdomen of *M. brandstetteri* are intense grey compared to light yellow in *M. reibellii* and light yellow and white in *M. proleuca* and *M. equatorialis.* Unlike the other species *M. brandstetteri* has a black costal spot on the ventral hindwing; in *M. reibellii* (Figs 23, 24) and *M. proleuca* (Fig. 22) uncus apically tapering, strongly sclerotised valvae not widening and not forming a straight angle; in *M. brandstetteri* uncus broad, apex of valvae form a straight angle; in M. *reibellii* and *M. proleuca* saccus rounded, apically without denticle, whereas in the new species saccus pointed, apically with a denticle; *M. proleuca* aedeagus at the basal end markedly narrowing, gradually widening towards apex; *M. reibellii* aedeagus of the same width from its middle to apex; in *M. brandstetteri* aedeagus widening at proximal end, gradually tapering towards apex. In the most closely related species, *M. proleuca*, the bursa is apically broader than basally (Fig. 28) unlike in the new species where the corpus bursae is significantly broader.



Figures 1–6. *Mormogystia* spp., adults. **1** *M. brandstetteri,* male, holotype, Yemen, Socotra (MWM/ZSM) **2** *M. brandstetteri,* female, paratype, Yemen, Socotra (ASV) **3** *M. proleuca,* male, S.Oman, Dhofar (ASV) **4** *M. proleuca,* female, S.Oman, Dhofar (ASV) **5** *M. reibellii,* male, Algeria, Tassili Mts. (ASV) **6** *M. equatorialis,* male, holotype, Kenya (MNHN);

Distribution. *M. brandstetteri* is endemic to the Socotra Archipelago while *M. reibellii* is distributed in North Africa and the northern part of the Arabian peninsula, *M. proleuca* is found in the southern part of the peninsula, and *M. equatorialis* is widespread in Kenya. Hampson (1903) and Rebel (1907) believed *M. proleuca* to be endemic to the Socotra Archipelago and later Hacker (1999) reported *M. reibellii* from Socotra, but the new species described herein was probably implied.

Molecular Analysis. While molecular results alone are insufficient to definitively separate *M. brandstetteri* from *M. proleuca*, they help corroborate the morphological evidence. Evolutionary distances using the Kimura two-parameter model for comparing four specimens of *M. brandstetteri* to four *M. proleuca* and to three *M. reibellii* specimens, was at least 1.55% and 5.65%, respectively.

Description. Male: Forewing costal margin length of holotype 15 mm, wingspan 33 mm; mean forewing length of paratypes 16 mm, wingspan 35 mm; head, thorax, abdomen and tegulae grey; antennae bipectinate, ½ the length of forewing; ground colour of forewing black, with white silvery pattern. Three white silvery patches form the pattern: fascia of even width runs along the entire costal margin, median fascia widening medially reaches the outer margin of forewing; lower silver patch originates at basal edge and extends along dorsal wing margin to middle. This patch enclosed by ground colour; adterminal line white; fringe grey. Dorsal surface of forewing greyish-white; costal, outer and dorsal margins greyish-black. Hindwing uniform, white, with greyish black spot at costal margin. **Female** (Fig. 2): Forewing length of allotype 23 mm, wingspan 48 mm; antennae filiform; wing pattern as in males. **Intraspecific variation.** Adterminal line in some specimens missing; contours of silvery spots forming the pattern vary; hindwings grey.

Male genitalia (Fig. 21). Uncus broad, slightly narrower than its length; apex wide, slightly rounded; arms of gnathos long and strong; gnathos very broad, with rounded apex; apex of saccus gradually tapering, with a pointed denticle; valvae symmetrical, with straight margins, gradually widening apically; costal margin with strong and wide sclerotisation; apex flat; arms of transtilla medium sized, strong, denticle-shaped; juxta large, strongly sclerotised, belt-shaped with a small indentation apically and a conspicuous boat-shaped margin at the basal area; aedeagus strong, straight, large, widening at the proximal end; vesica simple, wide, without cornuti.

Female genitalia (Fig. 28). Papilla analis narrow, covered with short, thin setae; apophysis posterioris 1.4 times longer than apophysis anterioris; antevaginal plate belt-shaped, pointed at the ends; ductus bursae sclerotised; corpus bursae shaped like a long narrow sac, not sclerotised; signa absent.

Bionomics and distribution. Both males and females of the new species were strongly attracted to light and were distributed in almost all habitats of Socotra Island as well as the smaller islands of the archipelago – Samha and Abd al Kuri. *Acacia* is a likely food plant for *M. brandstetteri* as larvae of the closely allied species *Mormogystia proleuca* feed on *Acacia* [Hampson, 1896]. Also, the new species is especially abundant in the central part of the island, in deeper canyons or rich oasis-like valleys where for-

ests haven't been cut for fuel like elsewhere on the island. Diksam canyon (Fig. 30), a prime locality *for M. brandstetteri,* contains the following plants: *Acacia pennivenia, Jatropha unicostata, Lycium socotranum, Gnidia socotrana, Buxus hildebrandtii, Croton socotranus, Leucas virgata, Cissus hamaderohensis, Punica protopunica, Ficus vasta, Euphorbia socotrana, Jathropha unicostata, Lycium socotranum, Gnidia socotrana, Buxus hildebrandtii, Trichocalyx* sp.*, Mitolepis intricata, Ballochia* spp.*, Aloe perryi, Adenium obesum, Asparagus africanus, Seddera fastigiata, Aerva lanata, Rhinacanthus scoparius, Levandula nimmoi, Ocimum forskahlei, Cissus hamaderohensis* (Miller and Cope 1996). *M. brandstetteri* flies with several other Socotra Archipelago endemic moths such as *Meharia yakovlevi* Saldaitis & Ivinskis, 2010, *Aethalopteryx diksami* Yakovlev & Saldaitis, 2010, (Cossidae), *Pelosia sokotrensis* (Hampson, 1900), *Siccia butvilai* Saldaitis & Ivinskis, 2008, (Arctiidae), *Cerocala socotrensis* Hampson, 1899, *Agrotis brachypecten* Hampson, 1899, *Leucania diopsis* Hampson, 1905 and *Mythimna sokotrensis* Hreblay, 1996 (Noctuidae).

Etymology. The new species is dedicated to our good friend Johann Brandstetter, an eminent German painter and entomologist.

Genus *Meharia* Chrétien, 1915

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

Meharia Chrétien, 1915, Ann. Soc. Ent. Fr. 84: 367. Type – species: *Meharia incurvariella* Chrétien, 1915.

Synonymy: *Blalia* Rungs, 1943; Rungs, [1943], 1942, Bull. Soc. Sc. Nat. Maroc. 22: 174. Type species – *Blalia vittata* Rungs, [1943].

Diagnosis. *Meharia* is distinguished from all other Cossidae genus by a number of apomorphous characters: the specific "tineoid appearance", the reduction of the lateral processes of the juxta, the specific dorsolateral sclerotization of the asymmetric aedeagus and the specific ribbon – like epiphysis.

Description. These are small to medium sized moths, females larger; eyes naked; male and female antennae bipectinate along their length; proboscis reduced; legs long, slender; foretibia bearing a ribbon-like epiphysis; forewing elongate, rounded on the outer margin; forewing pattern has alternate dark and pale spots and bands transversely; hindwing uniform.

Male genitalia. Simple; uncus unpaired, short, beak-shaped; tegumen massive; arms of gnathos short, slightly broadened distally, fused to form small gnathos; valvae short, broad, with no harpe and processes costally; juxta without lateral processes, simple; saccus protruding backwards, small; aedeagus rather long, slightly curved and asymmetical due to dorsoapical sclerotisation.

Female genitalia. Ovipositor lobes short, slightly acute apically, covered with relatively short, thick bristles, in the shape of triangular sclerites, with long and rather wide apophyses posteriores on the lower part, strongly widening oar-like in

the cranial fourth and bearing a slender membranous-like border; tergite and sternite of the 8th segment fused to form a complete circle; sternite slightly swollen, membranous caudally; tergite strongly elongate, bearing a pair of apophyses anteriores, widening oar-like cranially, approximately as long as ½ the length of apophyses posteriores; opening of ostium strongly protruding cranially, located on membrane between the 7th and 8th segments; ostium membranous, with poorly sclerotized lateral bands; antrum membranous, tube-shaped, 1½ times longer than the 8th tergite, narrowing sharply, separate form membranous ductus bursae; corpus bursae membranous, saccular, without signa.

Remarks. Eleven species of *Meharia* have been reported so far (Yakovlev and Saldaitis 2008), primarily from the deserts and arid mountains of the Western Palearctic and Africa.

***Meharia hackeri* Saldaitis, Ivinskis & Yakovlev sp. n.**
urn:lsid:zoobank.org:act:730024CA-3646-4660-9FBD-C307773D0E94
http://species-id.net/wiki/Meharia_hackeri
Figs 9, 10, 13, 14

Type material. Holotype ♀ (Fig. 9), NE Socotra Island, Wadi Difarroha, North side, 19 January 2010. leg. A. Saldaitis (deposited in MWM/ZSM); (slide No PI 2011/1) **Paratypes**: 3 ♀ (Fig. 10), S Socotra Island, Wadi Difarroha, South side, 15 January 2010. leg. A. Saldaitis; (coll. ASV; MWM/ZSM); (slide No BJ 1523).

Diagnosis. The new species differs from the related species *Meharia acuta* Wiltshire, 1982 (Figs 8, 12) by forewing pattern, DNA and distribution. In *M. acuta,* the basal spot at the costal wing margin is missing. *Meharia hackeri* has a straight basal fascia at the costal wing margin for ¼ the length of forewing and a narrow white fascia, with a wide interruption antemedially and a narrow interruption tornally, running along the entire inner margin. *M. acuta* has no such fascia, but has a wide subterminal band. DNA barcodes clearly separate *M. hackeri* from *M. acuta*. Three identical sequences of *M. hackeri* were compared to those of a single *M. acuta* specimen resulting in a significant 7.48% variation.

M. acuta is distributed in the Arabic peninsula, *M. hackeri* is endemic to Socotra Island.

Description. Female: Forewing costal margin length of holotype 10 mm, wingspan 21 mm; forewing length of paratypes 11 mm, wingspan 22 mm; antennae slightly longer than half the length of forewing; bipectinate, color white, black at base; head and tegular yellowish-white; labial palpi yellowish brown, white at base; ground colour of forewings yellowish-brown with white longitudinal fascia forming wing pattern, basal fascia in the costal area straight, running to ¼ the length of forewing, curved fascia extending medially from inner margin to ⅔ the length of forewing, its extension ends at terminal wing margin, medially the fascia and its interrupted portion in terminal area bordered by dark brown scales with black inserts; narrow white fascia, widely in-

terrupted antemedially and narrowly interrupted tornally, runs along the entire inner margin, cilia yellowish-white, ventral forewing brown; hindwing greyish-yellow, cilia light brown, ventral hindwing brown.

Male genitalia: unknown.

Female genitalia (Figs 13, 14): Papilla analis triangular, covered with short, thin, very long setae; apophysis posterioris about the same length as papilla analis; apophysis anterioris very short, broad, with V-shaped sclerotisation apically; ostium concave; antrum weakly sclerotised basally with a loop forming very narrow ductus bursae; corpus bursae not sclerotised, shaped like a small sac.

Bionomics and distribution. Known only from the central part of Socotra Island. *M. hackeri* is likely endemic to Socotra Island. All specimens were collected in mid-January; *M. hackeri* females were attracted to light and appear to have a very local distribution as the species was discovered only in Difarroha Valley (Fig. 31). The new species was collected in the central part of the country in an oasis-type valley dominated by various tree and shrub species such as: *Jatropha unicostata, Lycium socotranum, Gnidia socotrana, Buxus hildebrandtii, Croton socotranus, Punica protopunica, Ficus vasta, Euphorbia socotrana, Jathropha unicostata, Mitolepis intricata, Aloe perryi, Adenium obesum* (Miller and Cope 1996). It flies with several other Socotra Archipelago endemic moths such as *Meharia yakovlevi* Saldaitis & Ivinskis, 2010, (Cossidae), *Pelosia sokotrensis* (Hampson, 1900), (Arctiidae), *Cerocala socotrensis* Hampson, 1899, *Agrotis brachypecten* Hampson, 1899, *Plecoptera butkevicii* Hacker & Saldaitis, 2010, *Acantholipes canofusca* Hacker & Saldaitis, 2010, *Stenosticta wiltshirei* Hacker, Saldaitis & Ivinskis, 2010 (Noctuidae).

Etymology. The new species name is dedicated to Hermann Hacker, a prominent German lepidopterist, who has contributed much to the investigation of macro-moths of the Arabian peninsula and Africa.

