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The taxonomic status of *Dugesia biblica* from Israel and Turkey (Platyhelminthes, Tricladida, Dugesiidae)

Eduard Solà[1], Ronald Sluys[2], Ori Segev[3], Leon Blaustein[3], Marta Riutort[1]

1 *Departament de Genètica, Facultat de Biologia and Institut de Recerca de la Biodiversitat (IRBio), Universitat de Barcelona, Av. Diagonal 643, 08028, Barcelona, Spain* **2** *Naturalis Biodiversity Center, P.O. Box 9517, 2300 RA Leiden, The Netherlands* **3** *Department of Evolutionary & Environmental Biology and Institute of Evolution, Faculty of Sciences, University of Haifa, 3498838, Haifa, Israel*

Corresponding author: *Eduard Solà* (edu.sola@gmail.com)

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Abstract

The taxonomic status of *Dugesia biblica* (Platyhelminthes, Tricladida, Dugesiidae) from Israel and Turkey is problematic due to its morphological similarity with *D. sicula* since these nominal species present overlapping characters. In this study we analyzed histological preparations of specimens of these two nominal species and also compared mitochondrial *COI* gene sequences from Israeli populations to the already known haplotype composition of *D. sicula*. We concluded that these animals belong to the same species and therefore we consider *D. biblica* to be a junior synonym of *D. sicula*. This implies that the distribution range of *D. sicula* is even wider than previously thought, and that the species is present all around the Mediterranean Basin and on many of its islands.

Keywords

Platyhelminthes, Tricladida, *Dugesia*, taxonomy, synonymy, biogeography, Israel, *COI*, haplotype, karyology, morphology, Turkey

Introduction

The freshwater planarian fauna of Israel has been relatively well studied (Benazzi and Banchetti 1973; Bromley 1974, 1979, 1980; Bromley and Benazzi 1991). Hitherto, six species of triclad flatworms have been formally described for this country: two

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species of *Phagocata*, one *Atrioplanaria*, one *Dendrocoelum*, and two *Dugesia* species, most of them inhabiting the northern part of the State (Bromley 1980; Bromley and Benazzi 1991). The two species of *Dugesia* concern *D. golanica* Bromley & Benazzi, 1991 and *D. biblica* Benazzi & Banchetti, 1973. However, so far it has remained uncertain as to whether *D. biblica* is really a species different from *D. sicula* Lepori, 1948 (De Vries 1988).

Dugesia biblica was originally described from fissiparous specimens collected from the Jordan River in Israel (Benazzi and Banchetti 1973). Some of these specimens developed a copulatory apparatus under laboratory conditions. Later, Bromley carried out further studies (e.g. karyological and ecological) on this species by analyzing specimens collected from several springs and streams in the Jordan Rift Valley and from the Nahal Qishon water system (Bromley 1974, 1977, 1979). Bromley also found natural sexually reproducing populations (Bromley 1977, 1980). About a decade later, De Vries (1988) described *D. biblica* from two localities in the Mediterranean region of Turkey and noted that the original morphological description of *D. biblica* matches that of *D. sicula*, due to their partially overlapping diagnoses.

In the course of our studies on the evolution and diversification of the genus *Dugesia* in the Mediterranean region (cf. Lázaro et al. 2009; Lázaro and Riutort 2013; Solà et al. 2013; Sluys et al. 2013), we encountered a similar problem when we found many populations throughout Israel to be molecularly identical to *D. sicula*, a species that has never been described from Israel. This induced us to re-evaluate all currently available information. We re-examined the material studied by De Vries (1988) and also specimens from other populations of *D. sicula* that have become available to us over the past few years. Further, we have made extensive samplings throughout Israel in order to determine through DNA sequence analyses and, if possible, by morphological studies, which species are present in the area. On the basis of this integrative approach we were able to evaluate the taxonomic status of nominal *Dugesia biblica*.

Materials and methods

Sampling

New samples of *Dugesia* from Israel were obtained during winter, spring and summer seasons in 2009 and 2010. We visited 32 localities (Table 1, Suppl. material 1).

DNA extraction and sequencing

Total genomic DNA was extracted by using the commercial reagent DNAzol (Molecular Research Center Inc., Cincinnanti, OH), following the manufacturer's instructions. A fragment of the cytochrome c oxidase subunit I (*COI*) was amplified using specific primers. Sequences and annealing temperatures for the pair of primers are

Table 1. Israeli sampling localities from where *Dugesia* specimens were collected. The species have been identified on the basis of the *COI* gene sequence.

Code	Locality	Species	Sampling date	Site description	Coordinates
SHE	Ein Shefa	*D. sicula*	06/25/2009	Fast flowing man made spring channel	33°0'34.47"N, 35°8'11.15"E
BAN	Nahal Banias	*D. sicula*	08/27/2009	Fast flowing stream	33°14'47.44"N, 35°41'23.75"E
BET	Nahal Betzet	*D. sicula*	09/01/2009	Isolated temporary pools within dry stream	33°4'32.84"N, 35°13'34.18"E
TEO	Ein Te'o	*D. sicula*	02/03/2010	Shallow spring with moderate water flow	33°7'55.95"N, 35°34'8.54"E
ENU	Ein Nun	*D. sicula*	02/03/2010	Shallow spring with moderate water flow	32°50'18.35"N, 35°30'39.41"E
EHU	Einot Huga	Not *D. sicula*	05/09/2010	Shallow spring - rather saline water ≤2000 mg Cl/l	32°31'2.68"N, 35°32'17.27"E
EOV	Ein Ovdat	*D. sicula*	05/09/2010	Partly connected with slowly flowing spring pools of a desert stream	30°49'25.07"N, 34°45'50.00"E
TZU	Ein Tzuba	*D. sicula*	05/10/2010	Shallow man-made spring pool	31°46'58.33"N, 35°7'45.72"E
SAT	Ein Sataf	*D. sicula*	05/10/2010	Small spring pool inside a man-made underground cave	31°46'15.77"N, 35°7'38.00"E
GED	Ein Gedi	*Dugesia* sp.	08/04/2010	Small shallow spring pool - desert area	31°28'0.60"N, 35°23'19.11"E
DAN	Dan Springs	Not *D. sicula*	08/18/2010	Shallow slowly flowing stream	33°14'56.82"N, 35°39'1.95"E

Table 2. Forward (F) and Reverse (R) primers used in the amplification and sequencing of the *COI* mitochondrial gene sequence.

Name	Direction	Sequence 5'–3'	Annealing temperature (°C)	Source
BarT	F	ATGACDGCSCATGGTTTAATAATGAT	43	Álvarez-Presas et al. 2011
COIEF3	F	CCWCGTGCWAATAATTTRAG	43	Solà et al. 2013
COIR	R	CCWGTYARMCCHCCWAYAGTAAA	43	Lázaro et al. 2009

given in Table 2. Final PCR reaction volume was 25 µl. To 1 µl of DNA sample to amplify we added (1) 5 µl of Promega 5X Buffer, (2) 1 µl of dNTP (10 mM), (3) 0.5 µl of each primer (25 µM), (4) 2 µl of $MgCl_2$ (2 mM), (5) 0.15 µl of Taq polymerase (GoTaq® Flexi DNA Polymerase of Promega). Double-distilled and autoclaved water was added to obtain the final PCR volume. The purification of the PCR products was done with the purification kit illustra™ (GFX™ PCR DNA and Gel Band of GE Healthcare) or by using a vacuum system (MultiScreen$^{TM}_{HTS}$ Vacuum Manifold of Millipore). Sequencing reactions were performed by using Big-Dye (3.1., Applied Biosystems) with the same primers used to amplify the fragment, or with an inner forward

COI sequence (COIEF3), due to sequencing problems when using BarT primer. The sequencing reactions were carried out and run in an automated sequencer ABI Prism 3730 by the Unitat de Genòmica of Centres Científics i Tecnològics of the Universitat de Barcelona or by Macrogen Corporation in Europe (Amsterdam, The Netherlands). Obtained chromatograms were visually checked with the software Geneious v. 6.1.7.

Alignment and haplotype network

The number of *Dugesia* individuals analyzed per locality ranged between 1 and 7, depending on the available number of specimens and the success of sequencing (Table 3). The sequences were aligned online with MAFFT version 7 by setting the iterative refinement method in G-INS-i (Katoh and Standley 2013). We used the software Network version 4.613 (Bandelt et al. 1999), using Median-Joining for network calculations. Parameters were set as default.

Preparations

Material examined (collections Naturalis Biodiversity Center, Leiden):
Dugesia biblica:
ZMA V.Pl. 698.1, Banias Waterfall, Israel, transverse sections on 6 slides, V.Pl. 698.2, ibid., sagittal sections on 8 slides.
ZMA V.Pl. 699.1, Ein El Hanea, Israel, January 1972, sagittal sections on 8 slides; V.Pl. 699.2., ibid., transverse sections on 12 slides.
ZMA V. Pl. 813.1, spring, 5 km NW of Bucak, Turkey, sagittal sections on 2 slides; V.Pl. 813.2, ibid., sagittal sections on 3 slides; V.Pl. 813.3, ibid., frontal sections on 2 slides.
ZMA V.Pl. 814.1, stream near Yerkopru, Hadim, Turkey, sagittal sections on 4 slides; V.Pl. 814.2, ibid., sagittal sections on 3 slides; V.Pl. 814.3, ibid., frontal sections on 3 slides.
Dugesia sicula:
ZMA V.Pl. 7152.1, Tripes, Chios, Greece, 2 May 2010, sagittal sections on 10 slides.

Results

Samples

Out of the 32 localities that we visited in Israel, about one-third (11) yielded specimens of *Dugesia* (Fig. 1, Table 1, Suppl. material 1). At two of these localities we found some *Dugesia* specimens that were molecularly different from *D. biblica* or *D. sicula*. One of these two populations, from Dan Springs (Table 1), might be *D. go-*

Table 3. Details on the Israeli individuals sequenced for the present work.