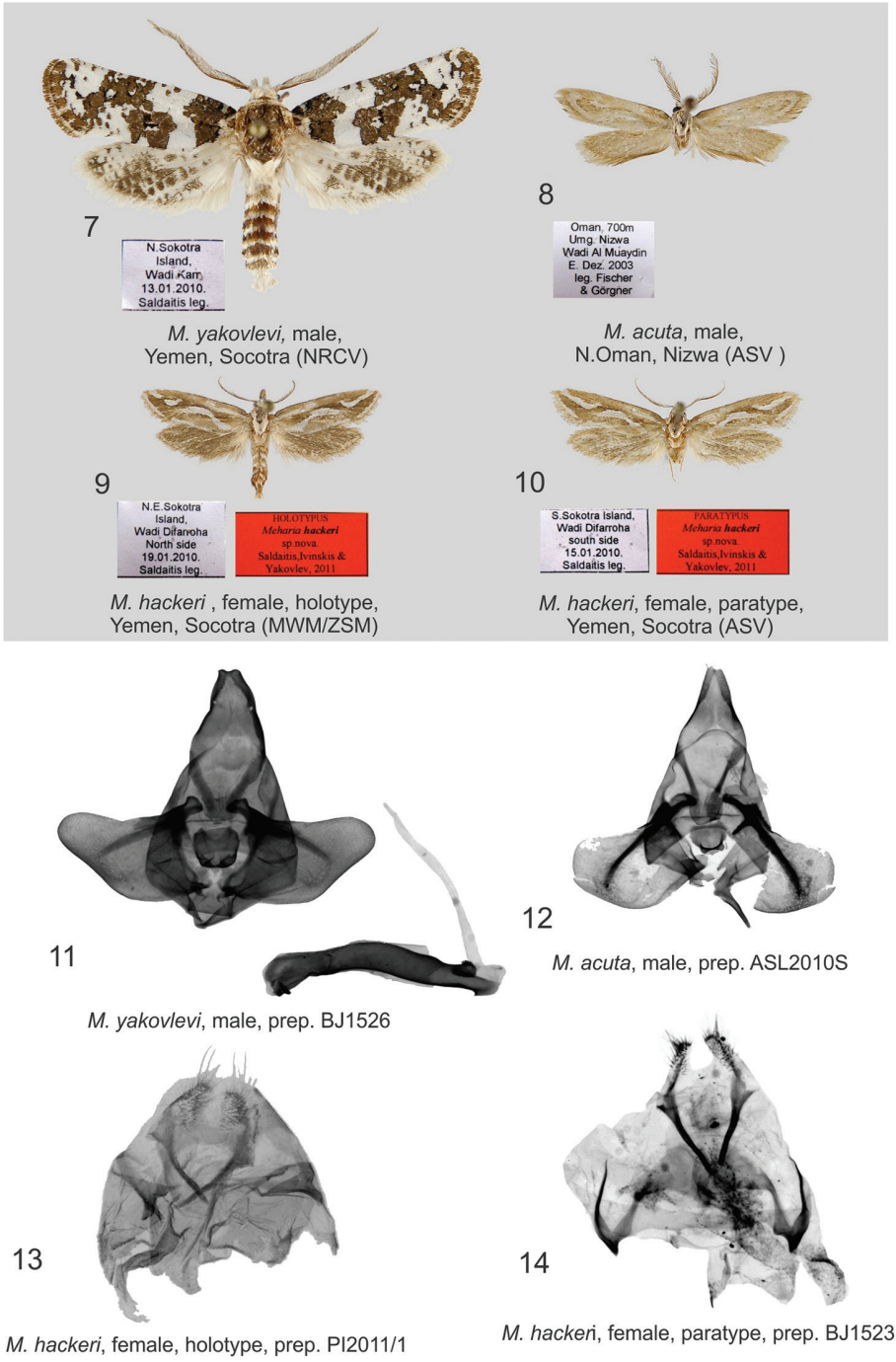
Meharia yakovlevi Saldaitis & Ivinskis, 2010

http://species-id.net/wiki/Meharia_yakovlevi
Figs 7, 11

Meharia yakovlevi Saldaitis & Ivinskis, 2010a, Esperiana 15: 379.

Description. Male genitalia (Fig. 11): The authors examined the genital structures of several more male specimens, noting that the valvae are variable in shape being slightly narrower and slightly concave in costal and dorsal areas. The vesica is narrow, long, and almost the same length as aedeagus.

Distribution. This species was described from a single male. This specimen was collected in Hadibu environs, in the hills covered by dense shrubby vegetation dominated by the following plants: *Rhus thyrsiflora, Buxus hildebrandtii, Carphalea obovata, Sterculia africana, Dracaena cinnabari, Rhus thyrsiflora, Carphalea obovata, Tamarindus indica, Commiphora socotrana, C. ornifolia, C. parvifolia, Boswellia ameero, B. elongata, B. bullata, B. dioscorides, B. nana, Punica protopunica, Aca-*



M. yakovlevi, male, Yemen, Socotra (NRCV)

M. acuta, male, N.Oman, Nizwa (ASV)

M. hackeri , female, holotype, Yemen, Socotra (MWM/ZSM)

M. hackeri, female, paratype, Yemen, Socotra (ASV)

M. yakovlevi, male, prep. BJ1526

M. acuta, male, prep. ASL2010S

M. hackeri, female, holotype, prep. PI2011/1

M. hackeri, female, paratype, prep. BJ1523

Figures 7–14. *Meharia* spp., adults and genitalia. **7** *M. yakovlevi,* male, Yemen, Socotra (NRCV) **8** *M. acuta,* male, N.Oman, Nizwa (ASV) **9** *M. hackeri ,* female, holotype, Yemen, Socotra (MWM/ZSM) **10** *M. hackeri,* female, paratype, Yemen, Socotra (ASV) **11** *M. yakovlevi,* male, prep. BJ1526 **12** *M. acuta,* male, prep. ASL2010S **13** *M. hackeri,* female, holotype, prep. PI2011/1 **14** *M. hackeri,* female, paratype, prep. BJ1523;

cia pennivenia, Cephalocroton socotranus, Indigofera socotrana, Dirachma socotrana, Allophylus rubifolius, Maerua socotrana, Acridocarpus socotranus, Sterculia africana, Zizyphus spina–christi, Ficus vasta, F. salicifolia, Arthrocarpum gracile, Ormocarpum caeruleum (Miller and Cope 1996). In January 2010, five more specimens were collected (1 ♂, N Socotra Island, Wadi Kam, 13 January 2010, leg. A. Saldaitis (Fig. 7); 2 ♂ central part of Socotra Island, Diksam loc., 14 January 2010, leg. A. Saldaitis; 2 ♂ S Socotra Island, Wadi Difarroha South side, 15 January 2010, leg. A. Saldaitis). *M. yakovlevi* appears to be a very rare and local species showing a slightly higher abundance in the central part of the country with oasis-like valleys and canyons with relict woody vegetation. These habitats were dominated by the following plants: *Jatropha unicostata, Lycium socotranum, Gnidia socotrana, Buxus hildebrandtii, Croton socotranus, Punica protopunica, Ficus vasta, Euphorbia socotrana, Jathropha unicostata, Mitolepis intricata, Aloe perryi, Adenium obesum* (Miller and Cope 1996).

Genus *Aethalopteryx* Schoorl, 1990
http://species-id.net/wiki/Aethalopteryx

Schoorl, 1990, Zool. Verhandelingen 263: 174–175. Type species – *Phragmatoecia atrireta* Hampson, 1910.

Diagnosis. *Aethalopteryx* is distinguished from close *Trismelasmos* Schoorl, 1990, *Acosma* Yakovlev, 2011, *Strigocossus* Houlbert, 1916 and *Azygophleps* Hampson, 1892 genus by having cup-shaped antennae in both sexes, forewings with slight reticulated patterns and reduced arms in males gnathos and particularly genital structure of the females.

Description. Medium sized moths. Male and female antennae cup-shaped; forewing elongate with slight reticular pattern, often with a spot in the costal area and spots in the postdiscal area; hindwing with indistinct reticular pattern.

Male genitalia. Uncus long, thin, basally considerably narrower than width of tegumen; arms of gnathos reduced; tegumen massive; valvae with slightly uneven margins and with rounded apex; saccus massive, semicircular; juxta broad, with wide leaf-shaped lateral processes; aedeagus slightly bent, vesica with a long belt-shaped sclerite forming the projection of lateral aedeagus wall.

Female genitalia. Form short oviductus; papilla analis elongate, gradually narrowing; apophyses posteriores twice the length of apophyses anteriores which are furcate at basal part; ductus membranous, broad, very short; corpus bursae shaped like a long narrow sac, with a star-shaped signum on the lateral surface; bulla located in basal third of bursa on a long membranous ductus.

Remarks. Thirty-four species of *Aethalopteryx* have been reported (Yakovlev 2011), primarily from the east Africa with some distributed elsewhere in Africa or in the Arabian peninsula.

Aethalopteryx diksami Yakovlev & Saldaitis, 2010

http://species-id.net/wiki/Aethalopteryx_diksami
Figs 20, 26

Aethalopteryx diksami Yakovlev & Saldaitis, 2010, Esperiana Memoir 5: 334, Pl. 20: fig. 5.

Description. Male genitalia (Fig. 26). The authors examined several more male specimens and found some variation in the genital structures. Valvae of newly examined specimens were significantly wider; apex rounded; costal margin even; vertical juxta processes not tapering, with obtuse apices; vesica simple, long, tapering, almost the same length as aedeagus.

Distribution. A newly described species, highly local, known only from the central part of Socotra Island from two valleys: the Diksam canyon (Fig. 30) and the Difarroha valley (Fig. 31), which are characterized by the following relict woody vegetation: *Dracaena cinnabari, Buxus hildebrandtii, Croton socotranus* and numerous other endemic plants (Miller and Cope 1996).

Genus *Azygophleps* Hampson, 1892

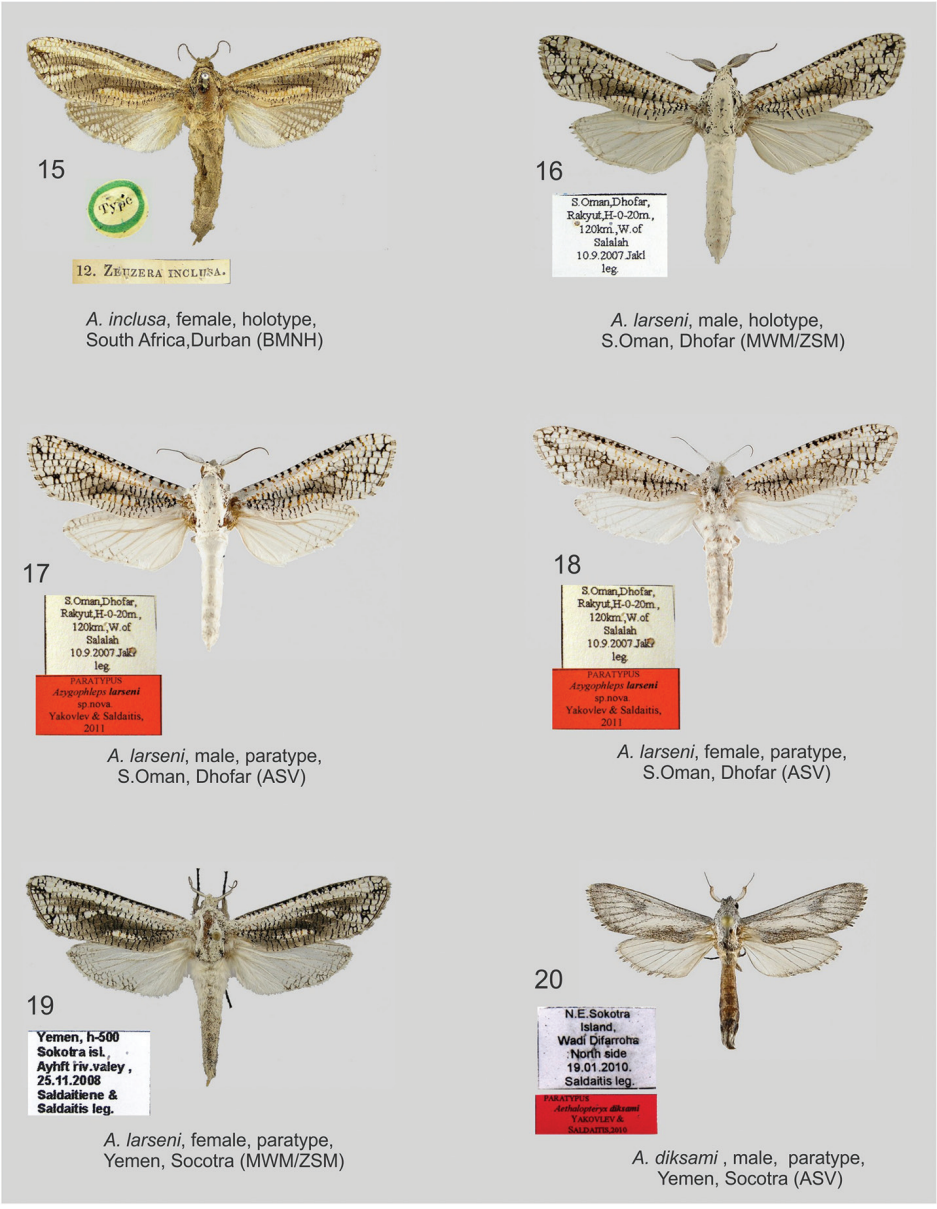
http://species-id.net/wiki/Azygophleps

Azygophleps Hampson, 1892, Fauna Brit. India **1**: 309.Type species – *Hepialis scalaris* Fabricius, 1775.

Synonymy: *Azygophlebs* Aurivillius, 1925, Ergeb. Zweit. Deutsch. Zentral-Afrika-Exped. 1910–1911: 1349; An incorrect subsequent spelling of *Azygophleps* Hampson, 1892.

Diagnosis. *Azygophleps* is distinguished from similar genera such as *Sansara* Yakovlev, 2004, *Strigocossus* Houlbert, 1916 and *Aethalopteryx* Schoorl, 1990 by its females' apically bipectinate antennae, its long forewings rounded at the apex, the abscence of arms in its males' gnathos, its thick aedeagus, and a short, wide ductus and corpus with a small star-like signum in its females.

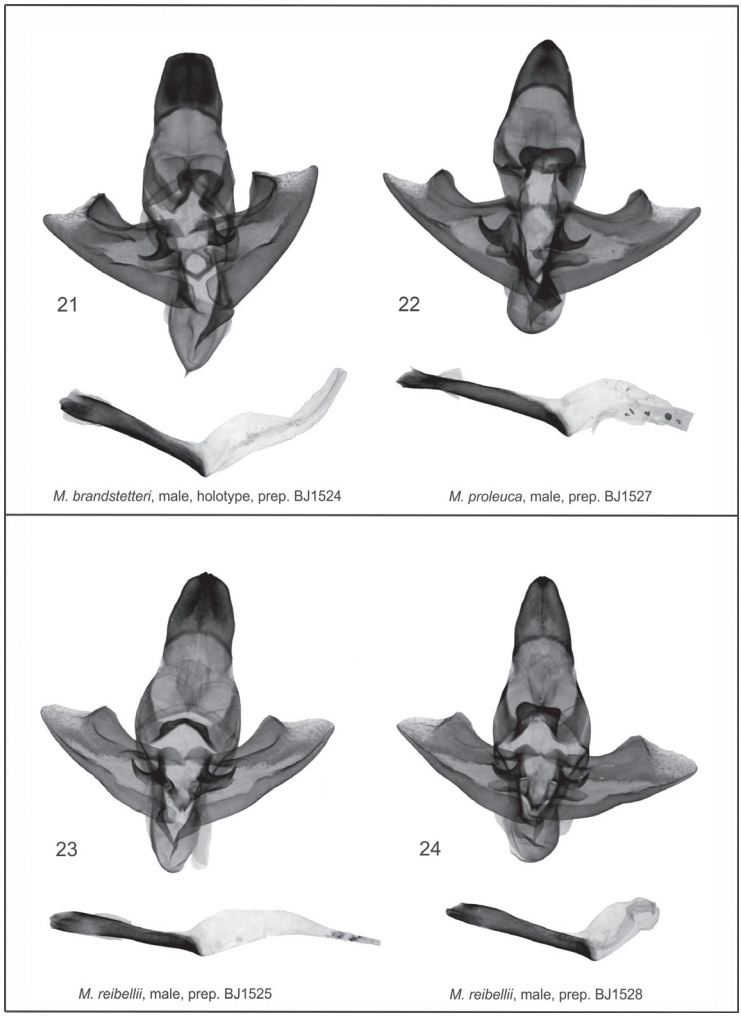
Description. Medium sized moths. Male antennae cup-shaped, those of female bipectinate (apically with gradually reducing pectin); forewing long, with rounded



Figures 15–20. *Azygophleps* spp. and *Aethalopteryx* spp., adults. **15** *A. inclusa,* female, holotype, South Africa, Durban (BMNH) **16** *A. larseni,* male, holotype, S.Oman, Dhofar (MWM/ZSM) **17** *A. larseni,* male, paratype, S.Oman, Dhofar (ASV) **18** *A. larseni,* female, paratype, S.Oman, Dhofar (ASV) **19** *A. larseni,* female, paratype, Yemen, Socotra (MWM/ZSM) **20** *A. diksami* , male, paratype, Yemen, Socotra (ASV);

apex, with dense reticular pattern formed by transverse lines and spots; hindwing lightly coloured and uniform.

Male genitalia. Uncus medium-sized, apically hooked; arms of gnathos absent; tegumen medium sized, usually wider than basal part of uncus; valvae with almost

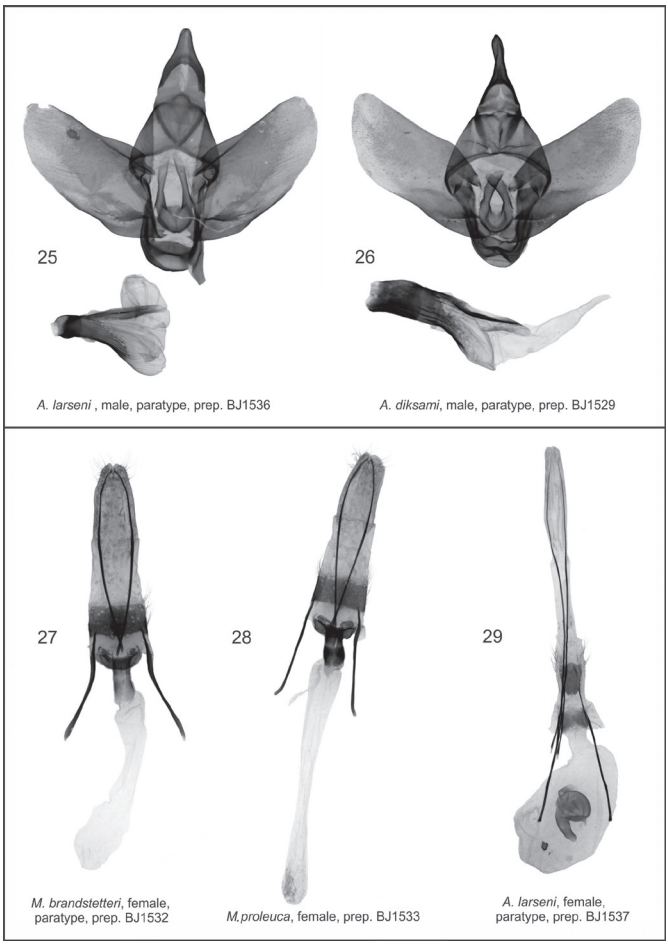


Figures 21–24. *Mormogystia* spp., males genitalia. **21** *M. brandstetteri,* male, holotype, prep. BJ1524 **22** *M proleuca,* male, prep. BJ1527 **23** *M. reibellii,* male, prep. BJ1525 **24** *M. reibellii,* male, prep. BJ1528;

straight margins and wide rounded apex; juxta medium-sized, with long, narrow, well-sclerotised lateral processes; saccus semicircular, massive; aedeagus thick, with long sclera forming aedeagus wall.

Female genitalia. Forming long ovipositor; papilla analis stretched, slightly tapering towards apex; apophyses posteriores more than twice as long as apophyses anteriores which are forked basally; ductus short, wide, sclerotised at base; corpus sac-shaped, with a small star-like signum; bulla located on the apical part of bursa.

Remarks. Twenty-eight species of *Azygophleps* have been reported (Yakovlev 2011), primarily throughout Africa with a few species distributed in the Arabian peninsula and Asia.



Figures 25–29. *Azygophleps sp.* and *Aethalopteryx* sp., male genitalia and *Mormogystia* spp. and *Azygophleps* sp., female genitalia. **25** *A. larseni ,* male, paratype, prep. BJ1536 **26** *A. diksami,* male, paratype, prep. BJ1529 **27** *M. brandstetteri,* female, paratype, prep. BJ1532; 28. *M proleuca,* female, prep. BJ1533; 29. *A. larseni ,* female, paratype, prep. BJ1537;

Azygophleps larseni Yakovlev & Saldaitis, 2011

http://species-id.net/wiki/Azygophleps_larseni
Figs 16–19, 25, 29

Azygophleps larseni Yakovlev & Saldaitis, 2011, Neue Entomologische Nachrichten 66: 84, Pl. 8: Figs 28–29.

Description. Female size and wing pattern similar to the male, however in Socotra specimens the pattern of the forewing is darker and the dorsal margin of hindwing has a reticular pattern. Antennae in females are cup-shaped as in males, but pecten are significantly shorter. Both female specimens from Socotra Island differ from typical *A.*

Figures 30, 31. *Mormogystia* sp. and *Meharia* sp., biotopes. **30** Central part of Socotra Island, Diksam Valley. Type locality of *Mormogystia brandstetteri* sp. n. **31** Northeast Socotra Island, Wadi Difarroha Valley. Type locality of *Meharia hackeri* sp. n.

larseni from Oman in external appearance. Without opportunity to compare *A. larseni* male genitalia we abstained from assigning the Socotra population to a separate taxon. Hampson (1903), Rebel (1907) and Hacker (1999) mistakenly attributed *Azygophleps inclusa* (Walker, 1856) (Fig. 15) to Socotra Island.

Male genitalia (Fig. 25). Oman's *A. larseni* male paratypus specimen's genitalia illustrated showing strong aedeagus, apically three times wider than proximally and simple, rounded, short vesica.

Female genitalia (Fig. 29). Papilla analis stretched, rounded apically; apophyses posteriores more than twice longer than apophyses anteriores which are forked at basal part; ductus short, wide, sclerotised basally; corpus sac-shaped, with a small star-like signum; bulla sclerotised, located on the median part of bursa.

Bionomics and distribution. This species is distributed in Iraq, Iran, Oman and mainland Yemen. Two specimens were caught in Socotra Island, ♀ (collecting date: Yemen, 500 m, Socotra isl., Ayhft riv. valley, 25 November 2008, Saldaitiene & Saldaitis leg.). *A. larseni* in Socotra is a very rare and local species. The Ayhft valley is a unique place in Socotra, with 80% of all vegetation found in Socotra Island. This valley is constantly fed by fresh water from the Haghier Mountains and its slopes are densely covered by tropical-type evergreen trees and shrubs: *Dracaena cinnabari, Rhus rhyrsiflora, Euryops arabicus, Buxus pedicillata, Gnidia socotrana, Cocculus balourii* and many other plants (Miller and Cope 1996).

Checklist of species

Genus *Mormogystia*

reibellii (Oberthür, 1876), *Hypopta reibellii* Oberthür, 1876, Et. Ent. 1: 40, pl. 4: fig. 1. LT: Biskra [Algeria]. Distribution: North part of Saudi Arabia, North Oman, UAE, Israel, Egypt, Algeria, Libya, Tunisia, Mauritania, Niger, Chad.

= *Hypopta mussolinii* Turati, 1927, Atti Soc. Ital. Scienze Naturali 66: 322, fig. 5. LT: Giarabub [NE Libya].

= *Hypopta cognata* Krüger, 1939, Ann. Mus. Libico Storia Nat. V. 1: 331–332, Tav. 13: fig. 13–14. LT: Beni Ulid [Libya].

=*Hypopta reibelli* – Wiltshire, 1980b, Jour. Oman Stud. Special report 2: 189; An incorrect subsequent spelling of *reibellii* Oberthür, 1876.

proleuca (Hampson in Walsingham et Hampson, 1896), **stat. n.**, *Eremocossus proleuca* Hampson in Walsingham et Hampson, 1896, Proc. Zool. Soc. London: 276, pl. 10: 24. LT: Aden, Yerbury [South Yemen]. Distributuion: Southern Saudi Arabia (Asir Mountains), South Oman (Dhofar), Yemen.

equatorialis (Le Cerf, 1933), *Hypopta reibeli* (sic!) Obt. ssp. *equatorialis* Le Cerf, 1933, Bull. Soc. Entomol. France: 158. LT: Lokitang, dans les monts Lubur, au Nord du lac Rodolphe [Lokitaung, Lake Turkana, N Kenya]. Distribution: N Kenya.

brandstetteri Saldaitis, Ivinskis & Yakovlev sp. n.

Genus *Meharia*

philbyi Bradley, 1952, Entomologist, LXXXXV (1074): 241–242: LT: Arabia, Kashabiya [Saudi Arabia]. Distribution: Saudi Arabia, Yemen, Oman.

acuta Wiltshire, 1982, Fauna Saudi Arab., 4:276, pl. 1: fig. 3, 3a. LT: wadi Hanaka [Saudi Arabia]. Distribution: Saudi Arabia, Oman, Yemen.

hackeri Saldaitis, Ivinskis & Yakovlev sp. n.

tanganyikae Bradley, 1952, Entomologist, LXXXXV (1074): 242–244. LT: Tanganyika, Ngaruka. Distribution: E Africa.

semilactea (Warren et Rothschild, 1905), Novit. zool., 12: 32, pl. 4 (12). LT: Nakheila, R. Atbara [NW Sudan]. Distribution: Israel, Jordan, Saudi Arabia, Oman, UAE, Yemen, Egypt (Sinai peninsula), N Sudan, Morocco, Mauritania.

yakovlevi Saldaitis & Ivinskis, 2010a, Esperiana 15: 379. LT: hills near Hadibu, Socotra Island [Yemen]. N [North]. Distribution: Yemen (Socotra Isl.).

incurvariella incurvariella Chrétien, 1915, Ann. Soc. Ent. Fr., 1915: 368. LT: Biskra [Algeria]. Distribution: Algeria, Morocco.

= *Blalia vittata* Rungs, [1943], 1942, Bull. Soc. Sc. Maroc. 22 (1942): 174, pl. 1: fig. 17. LT: Maroc, Saharien, Od Khiruf [Morocco].

incurvariella persica (Wiltshire, 1946); *Blalia vittata persica* Wiltshire, 1946a, Proc. R. Ent. Soc. London, Ser. B, 15: 120. LT: Shiraz [Fars, SW Iran]. Distribution: Iran, Afghanistan, Pakistan.

tancredii Sutton, 1963, Ann. Mag. Nat. Hist. 6 (13): 365–366, fig. 1–2, 6. LT: Meyan Kaleh peninsula, N Iran. Distribution: N Iran.

scythica D. Komarov et Zolotuhin, 2005. Nota lepid. 28 (1): 52–53, fig. 1–4. LT: [Russia] Astrakhan Prov., Akhtuba Distr., passing-track Martovsky, outsk. Bolshoe Bogdo Mt. Distribution: Russia, Volgograd and Astrakhan regions.

fischeri Yakovlev & Saldaitis, 2008b, Eversmannia 15–16: 49. LT: Marokko [Morocco], Jbel Bani, 3 km S Tiggane, 18 km SW Tata. Distribution: Morocco.

avicenna Yakovlev, 2011, Neue Entomologische Nachrichten 66: 1–129. LT: Iran, Hashtijan, 90 km S Gom. Distribution: Iran.

Genus *Aethalopteryx*

atrirета (Hampson, 1910), *Phragmatoecia atrirета* Hampson, 1910a, Ann. Mag. Nat. Hist. 8 (6): 129; LT: Bechuanaland, Lake N'gami [Botswana]. Distribution: Botswana, S Africa.

obscurascens (Gaede, 1930), *Xyleutes obscurascens* Gaede, 1930, Gross-Schmett. Erde, 14: 547, Taf. 79h; LT: Maraquo, Centr. Abyss. [Central Ethiopia]. Distribution: Ethiopia.

obsolete (Gaede, 1930), *Xyleutes obscurascens obsolete* Gaede, 1930, Gross-Schmett. Erde, 14: 547, Taf. 79g; LT: White Nile [Central Sudan]. Distribution: Sudan, Tanzania, Swaziland.

steniptera (Hampson in Poulton, 1916), *Duomitus steniptera* Hampson in Poulton, 1916, Proc. Zoll. Soc. London: 166, pl. 2: fig. 31; LT: Somaliland, Mandera, 47 miles SW of Berbera [Somalia]. Distribution: Somalia.

pindarus (Fawcett, 1916), *Duomitus pindarus* Fawcett, 1916: 733; LT: Kenya, Kedai. Distribution: Kenya, Uganda, S Africa.

wiltshirei Yakovlev, 2009, Euroasian Entomol. J; LT: Saudi Arabia, Azir, Al Foqa, Olea-Dodonea Zone. Distribution: Saudi Arabia.

simillima (Hampson in Poulton, 1916), *Duomitus simillima* Hampson in Poulton, 1916, Proc. Zoll. Soc. London: 166, pl. 2: fig. 32; LT: Somalia, 47 miles SW of Berbera. Distribution: Somalia, Ethiopia.

grandiplaga (Gaede, 1930), *Xyleutes grandiplaga* Gaede, 1930: 547; LT: Chad, Oubangui, Chari, Bangui [Central African Rep.]. Distribution: Central African Rep., Congo.

tristis (Gaede, 1915), *Hyleutes tristis* Gaede, 1915, D. Ent. Ztschr. Iris, 28: 147–148. LT: Nama-Land [Namibia]. Distribution: Namibia, Kenya, S Africa.

mesosticta (Hampson in Poulton, 1916), *Duomitus mesosticta* Hampson in Poulton, 1916, Proc. Zool. Soc. London: 165, pl. 2, fig. 20; LT: Somalia, Mandera. Distribution: Somalia.

diksami Yakovlev & Saldaitis, 2010, Esperiana,Memoir 5:333–337; LT: C Socotra [Central Socotra] isld., Top of Diksam valley. Distribution: Socotra Island, Yemen.

squameus (Distant, 1902), *Duomitus squameus* Distant, 1902, Entomologist, 35: 213; LT: Transvaal, Pretoria (S Africa). Distribution: South Africa, Botswana, Mozambique, Malawi, Ghana, Angola, Tanzania.