Individual	Locality	Polymorphic	Haplogroup	Haplotype in Figure 2	GenBank Acc. Number
D01TEO	Ein Te'o	No	A	7	KR140038
D01BAN	Nahal Banias	No	B	2	KR140035
D02BAN		Yes	–	–	KR140040
D03BAN		Yes	–	–	KR140045
D04BAN		No	B	2	KR140049
D02SHE	Ein Sheva	No	B	3	KR140043
D03SHE		No	B	3	KR140047
D04SHE		Yes	–	–	KR140052
D05SHE		Yes	–	–	KR140056
D06SHE		No	B	3	KR140059
D01BET	Nahal Betzet	No	B	8	KR140036
D02BET		No	B	8	KR140041
D03BET		No	B	8	KR140046
D04BET		No	B	3	KR140050
D05BET		No	B	3	KR140053
D01TZU	Ein Tzuba	No	B	4	KR140039
D02TZU		No	B	4	KR140044
D03TZU		No	B	4	KR140048
D07TZU		No	B	4	KR140062
D08TZU		No	B	4	KR140063
D09TZU		No	B	4	KR140066
D10TZU		No	B	4	KR140067
D04SAT	Ein Sataf	No	B	5	KR140051
D05SAT		No	B	5	KR140055
D06SAT		No	B	5	KR140058
D07SAT		No	B	5	KR140061
D11SAT		Yes	–	–	KR140068
D06EOV	Ein Ovdat	No	B	1	KR140057
D07EOV		No	B	1	KR140060
D09EOV		No	B	6	KR140065
D01ENU	Ein Nun	Yes	–	–	KR140037
D02ENU		Yes	–	–	KR140042
D05ENU		Yes	–	–	KR140054
D09ENU		Yes	–	–	KR140064
D16ENU		Yes	–	–	KR140069

lanica, which was originally described from Dan Springs and also from Banyas Springs, in the vicinity of Dan Springs. Our second series of specimens, from Einot Huga, may represent a different species, according to its very distant phylogenetic position (data not shown). Perhaps specimens from the latter locality represent *Dugesia salina* (Whitehouse, 1913), currently a *species inquirenda*. According to Bromley (1980), the chromosomal complement for *D. salina* is 2n = 16 and is different from *D. golanica*, although she did not describe the chromosomes from the latter species. Whitehouse

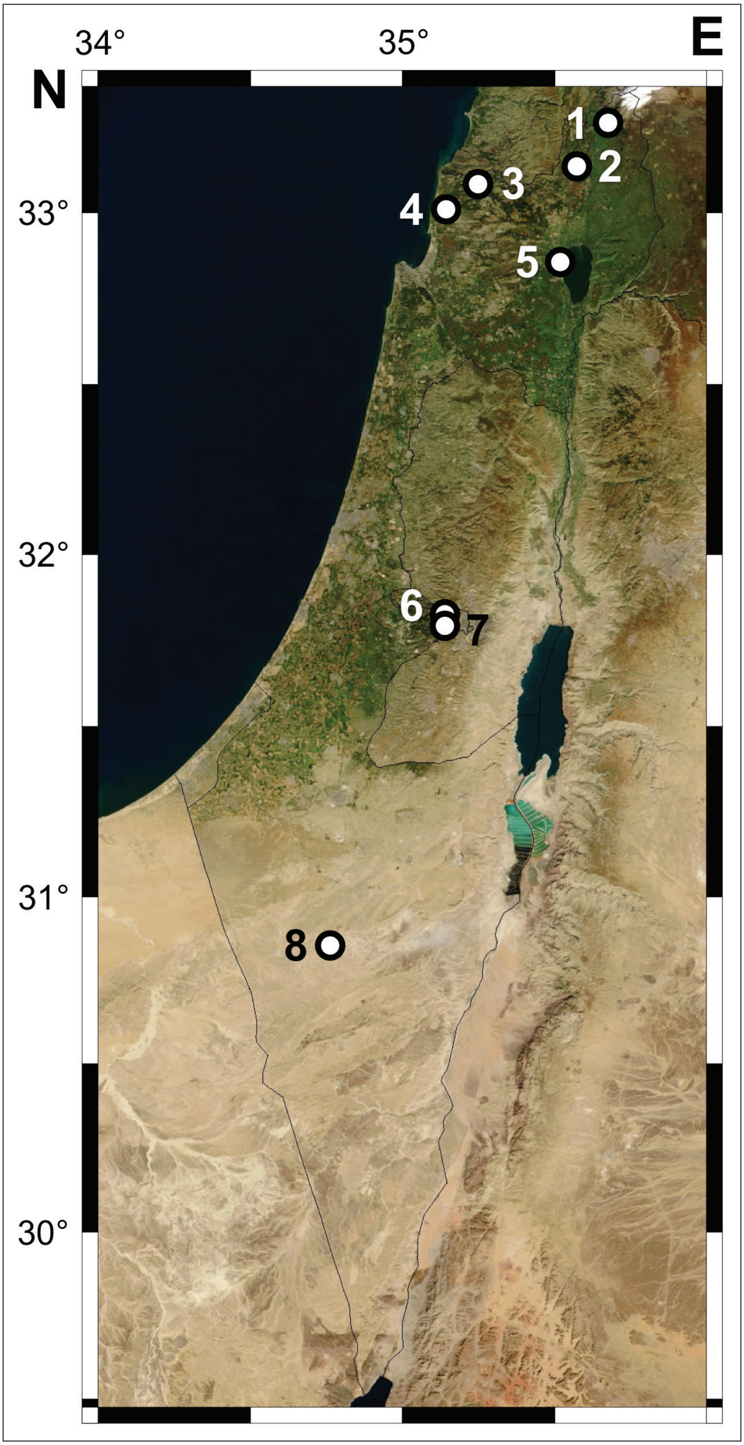

Figure 1. Map of Israeli localities sampled for this study: **1** Nahal Banias **2** Ein Te'o **3** Nahal Betzet **4** Ein Shefa **5** Ein Nun **6** Ein Tzuba **7** Ein Sataf **8** Ein Ovdat. For locality details, see Table 1.

(1913) reported *D. salina* from near et-Tabghah (= En Sheva), while Bromley (1974, 1980) reported populations from En Sheva, En Soda, and from River Jordan at its outlet from Lake Kinneret. Our locality of Einot Huga is actually very close to En Soda. However, as these two species, *D. golanica* and *D. salina*, fall outside of the scope of the present study, we did not include the specimens in our analyses.

Unfortunately, preservation and histological problems eventually prevented us of carrying out detailed morphological analyses on the reproductive apparatus of Israeli *Dugesia* specimens from the various newly sampled populations (Table 1, specimens from localities EOV, EHU, TZU, DAN).

Alignment and haplotype networks

We were successful in obtaining *COI* sequences for 8 out of the 9 sampling localities; 25 out of the 35 sequences obtained for the present study presented no polymorphism, while the remaining sequences showed between 1 and 12 polymorphic positions. We used both the 25 *COI* non-polymorphic sequences from presumed Israeli *D. biblica* obtained for this study (Table 3), as well as those of *D. sicula*, as obtained in a previous phylogeographic study of this species (95 sequences; GenBank Acc. number: KC536630–KC536644 and KC577271–KC577350; Lázaro and Riutort 2013) in order to carry out a haplotype network analysis. The alignment contained 120 *COI* sequences, included 604 nucleotides, and presented 15 polymorphic positions.

Most of the Israeli *COI* haplotypes are identical or are only 1–4 positions removed from the major *D. sicula COI* haplotype B (Fig. 2). One individual sequence (D01TEO) belongs to the other major *COI* haplotype, viz haplotype A (cf. Lázaro and

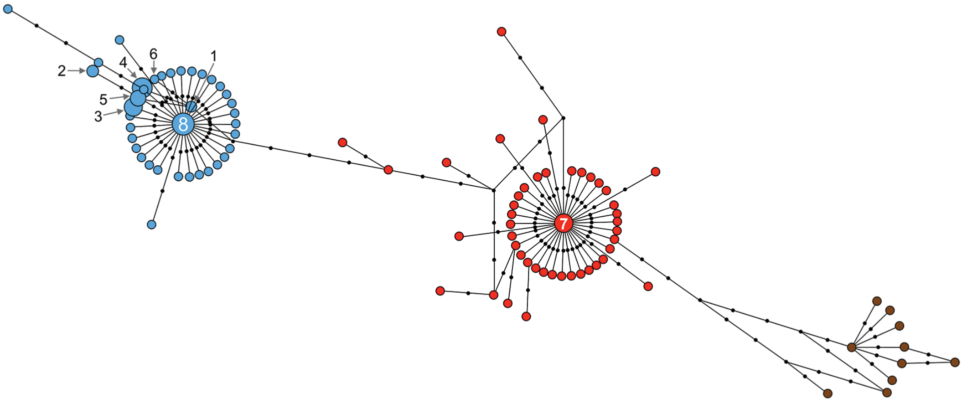

Figure 2. Haplotype network of *Dugesia sicula* and presumed *D. biblica COI* sequences. Filled red circles correspond to haplogroup **A**, filled blue circles correspond to haplogroup **B**, and filled brown circles correspond to haplogroup **C** of *D. sicula* (as defined in Lázaro and Riutort 2013). The size of the coloured circles is proportional to the haplotype representation. Small black dots indicate intermediate haplotypes (not-obtained). Numbers indicate the identity of Israeli haplotypes; for further details see Table 3.

Riutort 2013; Fig. 2). The geographical extension of the B haplogroup in the present study widens its known distributional range to the coast of Israel. The A haplogroup ranges from Morocco to Israel on both sides of the Mediterranean Sea.

Additionally, we compared the polymorphic sequences of the Israeli *Dugesia* not included in the haplotype network (Table 3) with the sequences of *D. sicula COI* haplotypes already defined (Lázaro and Riutort 2013; present work). We found that the polymorphic positions corresponded with those that are variable between haplotypes, indicating that these organisms were heteroplasmic for various known haplotypes.

The results of our molecular analyses suggest a wide distribution of *D. sicula* throughout Israel (Fig. 1), as well as the absence of any other molecularly related species in this area.

Morphological and karyological comparison between *Dugesia biblica* and *D. sicula*

We have been unable to find any stable structural morphological difference between *sicula* populations and presumed *biblica* populations. All of these animals are characterized by distinctly acentral opening of the ejaculatory duct; asymmetrical oviducal openings into the bursal canal; rather thick layer of circular muscles around bursal canal; bursal canal that runs somewhat laterally to the penis; zone of mesenchymatic gland cells around bursal canal; somewhat bilobed seminal vesicle; somewhat irregularly running bursal canal, with irregular diameter; distinct patch of cyanophil secretion in dorsal section of penis papilla. Benazzi and Banchetti (1973) described for *D. biblica* an outer pharynx musculature consisting of three layers. However, De Vries (1988) already correctly observed that such an extra, third layer is not present in *biblica* specimens from Israel. Bromley (1979) described atrial folds for *D. biblica,* but such structures were not observed by us in the available material from Israel. The vacuolated tissue that Bromley (1979) described for the penis of *D. biblica* in our opinion merely concerns tears in the mesenchyme of the penis papilla. Such tears or spaces in the dorsal part of the penis papilla, near its tip, were observed in histological preparations of specimens from several populations of *D. sicula*, e.g. specimen ZMA V.Pl. 7152.1 from Chios.

Characteristic of *D. biblica* is the occurrence in the field of a sexually reproducing diploid form with a chromosome complement of 2n = 18, and a triploid form that reproduces asexually by fission with a set of 3n = 27 + 1–5 supernumerary chromosomes. Under laboratory conditions, the normally fissioning animals can be induced to develop reproductive organs. The structure of the copulatory organs of these sexualized animals is identical to that of the normally sexually reproducing diploid forms. However, in the diploid forms, testes and ovaries show their normal dimensions and development, whereas in the sexualized animals the testes are underdeveloped and the ovaries hyperplasic (cf. Bromley 1974, 1977, 1979). The difference in karyology between the asexual individuals and the naturally sexual animals induced Bromley (1979, 1980) to coin the subspecies *Dugesia biblica biblica* Benazzi & Banchetti, 1973 and *D. biblica monticola* Bromley, 1980, respectively.

The situation that (1) in the field some populations may reproduce asexually and show a triploid set of 3n = 27 + 2–3 B chromosomes, (2) others reproduce sexually and show a complement of 2n = 18 gradually decreasing, metacentric chromosomes, and (3) sexualized, triploid specimens show hyperplasic ovaries and poorly developed testes is well-known for *D. sicula* (cf. Charni et al. 2004 and references therein). Thus, also from this perspective, there seems to be no difference between *D. sicula* and *D. biblica*.

Conclusion: the taxonomic status of *Dugesia biblica*

In addition to the morphological and karyological similarities between nominal *Dugesia biblica* and *D. sicula* (see above), our molecular analysis shows presumed *biblica* populations to be molecularly indistinguishable from *sicula* populations. The Israeli haplotypes obtained are either identical to previously obtained *sicula* or present few differences from these. Therefore, on the basis of our integrative analysis, we consider *D. biblica* to be a junior synonym of *D. sicula*.

This conclusion holds true for one of the two Turkish populations of presumed *biblica* described by De Vries (1988), viz. ZMA V.Pl. 814 from Yerkopru. But the

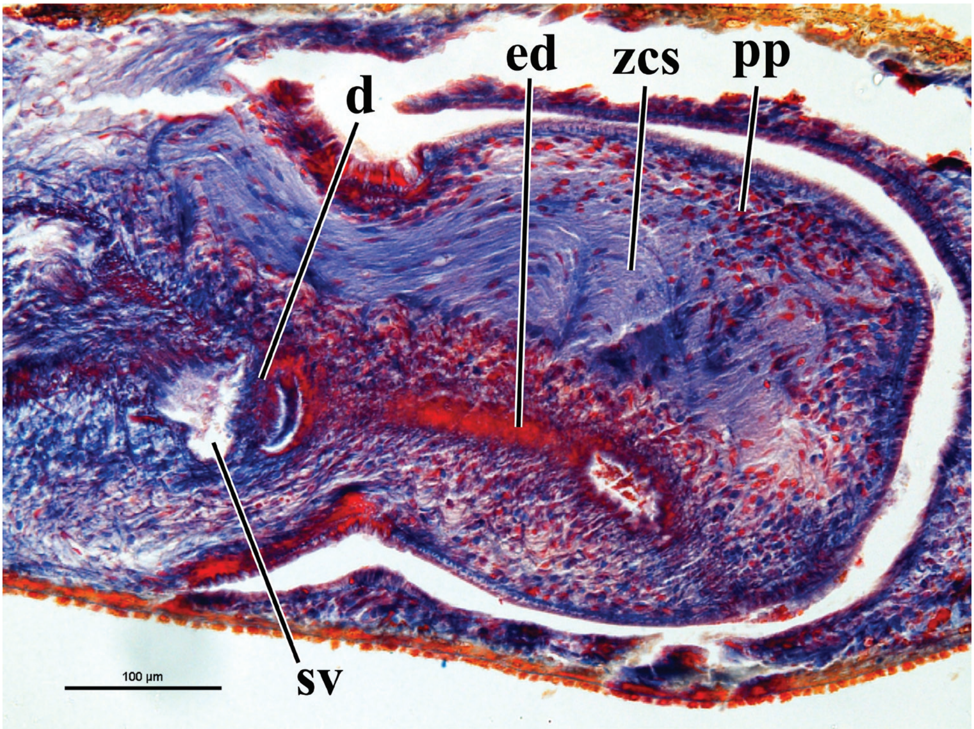

Figure 3. Presumed *Dugesia sicula* from Bucak, Turkey (ZMA V.Pl. 813.2), showing the presence of the zone of cyanophil secretion in the penis papilla. Abbreviations: **d** diaphragm **ed** ejaculatory duct **pp** penis papilla **sv** seminal vesicle **zcs** zone of cyanophil secretion.

other population (ZMA V.Pl. 813 from 5 km NW of Bucak) concerns animals that are morphologically somewhat different from *D. sicula*. Foremost, the ejaculatory duct does not have a subterminal opening (cf. De Vries 1988, Fig. 2). Other differences concern the position of the ovaries at 1/3rd – 1/4th of the distance between the brain and the root of the pharynx (1/4th – 1/5th in *D. sicula*), the much wider bursal canal, which is surrounded by a much thinner layer of circular muscle (depicted far too thick in De Vries 1988, Fig. 2), and the smaller copulatory bursa in the specimens from Bucak. The animals from Bucak agree with *D. sicula* in the presence of numerous mesenchymal glands discharging their erythrophil secretion into the lining epithelium of the bursal canal, the presence of the zone of cyanophil secretion in the penis papilla (Fig. 3), and the asymmetrical openings of the oviducts into the bursal canal. In several respects the animals from Bucak remind one of *D. naiadis* Sluys, 2013 from Chios, albeit that in the latter the oviducts open symmetrically into the bursal canal, in contrast to the asymmetrical oviducal openings in the Bucak specimens (cf. De Vries 1988, Fig. 2). However, for the moment we refrain from assigning the animals from Bucak to a different and possibly new species of *Dugesia* and postpone any taxonomic decision until more material has become available for both morphological and molecular analyses.

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Supplementary material 1

Supplementary Table 1

Authors: Eduard Solà, Ronald Sluys, Ori Segev, Leon Blaustein, Marta Riutort

Data type: occurence

Explanation note: Localities in Israel from which no specimens of *Dugesia* could be obtained during our samplings.

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The oribatid mite genus *Macrogena* (Acari, Oribatida, Ceratozetidae), with description of two new species from New Zealand

Sergey G. Ermilov[1], Maria A. Minor[2]

1 *Tyumen State University, Tyumen, Russia* **2** *Institute of Agriculture & Environment, Massey University, Palmerston North, New Zealand*

Corresponding author: *Sergey G. Ermilov* (ermilovacari@yandex.ru)

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Abstract

Two new species of oribatid mites of the genus *Macrogena* (Oribatida, Ceratozetidae) are described from alpine soils of the South Island of New Zealand. *Macrogena brevisensilla* **sp. n.** and *M. abbreviata* **sp. n.** differ from all species of this genus by the tridactylous legs and by the comparatively short interlamellar setae, respectively. New generic diagnosis and an identification key to the known species of *Macrogena* are provided.

Keywords

Oribatid mites, *Macrogena*, new species, generic diagnosis, key, New Zealand

Introduction

Macrogena is an oribatid mite genus of the family Ceratozetidae (Acari, Oribatida) which was proposed by Wallwork (1966) with *Macrogena monodactyla* Wallwork, 1966 as type species. At present, three species are known[1]: *M. crassa* Hammer, 1967,

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[1] Subías (2004, updated 2015) included in *Macrogena* the following three species: *Mycobates minor* Subías, Kahwash & Ruiz, 1990 from the Mediterranean, *Lophozetes truncatus* Balogh, 1985 from Australia and *Safrobates miniporus* Mahunka, 1989 from Tasmania. However, *M. minor* has rostral setae inserted laterally on prodorsum, dorsophragmata separated medially and six pairs of genital setae; *L. truncatus* and *S. miniporus* have lamellar cusps fused medially. Hence, the morphological characters of these species do not correspond absolutely to the generic diagnosis of *Macrogena*, therefore their systematic position need further investigations.

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M. rudentiger Hammer, 1967 (both from New Zealand) and *M. monodactyla* Wallwork, 1966 (from the Antarctic region).

During the recent study of oribatid mite fauna of the high alpine zone of several mountain ranges in New Zealand (Central Otago, South Island), we discovered two new species of the genus *Macrogena*; both species were common and abundant in the collected material. Additionally, we propose a new generic diagnosis for *Macrogena*, and provide an identification key for all known species of this genus.

Materials and methods

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

Specimens were mounted in lactic acid on temporary cavity slides for measurement and illustration. The body length was measured in lateral view, from the tip of the rostrum to the posterior edge of the ventral plate. Notogastral width refers to the maximum width in dorsal aspect. Lengths of body setae were measured in lateral aspect. All body measurements are presented in micrometers. Formulas for leg setation are given in parentheses according to the sequence trochanter–femur–genu–tibia–tarsus (famulus included). Formulas for leg solenidia are given in square brackets according to the sequence genu–tibia–tarsus. General terminology used in this paper follows that of Grandjean (summarized by Norton and Behan-Pelletier 2009). Drawings were made with a drawing tube using a Carl Zeiss transmission light microscope "Axioskop-2 Plus". Images were obtained with an AxioCam ICc3 camera using a Carl Zeiss transmission light microscope "Axio Lab.A1".

Taxonomy

Genus *Macrogena* Wallwork, 1966

Type species. *Macrogena monodactyla* Wallwork, 1966

Diagnosis (partially based on data from Wallwork 1966; Hammer 1967). Ceratozetidae with rostrum with medial rectangular ledge formed by two lateral incisions; rostral setae inserted dorsally or dorso-laterally on prodorsum; lamellar and interlamellar setae strong, straight; bothridial setae fusiform or globular; lamellae large, with short cusps, connected by translamella; tutoria and genal teeth long, reach the level of insertions of rostral setae; dorsophragmata fused medially; notogaster with three or four pairs of porose areas; ten pairs of short and thin notogastral setae; five pairs of genital, one pair of aggenital, two pair of anal, and three pairs of adanal setae; legs mono- or tridactylous.

***Macrogena brevisensilla* sp. n.**

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Figs 1–22

Diagnosis. Body size: 315–332 × 182–199. Lamellar cusps without teeth. Translamella broad. Rostral setae dilated in medio-distal parts, ciliated. Lamellar and interlamellar setae long, thickened, densely barbed. Bothridial setae globular. Tutoria broadly triangular. Four pairs of notogastral porose areas present. Notogastral setae short, thin. Epimeral setae *1c* thickened, barbed. Tridactylous.

Description. *Measurements*. Body length: 332 (holotype: female), 315–332 (six paratypes: three females, three males); notogaster width: 182 (holotype), 182–199 (six paratypes).