= *Azygophleps atriplaga* Le Cerf, 1919b, Bull. Mus. Nat. Hist. Nat. 25: 30; LT: Rivière Kuando, frontière Sud-Est Angola-Rhodesia [Kwando Riv., W Angola].

dictyotephra (Clench, 1959), *Kyleutes* (sic!) *dictyotephra* Clench, 1959, Veröff. zool. St. Samml. Münch. 6: 13–14, pl. II: fig. 6–7; LT: SW Africa, Okahandja [Namibia]. Distribution: SW Africa.

nilotica Yakovlev, 2011, Neue Entomologische Nachrichten 66: 1–129. LT: Sudan, Blue Nile Prov., Wadi Medani. Distribution: Sudan.

anikini Yakovlev, 2011, Neue Entomologische Nachrichten 66: 1–129. LT: S Africa, Free State, 15 km S Bloemhof, Sandveld N.R., S 47°43'55"; E 25°45'06". Distribution: S Africa.

forsteri (Clench, 1959), *Xyleutes forsteri* Clench, 1959, Veröff. zool. St. Samml. Münch. 6: 14–15, pl. II: fig. 8–9; LT: SW Africa, Okahandja [Namibia]. Distribution: SW Africa.

gyldenstolpei (Aurivillius, 1925), *Xyleutes gyldenstolpei* Aurivillius, 1925, Ark. Zoology, 17A (32): 20; LT: Ituri [Congo, Ituri prov.]. Distribution: Congo.

masai Yakovlev, 2011, Neue Entomologische Nachrichten 66: 1–129. LT: Kenya, Kibwezi; Distribution: Kenya.

elf Yakovlev, 2011, Neue Entomologische Nachrichten 66: 1–129. LT: Somalia m., Kisimayo. Distribution: Somalia.

politzari Yakovlev, 2011, Neue Entomologische Nachrichten 66: 1–129. LT: Somalia m., Caanole Fluss. Distribution: Somalia, Tanzania, Kenya.

gazelle Yakovlev, 2011, Neue Entomologische Nachrichten 66: 1–129. LT: Kenya, South Coast, Marenche forest. Distribution: Kenya.

rudloffi Yakovlev, 2011, Neue Entomologische Nachrichten 66: 1–129. LT: Swaziland, Ndzevane area, Matala near Nsogo, 240 m, Akazien, Agaven Buscland, S 26°58'; E 031°58'. Distribution: Swaziland.

kisangani Yakovlev, 2011, Neue Entomologische Nachrichten 66: 1–129. LT: Rep. Congo (Zaire), 17 km N Kisangani, Masako Field Stat., 388 m, N 00°36'; E 25°15', 02–08.02.2008. Distribution: Zaire.

sulaki Yakovlev, 2011, Neue Entomologische Nachrichten 66: 1–129. LT: Kenya, Eastern Province, Umg. Meru, 2 km NE Isiolo, S 00°21.623; E 37°36.231. Distribution: Kenya.

Genus *Azygophleps*

liturata (Aurivillius, 1879), *Zeuzera liturata* Aurivillius, 1879, Öfversigt af Kongl. Vetenskaps-Akademiens 7: 48–49 LT: Damara [Namibia]. Distribution: Namibia, Botswana, S Africa (Gründberg, 1910; Vári et al., 2002).

= *Zeuzera aurivillii Kirby, 1892, Cat. Lep. Het.* **1***: 872; Replacement name for Zeuzera liturata Aurivillius, 1879.*

leopardina Distant, 1902, Entomologist 35: 213–214; LT: Transvaal, Pretoria. Distribution: S Africa, Zambia, Namibia, Kenya.

= *Azygophleps borchmanni* Grünberg, 1910, Denkschriften Med.-Naturwiss. Ges. Jena. Vierter Bd.: 140; LT: Rietfontein [E Namibia].

= *Azygophleps leopardinae* – Dalla-Torre, 1923, Lep. Cat.: 43; An incorrect subsequent spelling of Azygophleps leopardina Distant, 1902.

nubilosa Hampson, 1910; 1910a, Ann. Mag. Nat. Hist. 8 (6): 129. LT: Uganda. Distribution: Uganda, Tanzania, S Africa.

atrifasciata Hampson, 1910; 1910b, Proc. Zool. Soc. London: 481; LT: NE Rhodesia, Kalungwisi distr., High Plateau [Zambia]. Distribution: Zimbabwe, Zambia, Uganda, Kenya, Angola, Malawi, S Africa.

regia (Staudinger, 1891), *Zeuzera* (?) *regia* Staudinger, 1891, Dtsch. Entomol. Ztschr. Iris **4**: 253; LT: Hadjin [Turkey]. Distribution: Turkey, Pakistan, Iran, Iraq.

= *Zeuzera regina* – Wiltshire, 1957, Lep. Iraq: 146; An incorrect subsequent spelling of regia Staudinger, 1891.

afghanistanensis (Daniel, 1964), *Zeuzera regia afghanistanensis* Daniel, 1964, Opuscula Zool. **77**: 6; LT: O-Afghanistan, Sarobi, Gulbahar [E Afghanistan]. Distribution: Afghanistan.

albofasciata (Moore, 1879), *Zenzera* (sic!) *albofasciata* Moore, 1879a, Descr. of new ind. lep. ins. from the coll. of the late Mr. W.S. Atkinson, M.A., F.L.S. & C.,

director of the Public Instruction, Bengal: 87; LT: Darjiling [India]. Distribution: India, Pakistan.

confucianus Yakovlev, 2006; 2006b, Tinea 19 (3): 205–207, figs, 18–19, 54; LT: China, SE Tibet, Markam; Distribution: China (SE Tibet, NW Sichuan, Yunnan, Guizhou, Qinghai).

inclusa (Walker, 1856), *Zeuzera inclusa* Walker, 1856, List. Spec. Lepid. Ins. Brit. Mus. **7**: 1534; LT: Port Natal [Durban, South Africa]. Distribution: Kenya, Tanzania, Zambia, Angola, Malawi, Mosambique, Botswana, South Africa, Lesotho, Uganda, Congo, Ghana, Sierra Leone, Guinea, Republic of Côte d'Ivoire.

= *Zeuzera petax* Wallengren, 1860, Wien. Entomol. Monatshcr 4 (2): 43; LT: Caffraria orientali [S Africa].

larseni Yakovlev & Saldaitis, 2011, Neue Entomologische Nachrichten 66: 1–129. LT: S. [South] Oman, Dhofar, Rakyut. Distribution: Iraq, Iran, Oman, Yemen, Socotra island.

kovtunovitchi Yakovlev, 2011, Neue Entomologische Nachrichten 66: 1–129. LT: Lesotho, 45 km Mokhothand. Distribution: Lesotho.

sheikh Yakovlev & Saldaitis, 2011, Neue Entomologische Nachrichten 66: 1–129. LT: W Saudi Arabia, N-Asir, 40 km W Taif, Distribution: Saudi Arabia, Yemen.

sponda (Wallengren, 1875), *Zeuzera sponda* Walengren, 1875, Öfver. Kongl. Vetenskaps-Akad. Förh. 32 (1): 96; LT: Transvaalia [S Africa, Transvaal]. Distribution: S Africa.

cooksoni Pinhey, 1968; 1968, Ann. Transvaal Mus. 25 (9): 156, pl. 13: fig. 2; LT: Muden, Natal. Distribution: Southern Africa (Natal prov.).

melanophele Hampson, 1910; 1910a, Ann. Mag. Nat. Hist. 8 (6): 130; LT: S Nigeria, Sapele [Kenya]. Distribution: Central Africa.

ganzelkozikmundi Yakovlev, 2009, Euroasian Entomol. J. 8 (3): 359–360; LT: Uele, Paulis [Congo]. Distribution: Camerun, Congo.

asylas (Cramer, 1779), *Phalaena asylas* Cramer, 1779, De uitlandsche kapellen voorkomende in de drie waereld-deelen Asia, Africa en America, by een verzameld en beschreeven: 61–62, pl. CXXXVII (C); LT: Cape [S Africa]. Distribution: Central to Southern Africa.

= *Zeuzera strigulosa* Walker, 1856, List Spec. Lep. Ins. Brit. Museum 7: 1534;LT: Cape [S Africa].

= *Zeuzera canadensis* Herrich-Schäffer, [1854], Sammlung aussereuropäscher Schmetterlinge: 58, Fig. 168; LT: Quebec (error).

pusilla (Walker, 1856), *Zeuzera pusilla* Walker, 1856, List Spec. Lep. Ins. Brit. Museum 7: 1538; LT: North India. Distribution: India.

albovittata Bethune-Baker, 1908, Ann. Mag. Nat. Hist. (8) 2: 263; LT: N Nigeria, Lokoja District; Distribution: Nigeria, Ghana, Uganda, Congo, Kenya, Guinea, Zimbabwe.

pallens (Herrich-Schäffer, [1854]), *Phragmataecia pallens* Herrich-Schäffer, [1854], Samml. aussereurop. Schmett. 1 (1), Taf. [35]: 169; LT: Guinea. Distribution: Sierra-Leone, Uganda, Nigeria, Cameroon, Kenya, Sudan.

simplex Aurivillius, 1905, Owk. f. Zool. 2 (12): 42; LT: [Nigeria]. Distribution: Nigeria.
liliyae Yakovlev, 2011, Neue Entomologische Nachrichten, 66: 1–129. LT: Tanzania, Mbulu in town, 1800 m, S 03°52'00", E 035°32'17". Distribution: Tanzania.
legraini Yakovlev & Saldaitis, 2011, Neue Entomologische Nachrichten, 66: 1–129. LT: Cameroon, Adamaoua, nr. Ngaoundéré, Ngaoundaba; Distribution: Cameroon.
godswindow Yakovlev & Saldaitis, 2011, Neue Entomologische Nachrichten, 66: 1–129. LT: RSA [Republic South Africa], Mpumalanga, nr. Graskop, 1750 m, God's Window Rd. Distribution: S Africa.
otello Yakovlev, 2011, Neue Entomologische Nachrichten, 66: 1–129. LT: Mauritania, Boghe. Distribution: Mauritania.
equatorialis Yakovlev, 2011, Neue Entomologische Nachrichten, 66: 1–129. LT: ♂, Congo, Odzala NP, 0,23N; 14,50E. Distribution: Congo.
scalaris (Fabricius, 1775), *Phalaena* (*Hepialus*) *scalaris* Fabricius, 1775, Syst, Ent.: 590; LT: China; Distribution: Pakistan, India, China, Sri-Lanka, Maynmar, Thailand, Cambodia, Bangladesh, Mauritania, Somali, Senegal, Republic of Côte d'Ivoire, Ghana, Nigeria, Congo, Kenya, Angola, Namibia, Tanzania, Sudan.
= *Zeuzera bivittata* Walker, 1865, List Lep. Het. Brit. Mus. 32 (suppl. 2): 586–587; LT: North Hindostan.
aburae (Plötz, 1880), *Zeuzera aburae* Plötz, 1880, Ent. Zeit. Stetting: 77; LT: Bei Aburi [Ghana]. Distribution: Zimbabwe, Kenya, Ghana, Cameroon, Sudan.
boisduvalii (Herrich-Schäffer, 1854), *Zeuzera boisduvalii* Herrich-Schäffer, 1854, Samml. aussereurop. Schmett., 1 (1): 58, Taf. 35: 167; LT: Gatam (Sierra Leone). Distribution: Africa (Guinea, Sierra Leone, Ghana, Cameroon, Nigeria, Sudan, Ethiopia, Kenya, Uganda, Congo, Zambia, Zimbabwe, Senegal, Malawi, Republic of Côte d'Ivoire).

Table 1. Voucher and GenBank numbers for barcoded individuals (deposited in NRCV).

Mormogystia proleuca	QUNOD300-10	HQ970475
Mormogystia proleuca	QUNOD301-10	HQ970476
Mormogystia proleuca	QUNOD302-10	HQ970477
Mormogystia proleuca	QUNOD303-10	HQ970478
Mormogystia reibellii	QUNOD304-10	HQ970479
Mormogystia reibellii	QUNOD305-10	HQ970480
Mormogystia reibellii	QUNOD307-10	HQ970482
Meharia hackeri	QUNOD309-10	HQ970483
Meharia hackeri	QUNOD310-10	HQ970484
Meharia hackeri	QUNOD311-10	HQ970485
Meharia acuta	QUNOD312-10	HQ970486
Mormogystia brandstetteri	QUNOD336-10	HQ970510
Mormogystia brandstetteri	QUNOD337-10	HQ970511
Mormogystia brandstetteri	QUNOD338-10	HQ970512
Mormogystia brandstetteri	QUNOD339-10	HQ970513

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RESEARCH ARTICLE

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A new synonym of the Neotropical parasitoid wasp genus *Notiospathius* (Braconidae, Doryctinae), with redescription of two species and description of five new species from Brazil

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§ *urn:lsid:zoobank.org:author:A401BE09-6822-4933-8C09-CB5D8C0CE07E*
| *urn:lsid:zoobank.org:author:C517A10D-5274-42E8-9ACF-41C34FCC7D2C*
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Abstract

A junior synonym of the parasitoid wasp genus *Notiospathius* Matthews and Marsh, *Hansonorum* **syn. n.**, with two new combinations, *N. carolinae* (Marsh) **comb. n.** and *N. pauli* (Marsh) **comb. n.**, are proposed. Two species of *Notiospathius* from Brazil originally described in early twentieth century are redescribed, *N. caudatus* (Szépligeti) and *N. diversus* (Szépligeti). Five new species of *Notiospathius* from southern Brazil are also described: *N. atra* **sp. n.**, *N. johnlennoni* **sp. n.**, *N. novateutoniae* **sp. n.**, *N. sulcatus* **sp. n.**, and *N. xanthofasciatus* **sp. n.** Most of the type specimens of the above new species were collected in the mid twentieth century in the Nova Teutonia region, which is now part of the municipality of Seara in the state of Santa Catarina.

Keywords
parasitoid wasps, Brazil, *Notiospathius*, Dorcytinae, Braconidae

Introduction

The braconid subfamily Doryctinae represents one of the most speciose subfamilies of braconid parasitic wasps, with species distributed on all continents but being especially diverse in the tropics (Belokobylskij, 1992; Belokobylskij et al., 2004a,b; Marsh, 2002). In the Neotropical Region, *Notiospathius* Matthews and Marsh potentially represents the second most diverse doryctine genus, only after the cosmopolitan *Heterospilus*. Its extraordinary species richness, however, has largely been overlooked, with only 27 species described to date (Zaldívar-Riverón and De Jesús-Bonilla, 2010, 2011). *Notiospathius* was erected by Matthews and Marsh (1973) to contain 14 species from Central and South America that were originally placed in the mainly Holarctic and Oriental *Spathius*. Since then, only 15 additional species of *Notiospathius* have been described, all of them from Costa Rica (Marsh, 2002), whereas two of the species that were transferred in the description of the genus, *N. meliorator* (Fabricius) and *N. necator* (Fabricius), were found to belong to an undescribed doryctine genus that is similar to *Ptesimogaster* (Zaldívar-Riverón and De Jesús-Bonilla, 2010).