Integument. Body color light brown to brown. Body surface punctate (visible under high magnification). Lamellae, epimeral region, pedotecta I and subcapitular mentum with striae.

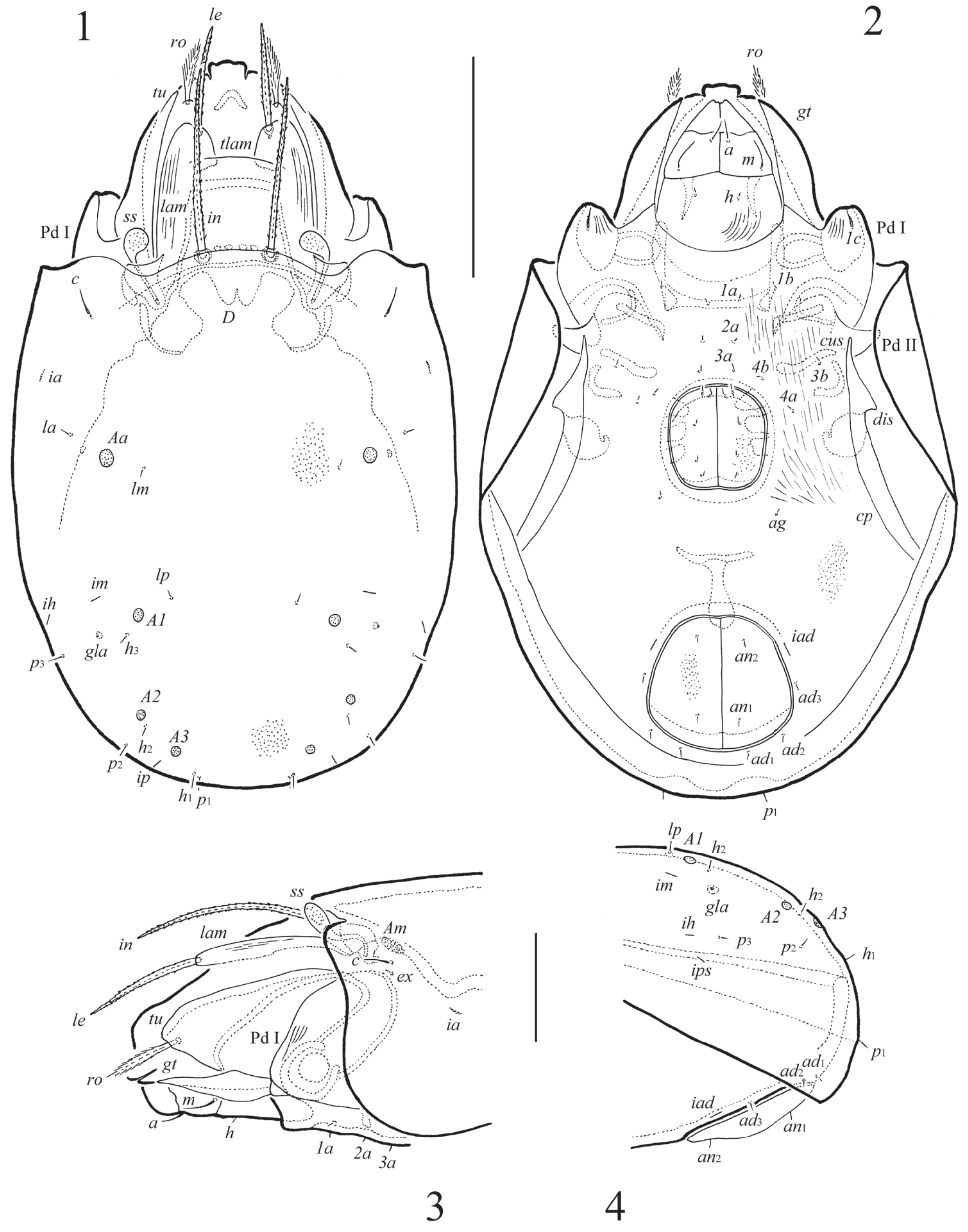
Prodorsum. Anterior edge of medial ledge of rostrum slightly wavy, lateral incisions very narrow. Lamellae shorter than half of prodorsum. Lamellar cusps without teeth. Translamella straight, broad. Rostral setae (*ro*, 32–41) dilated in medio-distal parts, ciliated. Lamellar (*le*, 49–57) and interlamellar (*in*, 82–90) setae thickened, densely barbed. Lamellar setae sometimes slightly dilated medio-distally. Bothridial setae (*ss*, 22–26) globular, with short stalk (4–6) and longer, indistinctly barbed head (18–20). Tutoria (*tu*) broadly triangular distally. Exobothridial setae (*ex*, 4) thin, smooth.

Notogaster. Anterior margin convex medially. Pteromorphs broadly rounded laterally. Porose areas *Am* elongate oval. Dorsophragmata (*D*) of medium size. Four pairs of porose areas present, all rounded: *Aa* (8), *A1*, *A2* and *A3* (6). Notogastral setae thin, smooth, *c* (12) little longer than other nine pairs (6–8). Lyrifissures *ia*, *im*, *ip*, *ih* and *ips* distinct. Opisthonotal gland openings (*gla*) located posteriorly to *im*.

Gnathosoma. Subcapitulum longer than wide (86 × 61–65). Subcapitular setae *h* (4–6) thin, smooth; *a* (12–16) and *m* (18–20) setiform, slightly barbed. Adoral setae (or_1, or_2, 8–10) simple, densely barbed. Palps (53–61) with setation 0–2–1–3–9(+ω). Solenidion attached to eupathidium, both located on dorsal tubercle. Chelicerae (90–94) with two simple, barbed setae; *cha* (28–32) longer than *chb* (16–20). Trägårdh's organ (Tg) long, tapered.

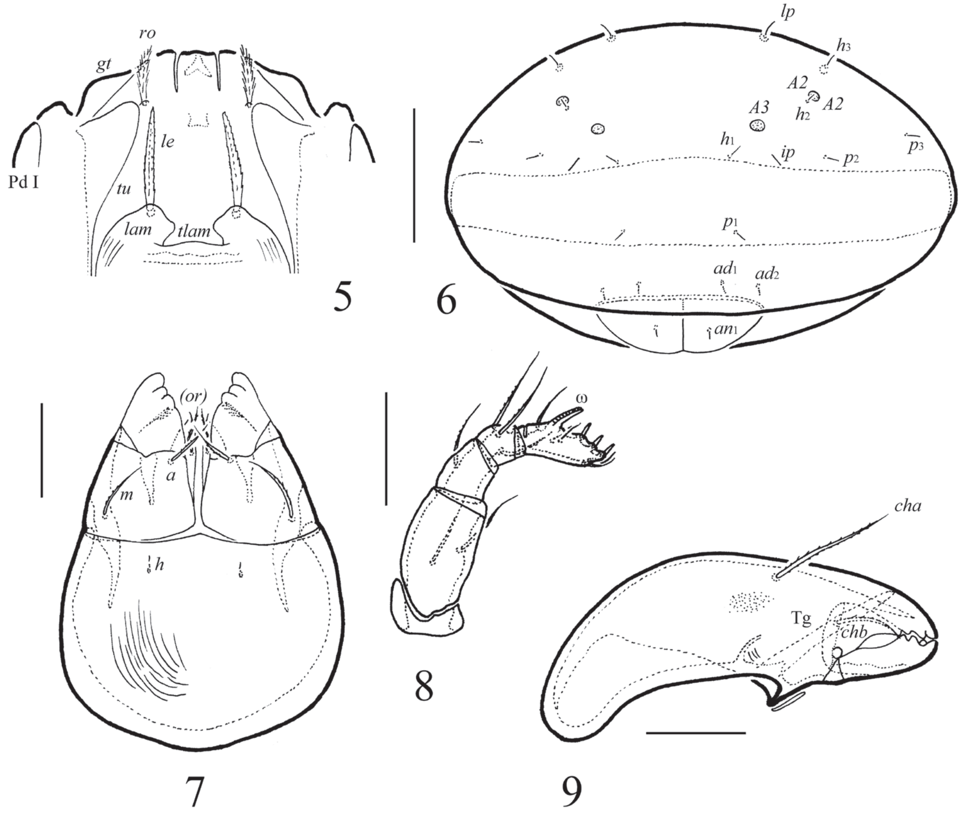
Epimeral and lateral podosomal regions. Pedotecta I (Pd I) large, concave in dorsal view. Pedotecta II (Pd II) of medium size, triangular, rounded distally in ventral view. All pedotecta scale-like in lateral view. Genal teeth (*gt*) elongate narrowly triangular. Apodemes 1, 2, sejugal and 3 distinctly developed. Epimeral setal formula 3–1–2–2. Epimeral setae *1c* (10) thickened, barbed; other setae (4–6) thin, smooth. Custodia (*cus*) with long, pointed tips. Discidia (*dis*) triangular. Circumpedal carinae (*cp*) distinct.

Anogenital region. Genital (g_1–g_5, 4–6), aggenital (*ag*, 4–6), anal (an_1, an_2, 4–6) and adanal (ad_1–ad_3, 6–8) setae thin, smooth. Lyrifissures *iad* located close to anal aperture, in paraanal position. Ovipositor elongated (102–110 × 28), blades (45–49) shorter



Figures 1–4. *Macrogena brevisensilla* sp. n., adult: **1** dorsal view **2** ventral view (legs not shown) **3** lateral view of anterior part of body (leg I not shown) **4** lateral view of posterior part of body. Scale bars 100 μm (**1, 2**), 50 μm (**3, 4**).

than length of distal section (beyond middle fold; 57–61). Each of three blades with four straight, smooth setae, $\psi_1 \approx \tau_1$ (32) longer than $\psi_2 \approx \tau_a \approx \tau_b \approx \tau_c$ (14–16). Six coronal simple setae (*k*, 8) present.



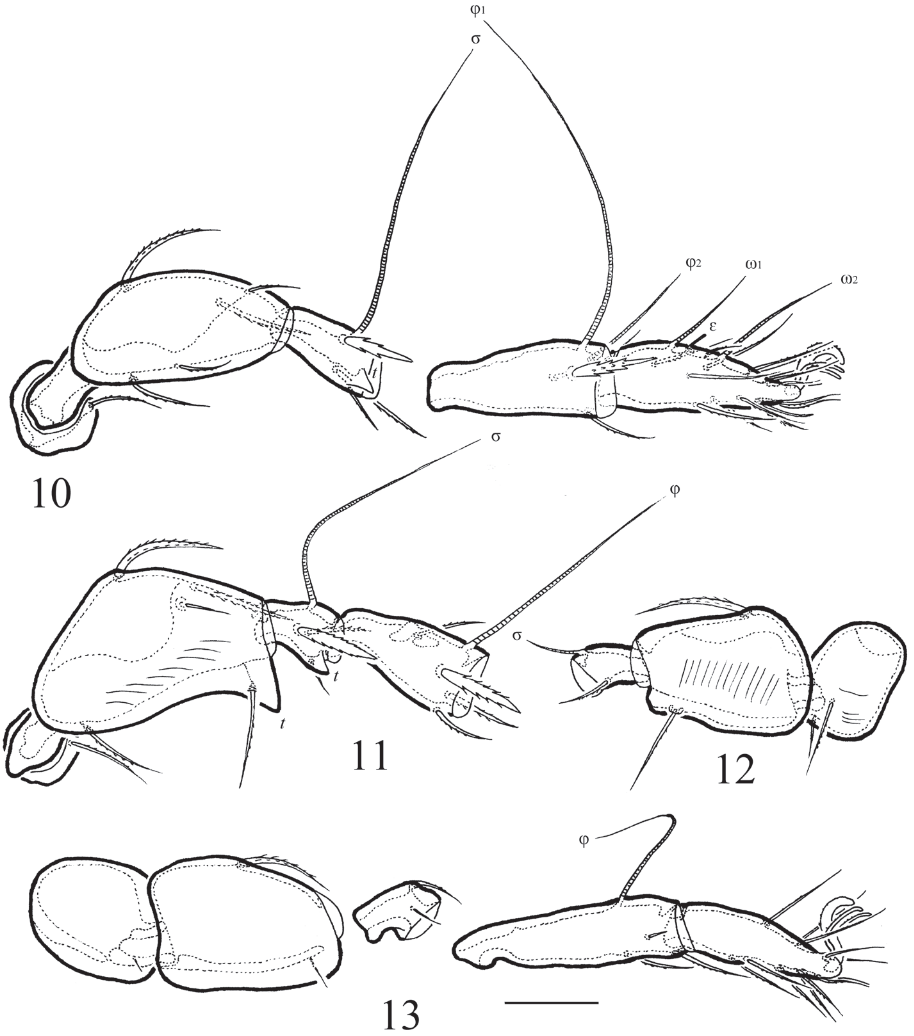
Figures 5–9. *Macrogena brevisensilla* sp. n., adult: **5** frontal view of prodorsum **6** posterior view **7** subcapitulum, ventral view **8** palp **9** chelicera. Scale bars 50 μm (**5, 6**), 20 μm (**7–9**).

Legs. Tridactylous. Medial claw thicker than two laterals; all indistinctly serrate dorsally. Genua I and II, and femora II with antero-ventral tooth (*t*). Formulae of leg setation and solenidia: I (1–5–3–3–18) [1–2–2], II (1–5–3–4–15) [1–1–2], III (2–2–1–3–15) [1–1–0], IV (1–2–2–3–12) [0–1–0]; homology of setae and solenidia as indicated in Table 1. Famulus (ε) short, blunted. Setae *l”* on tibiae and genua I, II thick.

Material examined. Holotype (female) and six paratypes (three females and three males): New Zealand, South Island, Central Otago, The Remarkables, 45°3'38"S, 168°48'43"E, 1867 m a.s.l., in the soil and debris under *Raoulia* sp. cushion, 19 February 2014, collected by M. Minor.

Type deposition. The holotype and two paratypes are deposited in the New Zealand National Arthropod Collection, Auckland, New Zealand; two paratypes are deposited in the collection of the Senckenberg Institution, Frankfurt, Germany; two paratypes are deposited in the collection of the Tyumen State University Museum of Zoology, Tyumen, Russia.

Etymology. The specific name *brevisensilla* refers to the short bothridial setae (sensilla).

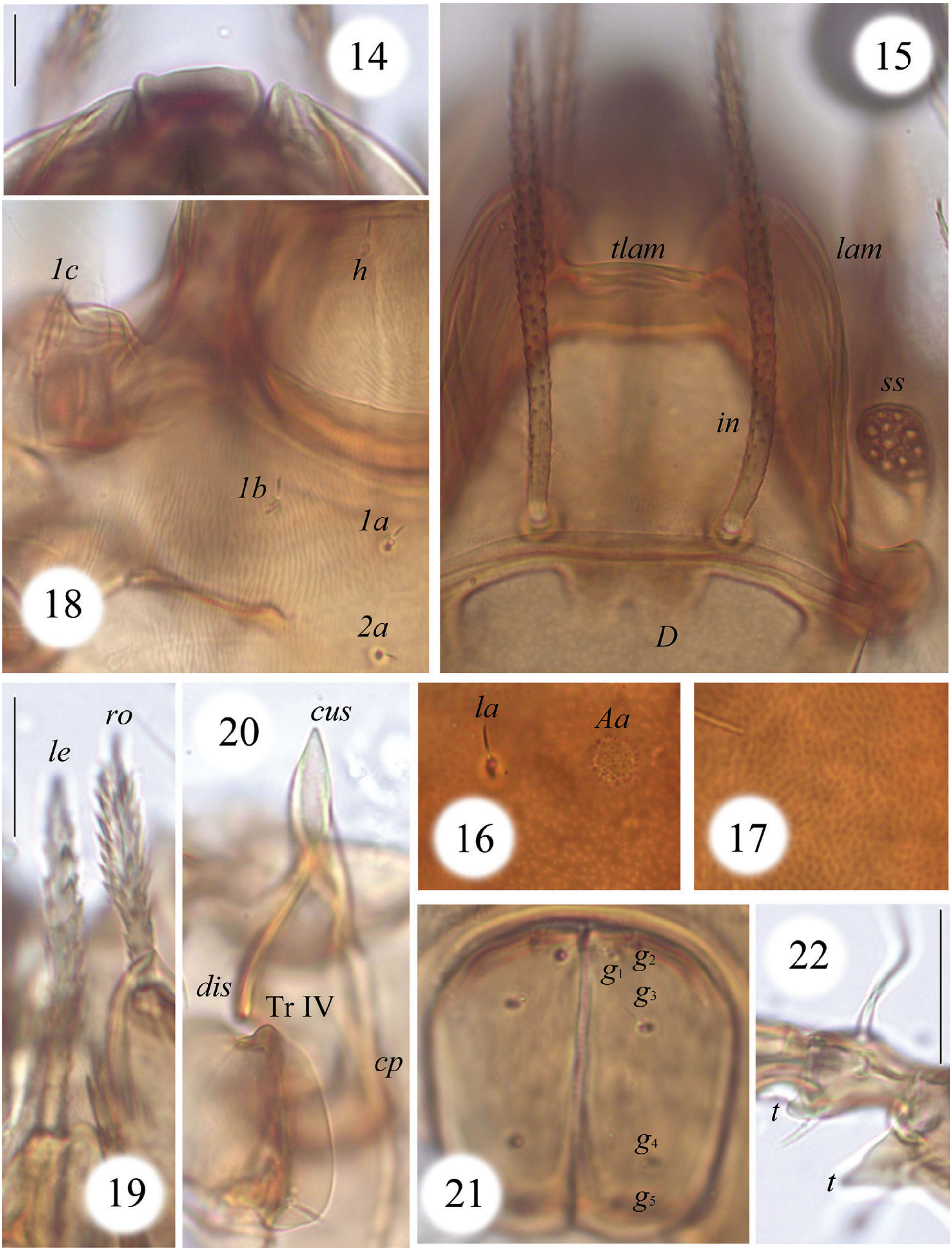


Figures 10–13. *Macrogena brevisensilla* sp. n., adult: **10** leg I, right, antiaxial view **11** tibia, genu, femur and trochanter of leg II, right, antiaxial view **12** genu, femur and trochanter of leg III, right, antiaxial view **13** leg IV, left, antiaxial view. Scale bar 20 µm.

Table 1. Leg setation and solenidia of adult *Macrogena brevisensilla* sp. n.

Leg	Trochanter	Femur	Genu	Tibia	Tarsus
I	*v’*	*d*, *(l)*, *bv”*, *v”*	*(l)*, *v’*, σ	*(l)*, *v’*, φ_1, φ_2	*(ft)*, *(tc)*, *(it)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*, *(pl)*, ε, ω_1, ω_2
II	*v’*	*d*, *(l)*, *bv”*, *v”*	*(l)*, *v’*, σ	*(l)*, *(v)*, φ	*(ft)*, *(tc)*, *(it)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*, ω_1, ω_2
III	*l’*, *v’*	*d*, *ev’*	*l’*, σ	*l’*, *(v)*, φ	*(ft)*, *(tc)*, *(it)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*
IV	*v’*	*d*, *ev’*	*d*, *l’*	*l’*, *(v)*, φ	*ft”*, *(tc)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*

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



Figures 14–22. *Macrogena brevisensilla* sp. n., dissected adult, microscope images: **14** rostrum, dorsal view **15** medio-basal part of prodorsum and medio-anterior part of notogaster **16** notogastral porose area *Aa* and seta *la* **17** microporose in medial part of notogaster **18** right parts of subcapitular mentum and epimere I **19** rostral and lamellar setae **20** custodium and discidium **21** genital plates **22** ventral teeth on leg II (left, antiaxial view). Scale bar 20 µm.

Remarks. *Macrogena brevisensilla* sp. n. differs from all species of this genus by the tridactylous legs.

Wallwork (1966) considered monodactylous legs as the generic character of *Macrogena*. The new species has tridactylous legs, however, all other morphological traits correspond to the other species of this genus. Thus, we included *M. brevisensilla* sp. n. in *Macrogena*, and included alternatively tridactylous legs in the revised generic diagnosis.

Macrogena abbreviata sp. n.

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Figs 23–44

Diagnosis. Body size: 254–291 × 143–151. Lamellar cusps without teeth. Translamella of medium thickness. Rostral setae setiform, ciliated. Lamellar and interlamellar setae of medium size, thickened, barbed. Bothridial setae fusiform. Three pairs of notogastral porose areas present. Notogastral setae short, thin. Monodactylous.

Description. *Measurements*. Body length: 270 (holotype: female), 254–291 (six paratypes: three females, three males); notogaster width: 143 (holotype), 143–151 (six paratypes).