Recent molecular phylogenetic (Zaldívar-Riverón et al., 2007, 2008) studies suggested the paraphyletic nature of *Notiospathius* with respect to three small Neotropical doryctine genera: *Hansonorum* Marsh, *Masonius* Marsh, and *Tarasco* Marsh. Species of the above four genera are morphologically similar, all having different degrees of enlargement of the basal sternal plate of the first metasomal tergum (acrosternite *sensu* Belokobylskij, 1992). Species of *Masonius* and *Tarasco* can be mainly distinguished from those of *Notiospathius* and *Hansonorum* by absence of the fore wing vein r-m, lack of hind wing vein cu-a (only *Masonius*), and a face swollen between antennae and clypeus (only *Tarasco*) (Marsh, 1993). In contrast, species of *Hansonorum*, are only distinguished from those of *Notiospathius* by the presence of a basal tubercle on the hind coxa (Marsh, 2002), this being one of the features traditionally employed to separate supraspecific taxa in Doryctinae. The relationships recovered by the aforementioned molecular phylogenetic studies revealed that this tubercle was gained and lost on several occasions within the subfamily. Moreover, as confirmed in other doryctine genera (e.g. *Ptesimogaster* Marsh; Zaldívar-Riverón et al., 2010), recent molecular work has revealed that this morphological feature varies among closely related species or even intraspecifically in *Notiospathius/Hansonorum* (Ceccarelli et al., submitted).

Currently, only three described species assigned to *Notiospathius* have been recorded for Brazil despite the actual enormous richness of the genus in this country (Nunes, unpubl.): *N. caudatus* (Szépligeti), *N. diversus* (Szépligeti), and *N. leucacrocera* (Enderlein). In this work we describe five new species of *Notiospathius* from southern Brazil, considering *Hansonorum* to be a junior synonym of *Notiospathius* syn. n. [*N. carolinae*

(Marsh) comb. n., *N. pauli* (Marsh) comb. n.] based on the above molecular phylogenetic evidence. We also redescribe *N. caudatus* (Szépligeti) and *N. diversus* based on their holotypes, which were originally described more than a century ago (Szépligeti, 1902). We decided to maintain the generic status of *Masonius* and *Tarasco* until additional molecular and morphological information help us to confirm whether they should be synonymised with *Notiospathius*. Most of the type specimens belonging to the new species of *Notiospathius* described in this work were collected during the mid twentieth century in the municipality of Seara, formerly known as Nova Teutonia, in the state of Santa Catarina, by the German entomologist Fritz Plaumann. This region, which was originally composed of mainly Atlantic forest (Mata Atlântica), has been subject to intense deforestation over the last two decades (Baptista, 2008), illustrating the urgency for describing its highly overlooked biodiversity.

Methods

This study was based on material deposited in the following collections: The Natural History Museum, London, UK (NHML), Departamento de Ecologia e Biologia Evolutiva, Universidade Federal de São Carlos, São Carlos, SP, Brazil (DCBU), Colección Nacional de Insectos, Instituto de Biología, Universidad Nacional Autónoma de México (CNIN-UNAM), Hungarian Natural History Museum (HNHM) and Canadian National Collection of Insects, Ottawa, Canada (CNCI). The surface sculpture and wing venation terminologies employed follow Marsh (2002). Colour digital photographs were taken and edited with a Leica® Z16 APO-A stereoscopic microscope, a Leica® DFC295/ DFC290 HD camera, and the Leica Application Suite® program. Digital SEM photographs were taken with a FEI Quanta™ 250 SEM in low vacuum mode. Specimens assigned to the five new species described below were compared with type specimens belonging to most of the described species of *Notiospathius* (= *Hansonorum* syn. n.).

Taxonomy

***Notiospathius atra* De Jesús-Bonilla, Nunes, Penteado-Dias, Zaldívar-Riverón, sp. n.**
urn:lsid:zoobank.org:act:38C6BAEC-2C24-40CF-89F7-766D8DEBB3D7
http://species-id.net/wiki/Notiospathius_atra
Figs 1A–F

Diagnosis. This species differs from other described Brazilian species of *Notiospathius* by having the following combination of features: (1) fourth median tergite coriaceous basally (smooth in *N. caudatus*, *N. diversus*, *N. leucacrocera* and *N. novateutoniae* sp. n., smooth to rugose basally in *N. sulcatus* sp. n., costate on basal half, smooth on apical half in *N. xanthofasciatus* sp. n., costate basolaterally in *N. johnlennoni* sp. n.), (2) scutellar disc coriaceous-granulate (Fig. 1C) (coriaceous in *N. diversus* and *N. novateutoniae* sp. n.,

coriaceous-rugose in *N. xanthofasciatus* sp. n., smooth in *N. caudatus*, N. *johnlennoni* sp. n., *N. leucacrocera*, and *N. sulcatus* sp. n.), and (3) hind coxa with distinct tubercle at base (Fig. 1E) (also present in *N. diversus*, *N. novateutoniae* sp. n., and *N. xanthofasciatus* sp. n.).

Description. Female. *Colour*: Head dark brown to black, pedicel light brown to honey yellow; flagellomeres brown; palpi yellow. Mesosoma and first three metasomal terga black, remaining terga brown except the last one, which is light brown. Ovipositor and sheaths dark brown to black. Fore and middle femora and tibia brown, trochanter and trochantellus yellow, coxae light brown; hind coxa dark brown, trochanter and trochantellus yellow, femur and tibia brown, turning yellow at base; tarsi brown. Wings dusky, veins and stigma brown, tegula dark brown. *Body length*: 5.8 mm (lateral view), ovipositor 6.0 mm. *Head*: Clypeus granulate, face and frons striate-rugose, face with smooth area in the middle, vertex striate to striate-rugose, temple striate, gena smooth (Fig. 1A,B); eye 1.1 times higher than wide (lateral view); malar space 0.4 times eye height (lateral view); temple 0.4 times eye width (dorsal view); hypoclypeal depression elliptic; ocular-ocellar distance 2.4 times diameter of lateral ocellus; length of scape 1.5 times its width (frontal view); antenna with 31 flagellomeres. *Mesosoma*: Length of mesosoma twice its maximum height; pronotum laterally costate-rugose, pronotal groove wide and scrobiculate, propleuron costate on anterior half, finely coriaceous on posterior half; lateral mesoscutal lobes coriaceous, slightly rugose laterally, median mesoscutal lobe coriaceous, rugose posteriorly (Fig. 1C); notauli scrobiculate, meeting before scutellum at middle of mesoscutum in a large, longitudinally rugose area; scutellar disc coriaceous on anterior half, granulate on posterior half (Fig. 1C); mesopleural sulcus surrounding mesopleuron strongly scrobiculate, mesopleuron coriacoeus medially and ventrally (Fig. 1B); precoxal sulcus wide, scrobiculate, as long as mesopleuron; venter of mesosoma coriaceous; propodeum and metapleuron rugose-areolate, propodeum with slightly indicated median longitudinal carina running to basal half; apical lateral corners without distinct tubercles, spines over hind coxa indistinct. *Wings*: Fore wing length 3.8 times its maximum width, length of pterostigma 3.8 times its maximum width, vein r 0.22 length of vein 3RSa, vein m-cu reaching first submarginal cell before vein 2RS, vein 1cu-a distinctly postfurcal to vein 1M; hind wing vein M+CU 0.5 times length of vein 1M. *Legs*: Middle and hind femora coriaceous, hind coxa coriaceous ventrally, slightly coriaceous-rugose dorsally with distinct tubercle at base (Fig. 1E); middle tibia with a row of at least seven spines (Fig. 1F). *Metasoma*: First metasomal median tergite rugose to costate-rugose, length 1.9–2.1 times its apical width (dorsal view) (Fig. 1D); basal sternal plate (acrosternite) about 0.5 times length of tergum; second and third median tergites costate with rugose microsculpture (Fig. 1D); suture between second and third median tergites distinct and sinuate; fourth median tergite coriaceous basolaterally, remaining area smooth and polished; remaining median tergites smooth and polished; ovipositor about 1.9 times length of metasoma.

Male. Unknown.

Variation. Females: *Body length*: 4.7–5.8 mm (lateral view), ovipositor 4.7–6.0 mm. *Head:* Eye 1.0–1.2 times higher than wide (lateral view); malar space 0.3–0.5 times eye height (lateral view); antenna with 27–33 flagellomeres. *Wings*: Fore wing length 3.5–4.0 times its maximum width, length of pterostigma 3.6–3.8 times its

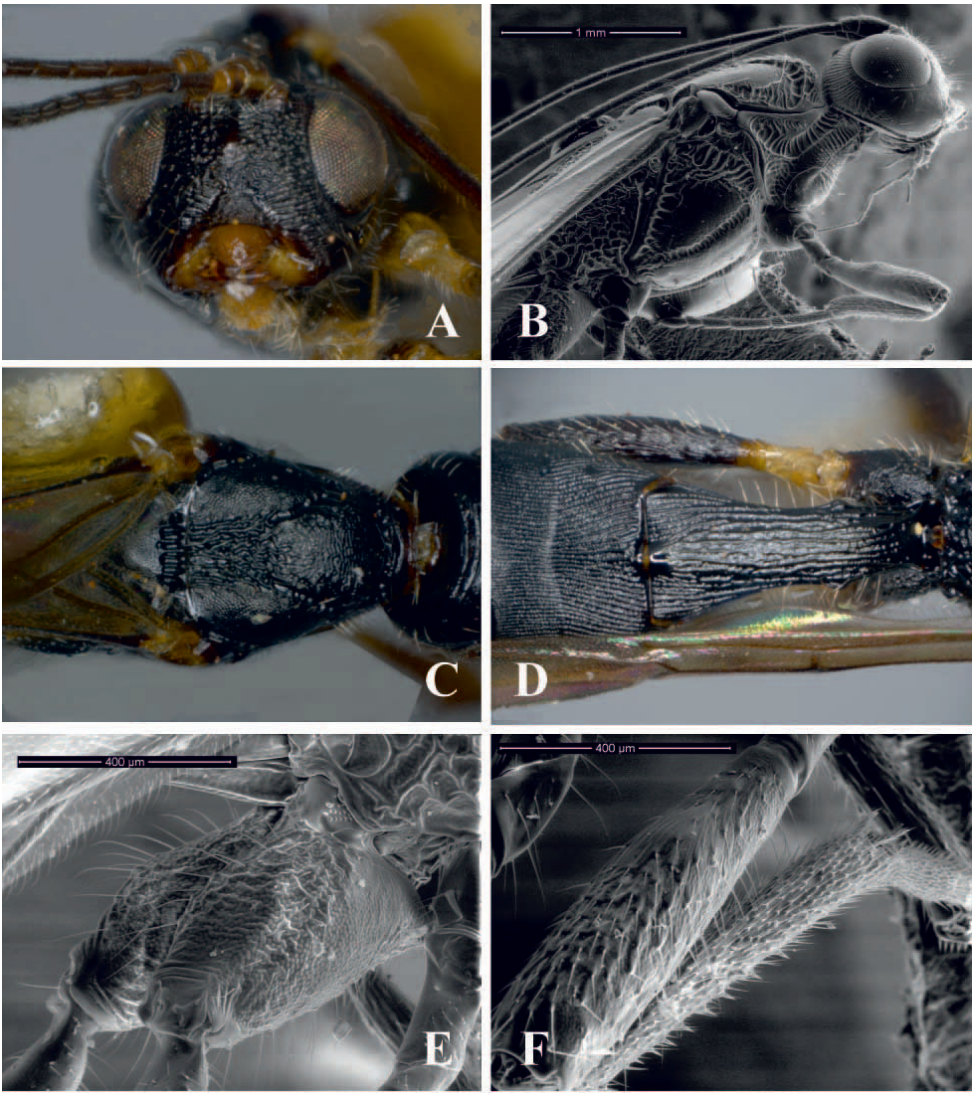

Figure 1. *Notiospathius atra* sp. n.: **A** head, frontal view **B** mesosoma and head, lateral view **C** mesoscutum, dorsal view **D** metasomal median tergites 1-3, dorsal view **E** hind coxa lateral view **F** middle leg with row of spines.

maximum width. *Metasoma*: length of first metasomal median tergite 1.9–2.1 times its apical width (dorsal view); ovipositor about 1.9–2.0 times length of metasoma.

Holotype. Female (NHML). "Brasil, Nova Teutonia, 27°11'B 52°23'L; 22-XI-1940; Fritz Plaumann coll, B. M. 1957-341".

Paratypes. Four females (NHML, CNIN-UNAM). Same data as holotype.

Biology. Unknown.

Etymology. From the Latin *atra*, meaning dark or black, due to the dark body colour of the species.

***Notiospathius caudatus* (Szépligeti)**
http://species-id.net/wiki/Notiospathius_caudatus
Figs 2A,B

Psenobolus caudatus Szépligeti, 1902
Notiospathius caudatus Matthews & Marsh, 1973

Diagnosis. This species differs from the remaining described Brazilian species of *Notiospathius* by having the following combination of features: (1) vertex striate (striate in *N. johnlennoni* sp. n. and *N. leucacrocera*, striate to striate-rugose in *N. atra*, rugose or striate-rugose in *N. diversus*, *N. novateutoniae* sp. n., *N. sulcatus* sp. n. and *N. xanthofasciatus* sp. n.), (2) scutellar disc smooth (Fig. 2B) (see *N. atra* diagnosis for character states of remaining species), (3) mesoscutal lobes coriaceous, transversally costate laterally (completely coriaceous in *N. leucacrocera*, with rugose areas in *N. atra*, *N. diversus*, *N. johnlennoni* sp. n., *N. novateutoniae* sp. n., *N. sulcatus* sp. n. and *N. xanthofasciatus* sp. n.), and (4) three first metasomal median tergites sculptured (only first two metasomal median tergites sculptured in *N. diversus*).