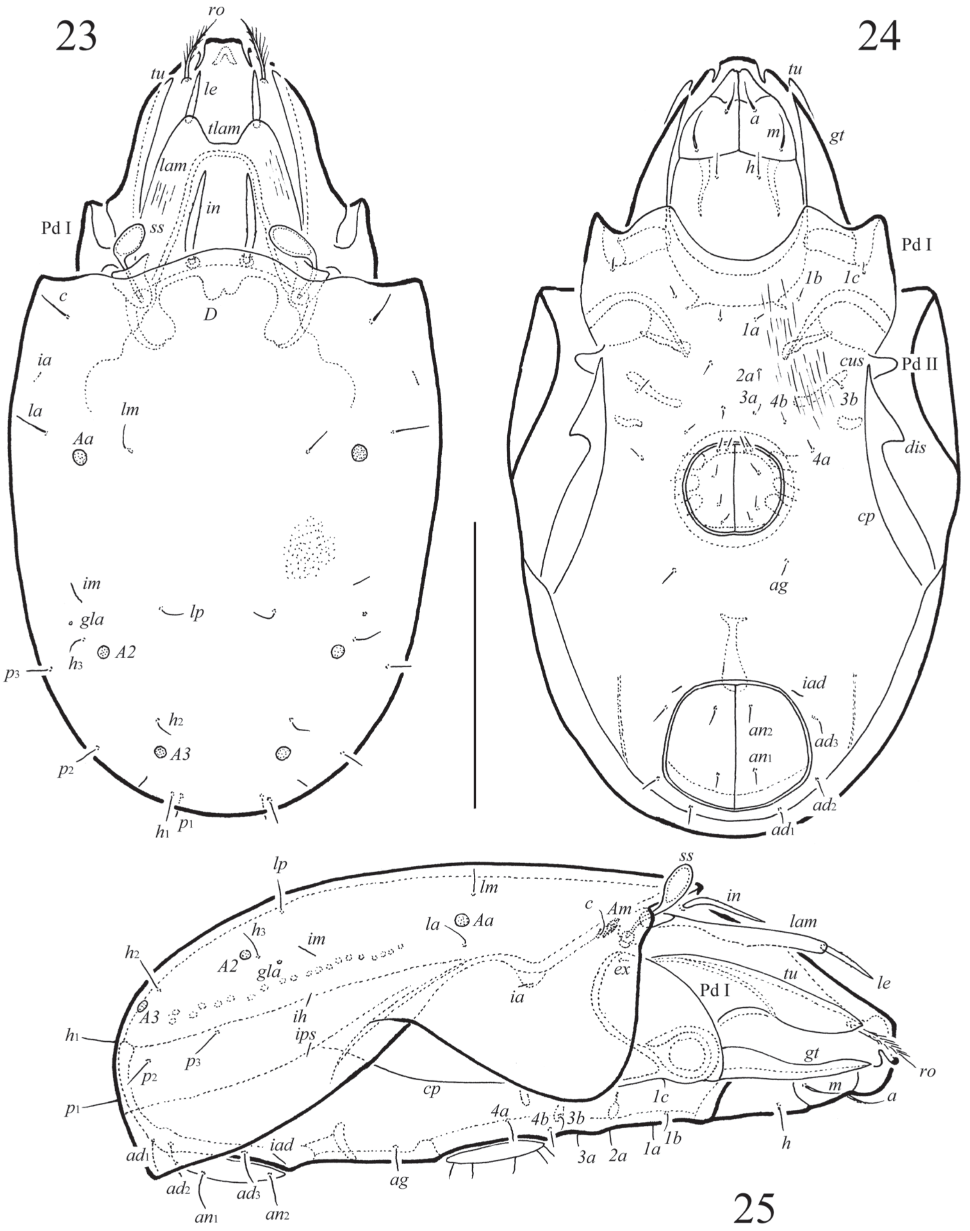
Integument. Body color light brown to brown. Body surface punctate (visible under high magnification). Lamellae and pedotecta I striate; epimeral region also with longitudinal striae, however it is visible only in dissected specimens.

Prodorsum. Medial ledge of rostrum truncated, lateral incisions well visible. Lamellae shorter than half of prodorsum. Lamellar cusps without teeth. Translamella straight, thickened. Rostral setae (24–28) setiform, ciliated. Lamellar (18–20) and interlamellar (32–36) setae thickened, usually indistinctly barbed (rarely with sparse, strong barbs). Bothridial setae (22–26) fusiform, with short stalk (6) and longer, indistinctly barbed head (16–20). Tutoria narrowly triangular distally, slightly rounded, sometimes pointed. Exobothridial setae (4) thin, smooth.

Notogaster. Anterior margin convex medially. Pteromorphs broadly rounded laterally. Porose areas *Am* elongate oval. Dorsophragmata of medium size. Three pairs of porose areas present, all rounded: *Aa* (6–8), *A2* and *A3* (4–6). Notogastral setae (12–14) thin, smooth. Lyrifissures distinct. Opisthonotal gland openings located posteriorly to *im*.

Gnathosoma. Subcapitulum longer than wide (65–69 × 45–53). Subcapitular setae thin, slightly barbed; *m* (18–20) longer than *a* (12–16) and *h* (8–10). Adoral setae (8) simple, densely barbed. Palps (45) with setation 0–2–1–3–9(+ω). Solenidion attached to eupathidium, both located on dorsal tubercle. Chelicerae (73–77) with two simple, barbed setae; *cha* (28) longer than *chb* (14–16). Trägårdh's organ long, tapered.

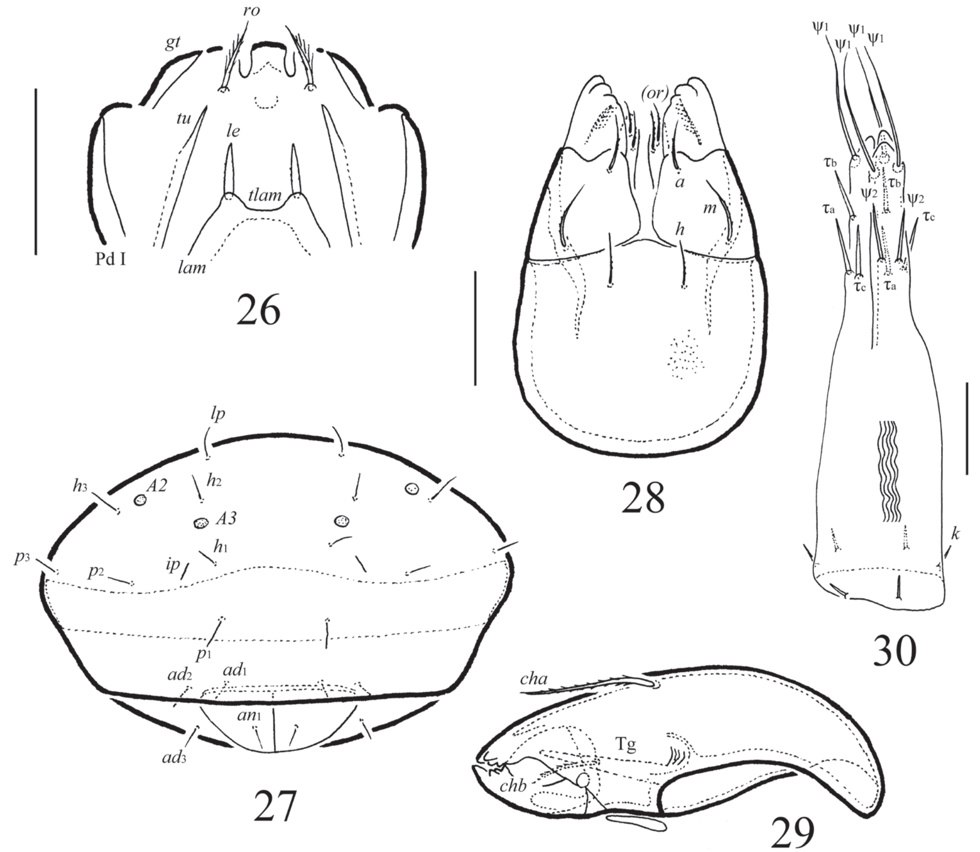
Epimeral and lateral podosomal regions. Pedotecta I large, concave in dorsal view. Pedotecta II of medium size, triangular, rounded distally in ventral view. All pedotecta scale-like in lateral view. Genal teeth elongate narrowly triangular. Apodemes 1, 2, sejugal and



Figures 23–25. *Macrogena abbreviata* sp. n., adult: **23** dorsal view **24** ventral view (legs not shown) **25** lateral view (leg I not shown). Scale bar 100 µm.

3 distinctly developed. Epimeral setal formula 3–1–2–2. Epimeral setae (8) thin, smooth. Custodia with long, pointed tips. Discidia triangular. Circumpedal carinae distinct.

Anogenital region. Genital (8–12), aggenital (8–12), anal (8–12) and adanal (12–14) setae thin, smooth. Lyrifissures *iad* located close to anal aperture, in inverse apoa-



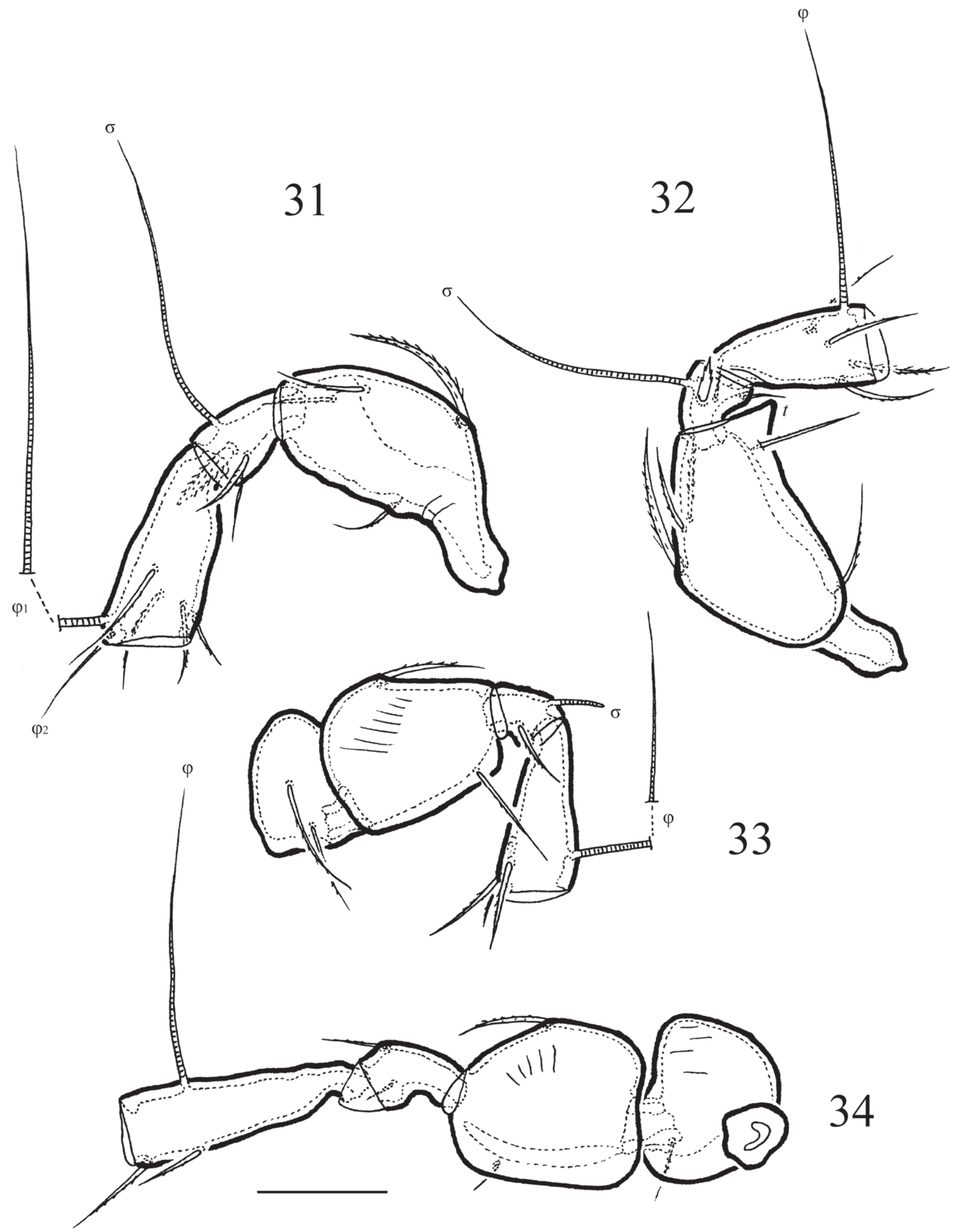
Figures 26–30. *Macrogena abbreviata* sp. n., adult: **26** frontal view of prodorsum **27** posterior view **28** subcapitulum, ventral view **29** chelicera **30** ovipositor. Scale bars 50 µm (**26, 27**), 20 µm (**28–30**).