Description. Female. *Colour*: Head brown, scape and pedicel light brown; flagellomeres brown; palpi yellow. Mesosoma and first metasomal tergum black, remaining terga brown. Ovipositor and sheaths brown. Fore and middle coxae and basal third of femora light brown, trochanter and trochantellus pale yellow, apical two thirds of femora, tibiae and tarsi brown; hind coxa dark brown to black, trochanter and trochantellus pale yellow, femur brown, basal third of tibia light brown, turning brown apically, tarsi brown. Wings dusky, veins and stigma brown, tegula brown. *Body length*: 5.1 mm (lateral view), ovipositor 5.4 mm. *Head*: Clypeus transversally costate, face striate-rugose, frons and vertex striate, temple smooth, gena smooth; eye 1.2 times higher than wide (lateral view); malar space 0.4 times eye height (lateral view); temple 0.4 times eye width (dorsal view); hypoclypeal depression elliptic; ocular-ocellar distance 2.2 times diameter of lateral ocellus; length of scape 1.3 times its width (frontal view); antennae broken, 18–20 flagellomeres remaining. *Mesosoma*: Length of mesosoma 1.8 times its maximum height; pronotum laterally costate, pronotal groove wide and scrobiculate, propleuron costate on anterior half, smooth on posterior half; mesoscutal lobes coriaceous, transversally costate laterally, median mesoscutal lobe costate-rugose posteriorly (Fig. 2B); notauli wide, deep and scrobiculate, not meeting before scutellum, finishing in a large longitudinally costate-rugose area; scutellar disc smooth (Fig. 2B); mesopleuron porcate dorsally, coriaceous-rugose medially and ventrally; precoxal sulcus wide, scrobiculate, as long as mesopleuron (Fig. 2A); venter of mesosoma slightly coriaceous; propodeum and metapleuron rugose, with a series of longitudinal carinae (Fig. 2B), apical lateral corners without distinct tubercles, spines over hind coxa indistinct. *Wings*: Fore wing length 4.0 times its maximum width, length of pterostigma 4.0 times its maximum

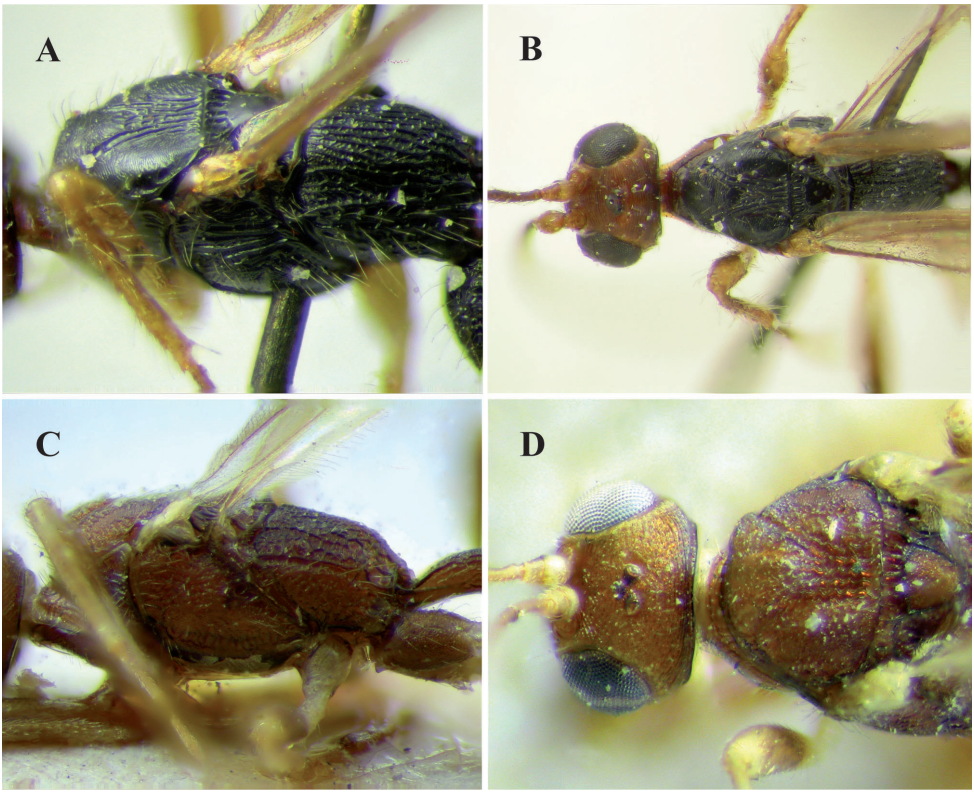

Figure 2. *Notiospathius caudatus*: **A** mesosoma, lateral view **B** Head and mesosoma, dorsal view; *Notiospathius diversus*: **C** mesosoma, lateral view **D** head and mesoscutum, dorsal view.

width, vein r 0.2 times length of vein 3RSa, vein m-cu interstitial to vein 2RS, vein 1cu-a interstitial to vein 1M; hind wing vein M +CU 0.4 times length of vein 1M. *Legs*: Middle and hind femora smooth to slightly coriaceous, hind coxa coriaceous ventrally, costate dorsally, without distinct tubercle at base; middle tibia with a row of at least six spines. *Metasoma*: First metasomal median tergite costate-rugose with coriaceous microsculpture; length 3.2 times its apical width (dorsal view); basal sternal plate (acrosternite) about 0.6 times length of tergum; second median tergite costate with rugose microsculpture; suture between second and third median tergites distinct and not sinuate; third median tergite costate with rugose microsculpture basally, remaining area smooth and polished; remaining median tergites smooth and polished; ovipositor about 2.0 times length of metasoma.

Male. Unknown.

Holotype. Female (HNHM). "Fonteboa, Brasil. Hym. Typ. No. 1605, Museum Budapest."

Biology. Unknown.

***Notiospathius diversus* (Szépligeti)**
http://species-id.net/wiki/Notiospathius_diversus
Figs 2C,D

Spathius diversus Szépligeti, 1902
Notiospathius diversus Matthews & Marsh, 1973

Diagnosis. This species differs from the remaining described species of *Notiospathius* by having the following combination of features: (1) vertex striate-rugose (Fig. 2D) (see *N. caudatus* diagnosis for character states of remaining species), (2) scutellar disc coriaceous (Fig. 2D) (see *N. atra* diagnosis for character states of remaining species), (3) mesoscutal lobes coriaceous, with large rugoe areas medially and laterally (see *N. caudatus* diagnosis for character states of remaining species), and (4) third metasomal median tergite smooth (scultpured in the remaining species).

Description. Female. *Colour*: Head brown, pedicel and scape light brown; flagellomeres light brown, turning brown to apex; palpi yellow. Mesosoma and first two metasomal terga brown, remaining terga dark brown. Ovipositor and sheaths yellow, turning brown to apex. Fore and middle coxae, trochanter and trochantellus yellow, femora, tibiae and tarsi light brown; hind coxa brown, trochanter, trochantellus and apical third of tibia yellow, basal two thirds of femur brown, tibia and tarsi light brown. Wings dusky, veins and stigma brown, tegula yellow. *Body length*: 3.8 mm (lateral view), ovipositor 2.3 mm. *Head*: Clypeus coriaceous, face, frons and vertex striate-rugose, temple striate, gena smooth; eye 1.2 times higher than wide (lateral view); malar space 0.4 times eye height (lateral view); temple 0.5 times eye width (dorsal view); hypoclypeal depression elliptic; ocular-ocellar distance three times diameter of lateral ocellus; length of scape 1.8 times its width (frontal view); antennae broken, 1–17 flagellomeres remaining. *Mesosoma*: Length of mesosoma 1.9 times its maximum height; pronotum laterally costate-rugose, pronotal groove wide and scrobiculate, propleuron costate; lateral mesoscutal lobes coriaceous, with large rugose areas medially and laterally, median mesoscutal lobe coriacoeus-rugose anteriorly, strongly rugose posteriorly (Fig. 2D); notauli scrobiculate, turning smooth on posterior third, not meeting before scutellum, finishing in a large longitudinally costate-rugose area (Fig. 2D); scutellar disc coriaceous; mesopleuron porcate-rugose dorsally, coriaceous-slightly rugose medially and ventrally (Fig. 2C); precoxal sulcus wide, scrobiculate, as long as mesopleuron; venter of mesosoma coriaceous; propodeum and metapleuron rugose-areolate, propodeum with a median longitudinal carina running to basal half; apical lateral corners without distinct tubercles, spines over hind coxa indistinct. *Wings*: Fore wing length 3.5 times its maximum width, length of pterostigma 4.0 times its maximum width, vein r 0.4 times length of vein 3RSa, vein m-cu postfurcal to vein 2RS, vein 1cu-a distinctly postfurcal to vein 1M; hind wing vein M +CU about 0.5 times length of vein 1M. *Legs*: Middle and hind femora slightly coriaceous, hind coxa coriaceous dorsally, costate ventrally, with a distinct tubercle at base; spines on middle tibia not visible due to leg position. *Metasoma*: First metasomal median tergite rugose basally, turning costate with coriaceous microsculpture costate medially and apically, length 2.0 times its apical width (dorsal view); basal sternal plate (acrosternite) about 0.5 times length of tergum;

second median tergite slightly costate-coriaceous anteriorly, remaining area smooth; suture between second and third median tergites distinct and slightly sinuate; remaining median tergites smoothand polished; ovipositor about 0.9 times length of metasoma.

Male. Unknown.

Holotype. Female (HNHM). "Brasilien, Blumenau, 738-47, Hym. Typ. No. 1604."

Biology. Unknown.

***Notiospathius johnlennoni* De Jesús-Bonilla, Nunes, Penteado-Dias, Zaldívar-Riverón, sp. n.**

urn:lsid:zoobank.org:act:FF0548AB-A220-475D-AEB8-3FB259163C1F
http://species-id.net/wiki/Notiospathius_johnlennoni
Figs 3A–F

Diagnosis. This species differs from the remaining described Brazilian species of *Notiospathius* by having the following combination of features: (1) most flagellomeres bicoloured, brown on basal half, turning honey yellow apically (flagellomeres having one colour in the remaining species), (2) fourth median tergite costate basolaterally (Fig. 3E) (see *N. atra* diagnosis for character states of remaining species), and (3) fifth median tergite usually with striate microsculpture basolaterally (Fig. 3E) (smooth and polished in the remaining species).

Description. Female. *Colour*: Head brown to light brown, eye orbits honey yellow; scape brown to light brown, pedicel light brown; first flagellomere light brown, following flagellomeres bicoloured, brown on basal half, turning honey yellow apically, apical eight flagellomeres yellow; palpi yellow. Mesosoma and first metasomal tergum dark brown to black, remaining terga brown. Ovipositor and sheaths light brown, dark brown at apex. Fore and middle coxae and trochantellus light brown to brown, femora and tibiae brown; hind coxa dark brown to black, trochanter and trochantellus light brown, femur brown, tibia brown basally, turning yellow apically; tarsi brown. Wings dusky, stigma and veins brown, tegula yellow to light brown. *Body length*: 6.5 mm (lateral view), ovipositor 7.0 mm. *Head*: Clypeus granulate-rugose, face and frons striate-rugose, vertex striate to striate-rugose, temple striate, gena smooth (Fig. 3A); eye 1.5 times higher than wide (lateral view); malar space 0.4 times eye height (lateral view); temple 0.6 times eye width (dorsal view); hypoclypeal depression elliptic; ocular-ocellar distance 2.4 times diameter of lateral ocellus; length of scape 1.6 times its width (frontal view); antenna with 29 flagellomeres. *Mesosoma*: Length of mesosoma twice its maximum height; pronotum laterally costate-rugose, pronotal groove strongly scrobiculate, propleuron costate; mesoscutal lobes transversally costate-rugose laterally, slightly coriaceous medially (Fig. 3C); notauli scrobiculate anteriorly, meeting before scutellum at middle of mesoscutum in a large costate-rugose area (Fig. 3C); scutellar disc smooth; mesopleuron porcate dorsally, smooth-slightly rugose medially and ventrally (Fig. 3B); precoxal sulcus wide, scrobiculate, as long as mesopleuron; venter of mesosoma slightly rugose; propodeum and metapleu-

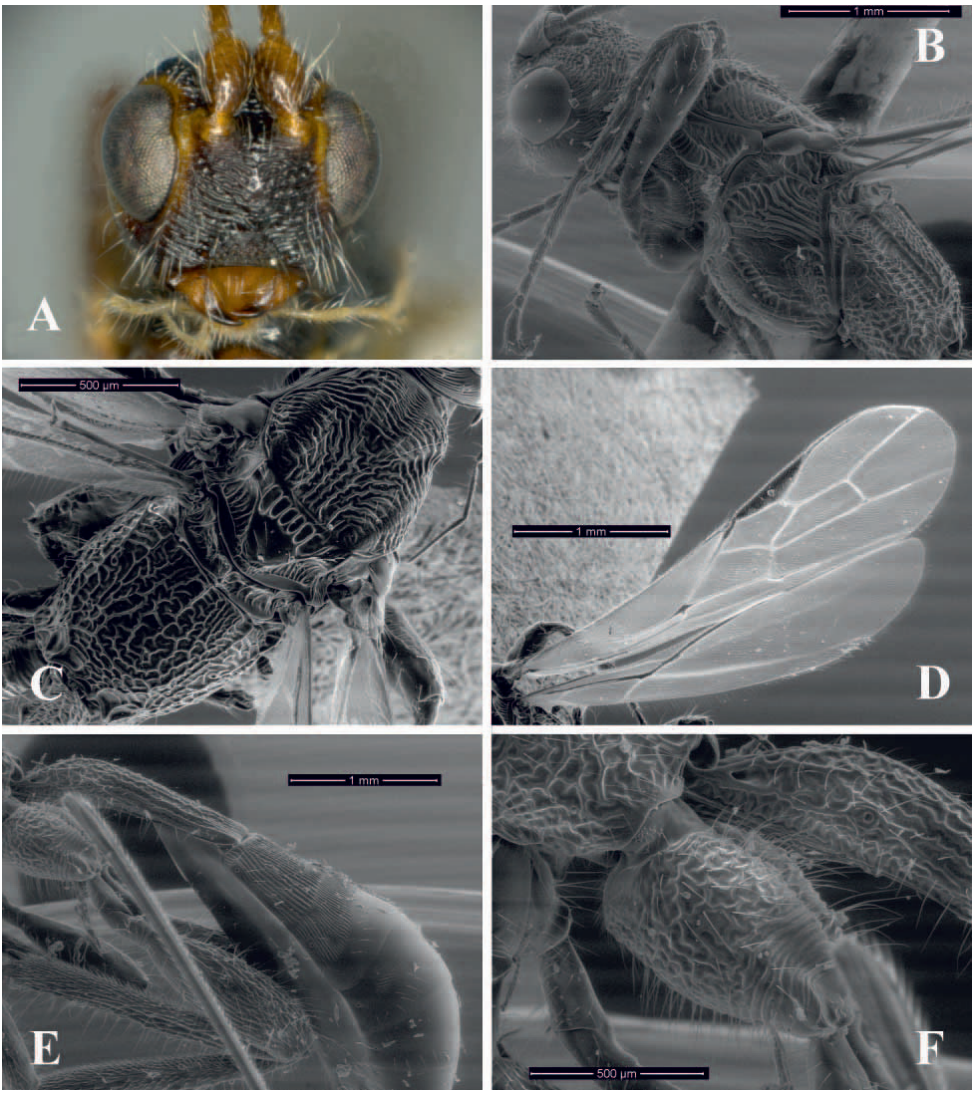

Figure 3. *Notiospathius johnlennoni* sp. n.: **A** head, frontal view **B** mesosoma and head, lateral view **C** mesosoma, dorsal view **D** fore and hind wings **E** metasoma, lateral view **F** hind coxa, lateral view.

ron rugose-areolate, propodeum with a slightly indicated median longitudinal carina running to basal half; apical lateral corners without distinguishable tubercles, spines over hind coxae short and blunt. *Wings*: Fore wing length 3.8 times its maximum width, length of pterostigma 5.0 times its maximum width, vein r about 0.2 times length of vein 3RSa, vein m-cu interstitial or slightly postfurcal to vein 2RS, vein 1cu-a interstitial with vein 1M (Fig. 3D); hind wing vein M+CU 0.4–0.45 length of vein 1M. *Legs*: Fore and middle femora rugose dorsally, hind femur costate-rugose dorsally, slightly rugose-coriaceous ventrally; hind tibia densely pilose, middle tibia with a row of at least four spines; hind coxa without tooth or tubercle at base (Fig.

3F). *Metasoma*: First metasomal median tergite rugose basally, turning costate-rugose apically, length 2.6–3.1 times its apical width (dorsal view); basal sternal plate (acrosternite) about 0.7 times length of tergum; second median tergite costate with rugose microsculpture; suture between second and third median tergites poorly defined and straight dorsally; third median tergite costate (Fig. 3E); fourth median tergite costate basolaterally, remaining area smooth and polished; fifth median tergite usually with striate microsculpture basolaterally; remaining median tergites smooth and polished; ovipositor about two times length of metasoma.

Male. Smaller than female. Body length 3.8 mm.

Variation. Female. *Colour*: apical 3-8 flagellomeres yellow. *Body length*: 5.3–7.0 mm (lateral view), ovipositor 5.8–9 mm. *Head*: Eye 1.3–1.6 times higher than wide (lateral view); malar space 0.4–0.5 times eye height (lateral view); ocular-ocellar distance 2.0–2.6 times diameter of lateral ocellus; length of scape 1.5–1.8 times its width (frontal view); antenna with 25–36 flagellomeres. *Wings*: Fore wing length 3.8–4.0 times its maximum width, length of pterostigma 4.8–5.0 times its maximum width. *Metasoma*: Length of first metasomal median tergite 2.8 times its apical width (dorsal view).

Holotype. Female (NHML). "Brasil, Nova Teutonia, 27°11'B 52°23'L; 3-XI-1938; Fritz Plaumann coll, B. M. 1938-632".

Paratypes. Fourteen specimens, 10 females, four males. One female (DCBU), "Jundiai do Sul, PR, Brasil, Faz. Monte Verde, Lev. Ent. PROFAUPAR, 11/1/1998, armadilha Malaise"; one female (CNCI), "Brasil, Nova Teutonia, 27°11'B 52°23'L; 21-II-1960; Fritz Plaumann coll."; remaining specimens (NHML, CNIN-UNAM) with same data as holotype.

Biology. Unknown.

Etymology. This species is named in honour of the 30th anniversary of the death of the British musician John Lennon in 2010.

***Notiospathius novateutoniae* De Jesús-Bonilla, Nunes, Penteado-Dias, Zaldívar-Riverón, sp. n.**

urn:lsid:zoobank.org:act:869C46BC-61D9-40AC-B8E7-220E22D065ED
http://species-id.net/wiki/Notiospathius_novateutoniae
Figs 4A–H

Diagnosis. This species differs from the remaining Brazilian species of *Notiospathius* by having: (1) suture between second and third median tergites strongly sinuate, with two lateral, subparallel depressions (Fig. 4E) (not sinuate and without subparallel depressions in the remaining species), (2) fourth median tergite costate on basal half, smooth on apical half (see *N. atra* diagnosis for character states of remaining species), and (3) hind coxa with a distinct tubercle at base (Fig. 4F) (see *N. atra* diagnosis for character states of remaining species).

Description. Female. *Colour*: Head brown to light brown, scape and pedicel light brown to honey yellow; flagellomeres light brown, turning brown to apex; palpi honey

yellow to white. Mesosoma and first metasomal tergum brown (Fig. 4E,H), second to fourth terga light brown to honey yellow, remaining terga brown except the last one, which is honey yellow. Ovipositor and sheaths light brown, dark brown at apex. Fore and middle coxae, trochanter, trochantellus, tibiae and tarsi pale yellow; all femora brown to light brown; hind coxa and tarsus brown to light brown, hind tibia brown to light brown with pale yellow base. Wings slightly dusky, veins brown, stigma brown with yellow base, tegula honey yellow. *Body length*: 6.0 mm (lateral view), ovipositor 5.0 mm. *Head*: Clypeus granulate-rugose, face and frons striate-rugose, vertex striate-rugose to rugose near ocelli, temple striate, gena smooth (Fig. 4A,B); eye 1.3 times higher than wide (lateral view); malar space 0.6 times eye height (lateral view); temple 0.7 times eye width (dorsal view); hypoclypeal depression elliptic; length of scape 1.5 times its width (frontal view); antenna with 28 flagellomeres. *Mesosoma*: Length of mesosoma around 1.8 times its maximum height; pronotum laterally costate-rugose, pronotal groove strongly scrobiculate, propleuron costate-rugose; mesoscutal lobes coriaceous medially, transversally costate-rugose laterally; notauli scrobiculate anteriorly, not joining, interrupting before scutellum at middle of mesoscutum in a large costate-rugose to rugose area (Fig. 4D); scutellar disc coriaceous; mesopleuron porcate-rugose dorsally, coriaceous medially and ventrally (Fig. 4C,H); precoxal sulcus wide, scrobiculate, as long as mesopleuron; venter of mesosoma slightly rugose-coriaceous; propodeum and metapleuron rugose-areolate, propodeum without distinct longitudinal carina or areola, without propodeal spines or tubercles. *Wings*: Fore wing length 3.7 its maximum width, length of pterostigma 3.6 times its maximum width, vein r about 0.3 length of vein 3RSa, vein m-cu interstitial or slightly basal to vein 2RS, vein 1cu-a postfurcal to vein 1M; hind wing vein M+CU 0.6 length of vein 1M. *Legs*: Hind coxa rugose dorsally, coriaceous ventrally, with a well-defined tubercle at base (Fig. 4F); tibiae and femora coriaceous, middle tibia with a row of at least seven spines. *Metasoma*: First metasomal median tergite costate apically, rugose basally, with coriaceous microsculpture, length 1.6 times its apical width (dorsal view) (Fig. 4G); basal sternal plate (acrosternite) 0.6 times length of tergum; second median tergite costate with coriaceous microsculpture medially; suture between second and third median tergites strongly sinuate, with two lateral, subparallel depressions (Fig. 4G); suture between third and fourth median tergites indistinct; remaining median tergites smooth and polished; ovipositor about 1.6 times length of metasoma.

Male. Smaller than female. Body length 3.0–3.6 mm.

Variation. Females. *Body length*: 4.3–6.0 mm (lateral view), ovipositor 3.7–5.0 mm. *Head*: Eye 1.1–1.3 times higher than wide (lateral view); malar space 0.5–0.6 times eye height (lateral view); antenna with 23–28 flagellomeres. *Wings*: Fore wing length 3.6–3.7 its maximum width. *Metasoma*: Length of first metasomal median tergite 1.5–1.6 times its apical width (dorsal view); basal sternal plate (acrosternite) 0.5–0.6 times length of tergum.

Holotype. Female (NHML). “Brasil, Nova Teutonia, 27°11'B 52°23'L; 16-VIII-1944; Fritz Plaumann coll, B. M. 1938-632”.

Paratypes. Ninety specimens, 85 females, 10 males. (NHML, CNIN-UNAM). Same data as holotype.

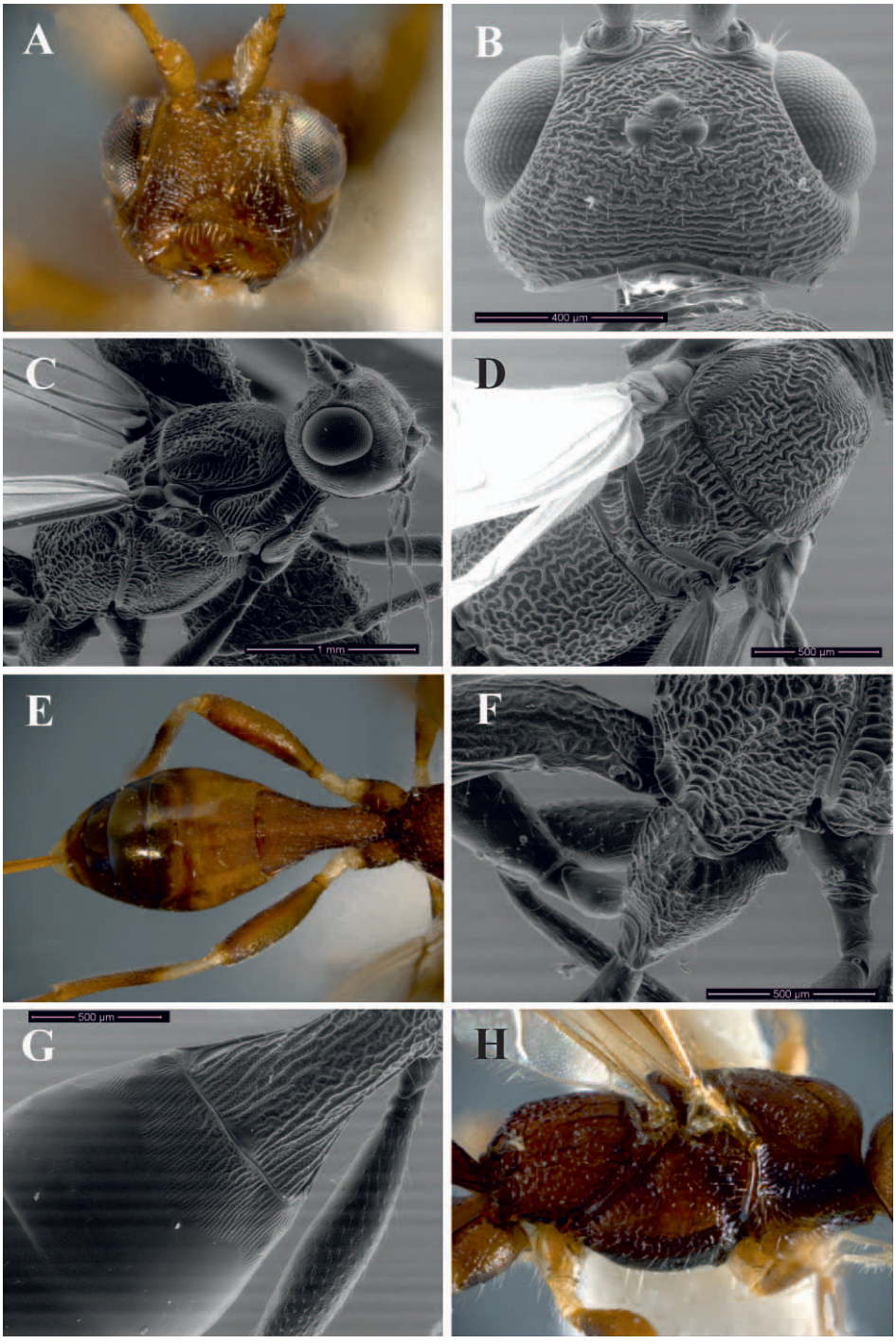

Figure 4. *Notiospathius novateutoniae* sp. n.: **A** head, frontal view **B** head, dorsal view **C** mesosoma and head, lateral view **D** mesosoma, dorsal view **E** metasoma, dorsal view **F** hind coxa, lateral view **G** metasomal median tergites 1-3, dorsal view **H** mesosoma, lateral view.

Biology. Unknown.

Etymology. The name *novateutoniae* refers the previous name of the type locality of this and all species described in this study, Nova Teutonia. This municipality is currently named as Seara and is located in the state of Santa Catarina, in the south of Brazil.

***Notiospathius sulcatus* De Jesús-Bonilla, Nunes, Penteado-Dias, Zaldívar-Riverón, sp. n.**

urn:lsid:zoobank.org:act:DB5A6568-FACB-4545-8CEC-0AA249AD1C7D
http://species-id.net/wiki/Notiospathius_sulcatus
Figs 5A–D

Diagnosis. This species differs from the remaining described Brazilian species of *Notiospathius* by having the following combination of features: (1) median mesoscutal lobe with a deep longitudinal groove running medially (Fig. 5C) (absent in the remaining species), (2) mesopleuron smooth medially and ventrally (Fig. 5B) (coriaceous in *N. atra* and *N. novateutoniae*, rugose-coriaceous in *N. xanthofasciatus* sp. n., coriaceous-rugose in *N. caudatus*, coriaceous-rugose in *N. diversus*, smooth-rugose in *N. johnlennoni* and *N. leucacrocera*), (3) venter of mesopleuron and venter of propodeum dark brown to black, contrasting with the light brown colour of the remainder of the mesosoma (Fig. 5B) (with different coloration in the remaining species), and (4) face, frons and vertex strongly rugose or striate-rugose (Fig. 5A) (not strongly rugose in the remaining species).