nal position. Ovipositor elongated (106–110 × 28), blades (45–49) shorter than length of distal section (beyond middle fold; 57–61). Each of three blades with four straight, smooth setae, $\psi_1 \approx \tau_1$ (24–28) longer than $\psi_2 \approx \tau_a \approx \tau_b \approx \tau_c$ (12–16). Six coronal simple setae (8) present.

Legs. Monodactylous. Claws indistinctly serrate dorsally. Femora II with anteroventral tooth (*t*). Formulae of leg setation and solenidia: I (1–4–3–4–18) [1–2–2], II (1–5–3–4–15) [1–1–2], III (2–2–1–3–15) [1–1–0], IV (1–2–2–2–12) [0–1–0]; homology of setae and solenidia as indicated in Table 2. Famulus (ε) short, blunted. Setae *l”* on genua I, II thick.

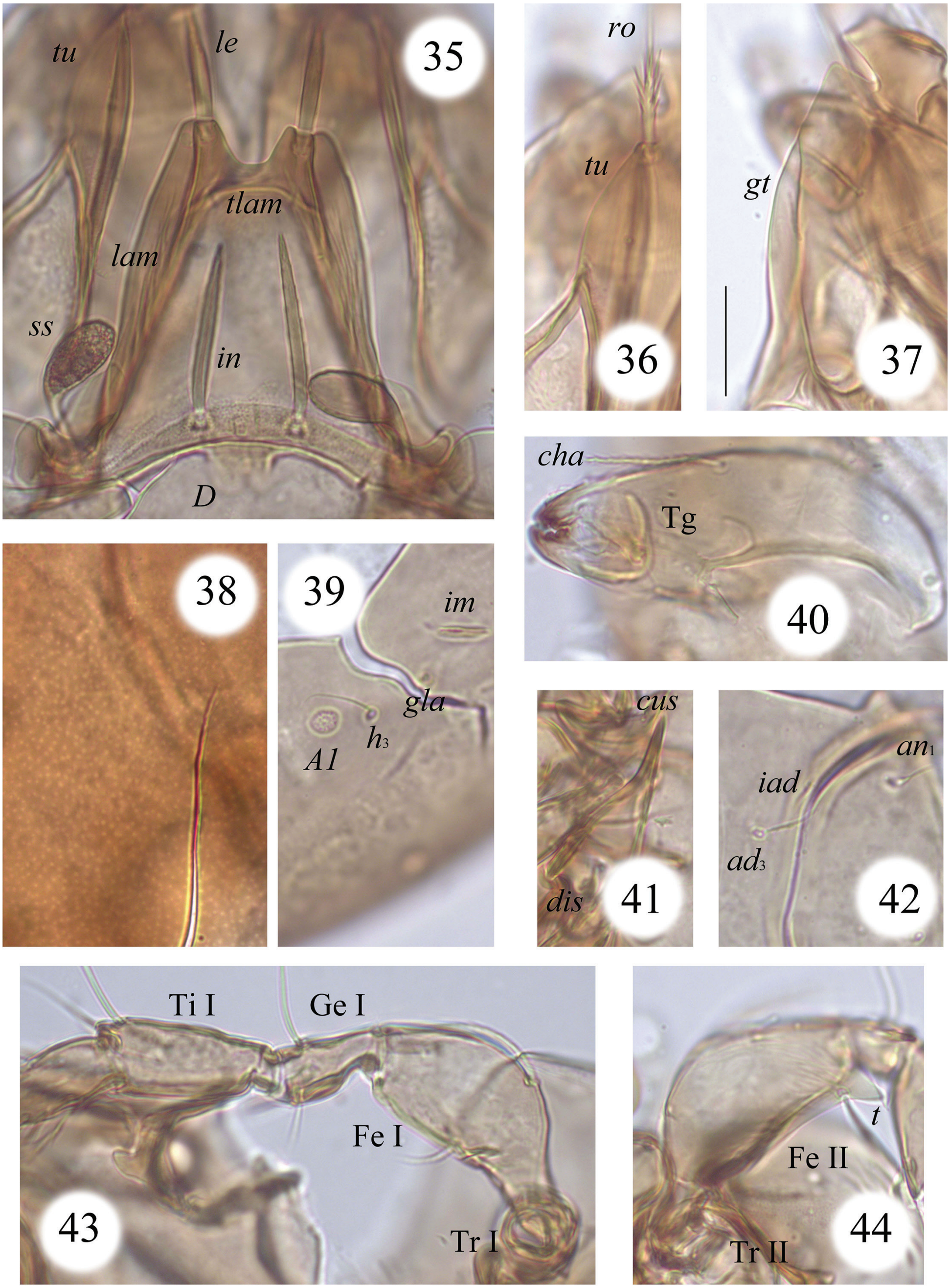
Material examined. Holotype (female) and six paratypes (three females and three males): New Zealand, South Island, Central Otago, Old Man’s Range, 45°19'24"S, 169°12'28"E, 1655 m a.s.l., in the bare soil with some lichen outside of *Dracophyllum muscoides* cushion, 17 February 2014, collected by M. Minor.

Type deposition. The holotype and two paratypes are deposited in the New Zealand National Arthropod Collection, Auckland, New Zealand; two paratypes are de-



Figures 31–34. *Macrogena abbreviata* sp. n., adult: **31** tibia, genu and femur of leg I, right, paraxial view **32** tibia, genu and femur of leg II, right, antiaxial view **33** tibia, genu, femur and trochanter of leg III, left, antiaxial view **34** tibia, genu, femur and trochanter of leg IV, left, paraxial view. Scale bar 20 µm.

posited in the collection of the Senckenberg Institution, Frankfurt, Germany; two paratypes are deposited in the collection of the Tyumen State University Museum of Zoology, Tyumen, Russia.



Figures 35–44. *Macrogena abbreviata* sp. n., dissected adult, microscope images: **35** medio-basal part of prodorsum and medio-anterior part of notogaster **36** rostral seta and medio-anterior part of tutorium **37** genal tooth and rostral incision **38** microporose in medial part of notogaster **39** notogastral porose area *Aa*, seta h_3, lyrifissure *im* and opisthonotal gland opening **40** chelicera **41** custodium and discidium **42** anal seta an_2, adanal seta ad_3 and lyrifissure *iad* **43** leg I (except anterior part of tarsus), right, paraxial view **44** ventral tooth on leg II (right, antiaxial view). Scale bar 20 μm.

Table 2. Leg setation and solenidia of adult *Macrogena abbreviata* sp. n.

Leg	Trochanter	Femur	Genu	Tibia	Tarsus
I	*v'*	*d*, *(l)*, *bv"*	*(l)*, *v'*, σ	*(l)*, *(v)*, φ_1, φ_2	*(ft)*, *(tc)*, *(it)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*, *(pl)*, ε, ω_1, ω_2
II	*v'*	*d*, *(l)*, *bv"*, *v"*	*(l)*, *v'*, σ	*(l)*, *(v)*, φ	*(ft)*, *(tc)*, *(it)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*, ω_1, ω_2
III	*l'*, *v'*	*d*, *ev'*	*l'*, σ	*l'*, *(v)*, φ	*(ft)*, *(tc)*, *(it)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*
IV	*v'*	*d*, *ev'*	*d*, *l'*	*(v)*, φ	*ft"*, *(tc)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*

Note: See Table 1 for explanations.

Etymology. The specific name *abbreviata* refers to the comparatively short interlamellar setae of this species.

Remarks. *Macrogena abbreviata* sp. n. differs from all other species of this genus by the short interlamellar setae, which do not reach the lamellar cusps.

Key to known species *Macrogena*

1 Legs tridactylous; four pairs of porose areas present; body size: 315–332 × 182–199 .... ***Macrogena brevisensilla* sp. n.** Distribution: New Zealand.

– Legs monodactylous; three pairs of porose areas present **2**

2 Bothridial setae with a short stalk (half or less than the length of head) **3**

– Bothridial setae with a long stalk (similar or longer than the length of head) **4**

3 Lamellar cusps without teeth; interlamellar setae of medium size, not reaching the lamellar cusps; body size: 254–291 × 143–151 .... ***Macrogena abbreviata* sp. n.** Distribution: New Zealand.

– Lamellar cusps with lateral teeth; interlamellar setae long, reaching the lamellar cusps; body size: 308–330 × 198–213 .... ***Macrogena monodactyla* Wallwork, 1966**. Distribution: Antarctic region.

4 Lamellar cusps with lateral teeth; interlamellar setae not reaching the rostrum; body length: 240 .... ***Macrogena rudentiger* Hammer, 1967**. Distribution: New Zealand.

– Lamellar cusps without teeth; interlamellar setae reaching the rostrum; body length: 280 .. ***Macrogena crassa* Hammer, 1967**. Distribution: New Zealand.