Description. Female. *Colour*: Head brown, orbit surrounding eyes light brown; scape light brown, with a longitudinal brown stripe laterally, pedicel brown; first flagellomere brown, following flagellomeres light brown, turning brown at apex, seven apical flagellomeres yellow; palpi white to pale yellow. Mesosoma light brown; propleuron and pronotal groove region brown to dark brown; lateral mesoscutal lobes brown medially; venter of mesopleuron and venter of propodeum dark brown to black. First metasomal tergum light brown to brown, remaining terga light brown to pale yellow, with sutures between median tergites brown. Ovipositor and sheaths honey yellow to light brown, dark brown to black at apex. Legs honey yellow to brown, usually with fore and middle coxae, trochanter and trochantellus lighter. Wings slightly dusky, stigma,veins and tegula light brown to honey yellow. *Body length*: 6.5 mm (lateral view), ovipositor 7.2 mm. *Head*: Clypeus granulate-rugose, face striate-rugose, frons and vertex rugose to striate-rugose, temple striate, gena smooth (Fig. 5A); eye 1.4 times higher than wide (lateral view); malar space 0.5 times eye height (lateral view); temple 0.5 times eye width (dorsal view); hypoclypeal depression elliptic; ocular-ocellar distance 3.2 times diameter of lateral ocellus; length of scape 1.7 times its width (frontal view); antenna with 34 flagellomeres. *Mesosoma*: Length of mesosoma twice its maximum height; pronotum laterally costate to costate-rugose, pronotal groove smooth to weakly scrobiculate, propleuron costate anteriorly, smooth posteriorly; mesoscutal lobes transversally costate to costate-rugose, median mesoscutal lobe costate-coriaceous medially, with a deep longitudinal groove running medially; notauli deep and scrobiculate, meeting before scutellum at middle of mesoscutum in a large costate-rugose

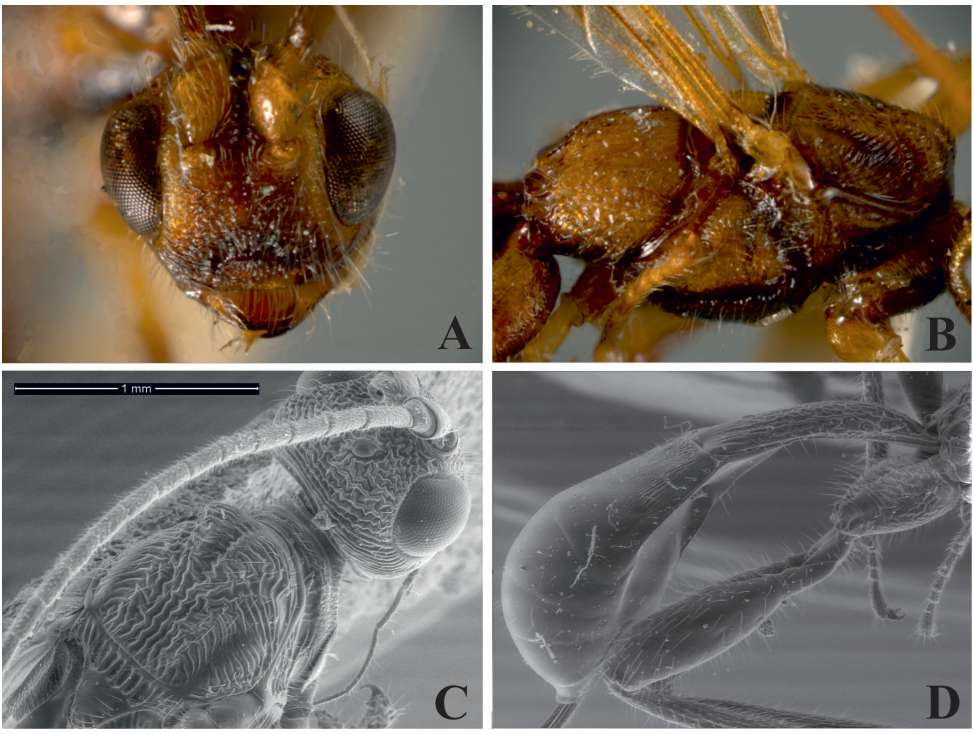

Figure 5. *Notiospathius sulcatus* sp. n.: **A** head, frontal view **B** mesosoma, lateral view **C** mesoscutum and head, dorsal view **D** metasoma, lateral view.

area (Fig. 5C); scutellar disc smooth; mesopleuron porcate dorsally, smooth medially and ventrally, slightly costate-rugose antero-ventrally (Fig. 5B); precoxal sulcus wide, scrobiculate, as long as mesopleuron; venter of mesosoma smooth; propodeum and metapleuron entirely rugose, without visible median carina or areola; apical lateral corners without distinguishable tubercles, spines over hind coxae short and slightly pointed. *Wings*: Fore wing length 3.5 times its maximum width, length of pterostigma 4.7 times its maximum width, vein r about 0.2 length of vein 3RSa, vein m-cu interstitial with vein 2RS, vein 1cu-a slightly to distinctly postfurcal to vein 1M; hind wing vein M+CU 0.5 length of vein 1M. *Legs*: Hind coxa rugose ventrally, costate dorsally without tooth or tubercle at base; middle tibia with a row of at least seven spines. *Metasoma*: First metasomal median tergite rugose basally, turning costate-rugose apically, length around 3.2 times its apical width (lateral view) (Fig. 5D); basal sternal plate (acrosternite) about 0.6 times length of tergum; second median tergite costate with rugose microsculpture (Fig. 5D); third median tergite finelly costate; suture between second and third median tergites weakly sinuate; suture between third and fourth median tergites almost indistinct; remaining median tergites smooth and polished; ovipositor 2.5 times length of metasoma.

Male. Smaller than female. Fourth metasomal median tergite rugose basally, mesosoma of some specimens slightly darker than females; suture between third and fourth median tergites considerably curved to base.

Variation. Females. *Colour*: seven to 10 apical flagellomeres yellow. *Body length*: 6.0–8.0 mm (lateral view), ovipositor 5.2–10 mm. *Head*: Eye 1.3–1.4 times higher than wide (lateral view); malar space 0.4–0.6 times eye height (lateral view); ocular-ocellar distance 3.0–3.8 times diameter of lateral ocellus; antenna with 30–38 flagellomeres. *Wings*: Fore wing length 3.0–3.9 times its maximum width, length of pterostigma 4.2–5.0 times its maximum width. *Metasoma*: ovipositor 2.3–2.5 times length of metasoma.

Holotype. Female (NHML). "Brasil, Nova Teutonia, 27°11'B 52°23'L; 4-V-1938; Fritz Plaumann coll, B. M. 1938-682".

Paratypes. Twenty one specimens, 12 females, nine males. One female (CNCI), "Brazil, Est. Rio de Janeiro, Silva Jardim, III.1974, F. M. Oliveira col."; one female (DCBU), "BIOTA-FAPESP, Nova Iguaçú, RJ, Brasil, Reserva Biológica do Tinguá, 6-9.III.2002, Moericke, 5ª trilha, S.T.P. Amarante col."; two females (DCBU), "BIOTA-FAPESP, Sta. Maria Madalena, RJ, Brasil, Parque Estadual do Desengano, 16-19.IV.2002, 560m, Moericke, 2ª Trilha Bosque, Penteado-Dias col.", and "20-23.IV.2002, 2ª Bosque, Penteado-Dias col."; two females, one male (DCBU) "BIOTA-FAPESP, Santa Tereza, ES, Brasil, Est. Biol. Sta. Lúcia, 749, 755, and 867 m, respectively, 9-12.IV.2001, Moericke, ponto T2, C.O. Azevedo & equip col."; one female (DCBU), "BIOTA-FAPESP, Pque. Est. Intervales, SP, Brasil, Base Barra Grande, Trilha da Anta, 11-14.XII.2000, Moericke, Ponto B9, M.T. Tavares e equioe col."; one female (DCBU), "Ubatuba, SP, Brasil, 29.I.1990, N.F. Cristo col."; one female (DCBU), "BIOTA-FAPESP, Morretes, PR, Brasil, Parque Est. do Pau Oco, 11-14.IV.2002, Moericke, Ponto 6 Bosque, M.T. Tavares e equipe col."; one male (DCBU), "BIOTA-FAPESP, Nova Iguaçú, RJ, Brasil, Reserva Biológica do Tinguá, Varredura, Ponto 13, 8.III.2002, S.T.P. Amarante col."; one male (DCBU), "BIOTA-FAPESP, Sta. Maria Madalena, RJ, Brasil, Parque Estadual do Desengano, 20.IV.2002, 560m, Varredura, 15:32 a 15:37, Penteado-Dias col."; five males (DCBU), "BIOTA-FAPESP, Santa Tereza, ES, Brasil, Est. Biol. Sta. Lúcia, 755m, 7.IV.2001, Varredura Pto. 7; 8.IV.2001 Varredura Pto. 21; 867m 11.IV.2001, Varredura Pto. 48 (two of these males with 867m 11.IV.2001, Varredura pto 44, C.O. Azevedo & equip col.)"; one male (DCBU), "BIOTA-FAPESP, Peruíbe, SP, Brasil, Est. Ecol. Juréia-Itatins, 5.V.2002, Varredura 29, Bosque, N.W. Periotto e equip ecol."; remaining specimens (NHML, CNIN-UNAM) with same data as holotype.

Biology. Unknown.

Etymology. From the perfect passive infinitive Latin word *sulco*, referring to the deep longitudinal groove that runs along the median mesoscutal lobe in this species.

Notiospathius xanthofasciatus De Jesús-Bonilla, Nunes, Penteado-Dias, Zaldívar-Riverón, sp. n.

urn:lsid:zoobank.org:act:D9A2FEA7-2105-4880-9EED-83AEF1EEEF94
http://species-id.net/wiki/Notiospathius_xanthofasciatus
Figs 6A–D

Diagnosis. This species differs from the remaining described Brazilian species of *Notiospathius* by having the following combination of features: (1) hind femur brown with

Figure 6. *Notiospathius xanthofasciatus* sp. n.: **A** mesosoma and head, lateral view **B** mesosoma, dorsal view **C** metasomal median tergites 1-3, dorsal view **D** metasoma, dorsal view.

yellow transverse stripe in the middle (Fig. 6C) (hind femur without yellow transverse stripe in the remaining species), (2) fourth metasomal median tergite sculptured on basal half (Fig. 6D) (see *N. atra* diagnosis for character states of remaining species), (3) mesopleuron rugose dorsally (Fig. 6A) (at least partially porcate or coriaceous dorsally in the remaining species), and (4) hind coxa with a distinct tubercle at base (see *N. atra* diagnosis for character states of remaining species).

Description. Female. *Colour*: Head brown to light brown, eye orbits yellow; scape and pedicel honey yellow; flagellomeres honey yellow, turning brown at apex; palpi yellow to white. Mesosoma and first metasomal tergum brown to dark brown, remaining terga brown except the last one, which is light brown. Ovipositor and sheaths light brown, dark brown to black at apex. Fore and middle coxae, trochanter and trochantellus yellow, fore femur yellow, turning brown dorsally, middle femur brown with a lighter transversal stripe medially, fore and middle tibiae light brown; hind coxa dark brown to black, trochanter and trochantellus yellow, femur brown with yellow transverse stripe medially, tibia light brown, turning yellow to white apically; tarsi light brown to honey yellow. Wings dusky, veins brown, stigma brown with yellow at extreme base, tegula honey yellow to ligth brown. *Body length*: 5.0 mm, ovipositor 6.0 mm. *Head*: Clypeus granulate, face striate-rugose, frons striate-rugose to rugose, vertex strongly rugose anteriorly, striate-rugose posteriorly, temple striate, gena smooth; eye 1.2 times higher than

wide (lateral view); malar space 0.5 times eye height (lateral view); temple 0.3 times eye width (dorsal view); hypoclypeal depression elliptic; ocular-ocellar distance 2.3–2.6 times diameter of lateral ocellus; length of scape 1.6 times its width (frontal view); antenna with 32 flagellomeres. *Mesosoma*: Length of mesosoma about twice its maximum height; pronotum laterally costate-rugose, pronotal groove wide and scrobiculate, propleuron costate-coriaceous; mesoscutal lobes strongly rugose, with a median, transverse coriaceous area (Fig. 6B); notauli scrobiculate, meeting before scutellum at middle of mesoscutum in a large rugose area (Fig. 6B); scutellar disc coriaceous- rugose; mesopleuron rugose dorsally, rugose-coriaceous medially and ventrally (Fig. 6A); precoxal sulcus wide, scrobiculate, as long as mesopleuron; venter of mesosoma coriaceous, region near precoxal sulcus slightly transversely striate; propodeum and metapleuron rugose, propodeum without median longitudinal carina or areola; apical lateral corners without tubercles, spines over hind coxae absent. *Wings*: Fore wing length 4.1 times its maximum width, length of pterostigma 5.3 times its maximum width, vein r 0.2 times length of vein 3RSa, vein m-cu interstitial with vein 2RS, vein 1cu-a interstitial with vein 1M; hind wing vein M+CU 0.6 times length of vein 1M. *Legs*: Hind coxa rugose-coriaceous, with a well-defined tubercle at base; fore, middle and hind tibiae granulate; fore, middle and hind femora coriaceous; middle tibia with a row of at least seven spines. *Metasoma*: First metasomal median tergite rugose basally, costate-rugose apically, length 2.8 times its apical width (lateral view); basal sternal plate (acrosternite) about 0.6 times length of tergum (Fig. 6C,D); second and third median tergites costate with rugose microsculpture, sutures between second and third and third and fourth median tergites distinct and sinuate; fourth median tergite costate on basal half, smooth on apical half (Fig. 6D); remaining median tergites smooth and polished; ovipositor 1.5 times length of metasoma.

Male. Smaller than female. Body length 3.7 mm.

Variation. Female. *Body length*: 4.5–6.0 mm. *Head*: eye 1.1–1.2 times higher than wide (lateral view); malar space 0.4–0.5 times eye height (lateral view); ocular-ocellar distance 2.3–2.6 times diameter of lateral ocellus; length of scape 1.4–1.6 times its width (frontal view); antenna with 30–32 flagellomeres. *Wings*: Length of pterostigma 5.0–5.3 times its maximum width. *Metasoma*: Length of first metasomal median tergite 2.6–2.9 times its apical width (lateral view); ovipositor 1.5–1.6 times length of metasoma.

Holotype. Female (NHML). "Brasil, Nova Teutonia, 27°11'B 52°23'L; 30-XII-1938; Fritz Plaumann coll, B. M. 1937-724".

Paratypes. Five females, three males (NHML, CNIN-UNAM). Same data as holotype.

Biology. Unknown.

Etymology. From the Greek *xanthos*, meaning yellow or golden, and the Latin *fascia*, meaning band or stripe, referring to the yellow stripe on the hind femur of the species.

Comments. We examined a large series of specimens from south and southeast Brazil that are morphologically very similar to *N. xanthofasciatus*. However, the latter species distinguishes from these specimens by having the venter of mesosoma coriaceous, (consistently coriaceous-rugose in the other specimens), the fourth metasomal median tergite sculptured on basal half (always smooth in the other specimens), and the length

between ocelli evidently longer. We also found considerable variation in some diagnostic features in the above specimens, suggesting there is more than one undescribed species involved, though we need to confirm their boundaries before describing any of them.

Acknowledgments

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