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Review of the genus *Canalirogas* van Achterberg & Chen (Hymenoptera, Braconidae, Rogadinae) from Vietnam, with description of ten new species

Khuat Dang Long[1], Cornelis van Achterberg[2]

1 *Institute of Ecology & Biological Resources, Vietnam Academy of Science & Technology, 18 Hoang Quoc Viet Road, Cau Giay, Ha Noi, Vietnam* **2** *Department of Terrestrial Zoology, Naturalis Biodiversity Center, Postbus 9517, 2300 RA Leiden, The Netherlands*

Corresponding author: *Khuat Dang Long* (khuatdanglong@iebr.ac.vn)

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Abstract

The Vietnamese species of the genus *Canalirogas* van Achterberg & Chen, 1996 (Hymenoptera: Braconidae: Rogadinae) are revised. Ten species are new to science, viz., *Canalirogas affinis* **sp. n.**, *C. cucphuongensis* **sp. n.**, *C. curvinervis* **sp. n.**, *C. eurycerus* **sp. n.**, *C. hoabinhicus* **sp. n.**, *C. intermedius* **sp. n.**, *C. parallelus* **sp. n.**, *C. robberti* **sp. n.**, *C. vittatus* **sp. n.** and *C. vuquangensis* **sp. n.** One species is new for the Vietnamese fauna: *Canalirogas spilonotus* (Cameron, 1905) and *C. balgooyi* van Achterberg & Chen, 1996, is synonymized with it (**syn. n.**); a lectotype is designated for *Troporhogas spilonotus*. A key to the Vietnamese species of the genus is also provided.

Keywords

Braconidae, Rogadinae, *Canalirogas*, new species, new synonym, key, Vietnam

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Introduction

Little is known about most subfamilies of Braconidae from Vietnam, and the subfamily Rogadinae is no exception. For 15 years specialists of the Institute of Ecology & Biological Resources (IEBR) at Vietnam Academy of Science & Technology (VAST) and RMNH have been collecting Braconidae from all over Vietnam to get a first understanding of the Vietnamese fauna of Braconidae, partly in collaboration with Dr S.A. Belokobylskij (St. Petersburg, Russia). In this paper, the newly discovered species of the Indo-Australian genus *Canalirogas* van Achterberg & Chen, 1996 (Rogadinae) from Vietnam are described. It is a rather small genus comprising eleven known species (Yu et al. 2012), with *Troporhogas spilonotus* Cameron, 1905, from Sri Lanka to be added (Quicke and Shaw 2005). The Vietnamese species were mainly collected using sweep nets and Malaise traps. Specimens of *Canalirogas* mainly occur in more or less open habitats, viz., secondary forest and gardens, as indicated by the pale colour pattern of the body. As far as known, all species of Rogadinae are endoparasitoids of lepidopteran larvae and the larvae are mummified. The checklist and distribution of twenty *Canalirogas* species from the Oriental and Australian regions are given and a key to all known Vietnamese species is provided.

Material and methods

Most of the examined specimens (including the types) are deposited in the collections of IEBR and VNMN (Ha Noi, Vietnam) and RMNH (Leiden, The Netherlands). The lectotype of *C. spilonotus* (Cameron) is housed in BMNH (London, UK). The following abbreviations are used: Od = diameter of posterior ocellus; OOL = oculacellar line; POL = postocellar line; MT: Malaise trap; 'Rog. + number': code number indexing for specimens of the Rogadinae in the collection; N: North; S: South, NC: North Central, NE: Northeast, NW: Northwest; NP: National Park; IEBR = Institute of Ecology & Biological Resources (Ha Noi, Vietnam), BMNH = Natural History Museum (London, UK), RMNH = Naturalis Biodiversity Center (Leiden, The Netherlands) and VNMN = Vietnam National Museum of Nature (Ha Noi, Vietnam).

For identification of the subfamily, see van Achterberg (1990, 1993, 1997); for the subdivision of the subfamily, see van Achterberg (1991). For separating *Canalirogas* from both similar genera *Macrostomion* Szépligeti and *Colastomion* Baker and for a key to the genera see Chen and He (1997). For the terminology used in this paper, see van Achterberg (1988). Drawings were made under an Olympus SZ40 binocular microscope by the first author. Photographs with scale lines were made with a Canon® G10 camera attached to a Zeiss® 426126 binocular microscope or with a Canon® G15 camera attached to an Olympus® SZ61 binocular microscope by the first author. Those without scale lines were taken with an Olympus SZX12 motorized stereomicroscope with AnalySIS Extended Focal Imaging Software by the second author. Measurements were taken as indicated by van Achterberg (1988).

Systematics

Canalirogas **van Achterberg & Chen, 1996**

Figs 1–78

Canalirogas van Achterberg & Chen, 1996: 63–64. Type-species (by original designation): *Canalirogas balgooyi* van Achterberg & Chen, 1996 (examined; = *C. spilonotus* (Cameron, 1905), **syn. n.**).

Diagnosis. *Canalirogas* can be separated from related genera by the combination of (1) hypopygium of female distinctly convex ventrally and strongly enlarged (Figs 15, 21, 30, 35, 41, 47, 56, 64, 69, 78); (2) ovipositor distinctly curved downwards (Figs 30, 41, 64, 78); (3) ovipositor sheath widened (Figs 15, 25, 30, 47, 56, 64, 78); (4) second metasomal tergite without distinct medio-basal area (Figs 3–4, 6–11, 18, 37, 54, 62, 76); (5) anterior half of fourth-fifth tergites usually (partly) obliquely striate; (6) tarsal claws simple. The vertex is smooth, the prepectal carina complete, the tarsal claws simple, the hind tibia with apical comb on inner side and the dorsope is present.

Biology. Parasitoids of Lymantriidae on clove trees (Quicke and Shaw 2005).

Checklist and distribution

Canalirogas acutus van Achterberg, 1996, from Indonesia, Malaysia
Canalirogas agilis van Achterberg, 1996, from Indonesia
Canalirogas affinis sp. n., from Vietnam
Canalirogas cucphuongensis sp. n., from Vietnam
Canalirogas curvinervis sp. n., from Vietnam
Canalirogas eurycerus sp. n., from Vietnam
Canalirogas fuscipalpis van Achterberg, 1996, from Indonesia
Canalirogas heijningeni van Achterberg, 1996, from Indonesia
Canalirogas hoabinhicus sp. n., from Vietnam
Canalirogas infuscatus van Achterberg, 1996, from Malaysia
Canalirogas intermedius sp. n., from Vietnam
Canalirogas kahonoi van Achterberg, 1996, from Indonesia, Malaysia
Canalirogas maculatus van Achterberg, 1996, from Indonesia
Canalirogas nigratus van Achterberg, 1996, from Indonesia
Canalirogas parallelus sp. n., from Vietnam
Canalirogas robberti sp. n., from Vietnam
Canalirogas spilonotus (Cameron, 1905), from Sri Lanka and including *C. balgooyi* van Achterberg & Chen, 1996, from Burma, China, India, Indonesia, Malaysia, Nepal, Vietnam. Syn. n.
Canalirogas tuberculatus van Achterberg, 1996, from Indonesia
Canalirogas vittatus sp. n., from Vietnam
Canalirogas vuquangensis sp. n. from Vietnam
Canalirogas yvonnae van Achterberg, 1996, from Indonesia, Malaysia

Key to Vietnamese species of the genus *Canalirogas* van Achterberg & Chen

1 Second metasomal tergite about twice as long as third tergite medially (Figs 11, 18); mesosternum behind prepectal (= epicnemial) carina; mesopleuron medially dark brown or reddish brown (Fig. 17).... ***C. cucphuongensis*** **sp. n.**

– Second tergite 1.5–1.8 times longer than third tergite medially (Figs 3, 4, 6–10, 62, 76); mesosternum (except more or less anteriorly) and mesopleuron medially yellowish-brown, pale yellow or ivory (Figs 2, 13, 23, 28, 33, 39, 45, 51, 59, 66).. **2**

2 Hind tarsus mainly dark brown; first metasomal tergite hardly longer than wide apically and distinctly widened apically (Fig. 7); hypopygium of female largely dark brown ventrally (Fig. 69) .... ***C. vittatus*** **sp. n**.

– Hind tarsus mainly yellowish-brown (usually except dark brown or brown telotarsus); first tergite 1.2–2.1 times longer than wide apically and usually slightly widened or parallel-sided (Figs 3, 4, 6, 8–10, 62, 76); hypopygium of female at least partly pale yellowish ventrally (Figs 30, 41, 56, 64), but brownish in *C. parallelus* and *C. vuquangensis* (Figs 47, 78) **3**

3 Basal third of vein SR of hind wing sclerotised and distinctly curved (Fig. 26); hypopygium of female less convex baso-ventrally (Fig. 25); clypeus flattened; ovipositor nearly straight (Fig. 25); second metasomal tergite mainly blackish or dark brown.. ***C. curvinervis*** **sp. n.**

– Basal third of vein SR of hind wing only pigmented and slightly curved (Figs 37, 43, 48, 49); hypopygium of female distinctly convex baso-ventrally (Figs 30, 35, 56); clypeus convex or concave (Figs 12, 50, 58, 72); ovipositor distinctly curved (Figs 35, 56, 69, 78); second metasomal tergite partly yellowish-brown or pale yellowish.. **4**

4 First metasomal tergite gradually widened subapically, first tergite 1.2–1.3 times longer than its apical width (Figs 6, 10); outer side of hind femur pale yellowish, at most partly infuscate; hypopygium yellow or ivory ventrally (Fig. 30); ovipositor rather slender (Figs 30, 35) **5**

– First tergite subparallel-sided, first tergite 1.4–1.9 times as long as apical width (Figs 4, 8, 9, 54), if apically somewhat widened, outer side of hind femur usually partly distinctly infuscate, dark yellowish brown or dark brown (Figs 55, 63, 77); ovipositor less slender (Figs 56, 69, 78).......................... **6**

5 Ocelli smaller (Fig. 34), diameter of posterior ocellus of female 1.2–1.3 times POL; second segment of maxillary palp widened medially; hind femur about 6 times as long as wide, its outer side without infuscation; vertex partly (Fig. 34) and mesoscutum pale brown; propodeum brown laterally (Fig. 33); vein r of fore wing slender (Fig. 36).................................. ***C. hoabinhicus*** **sp. n.**

– Ocelli larger (Fig. 29), diameter of posterior ocellus of female about 2.3 times POL; second segment of maxillary palp normal medially; hind femur about 5 times as long as wide, its outer side partly infuscate; vertex (Fig. 29) and mesoscutum pale yellowish; propodeum dark brown laterally (Fig. 28); vein r of fore wing widened (Fig. 31) .... ***C. eurycerus*** **sp. n.**

6 Apex of third tergite without medio-apical divergent striation (Fig. 9); mesopleuron behind prepectal carina mainly brownish-yellow, without dark brown patch (Fig. 13); hypopygium mainly ivory or somewhat pale yellow.... ***C. affinis*** **sp. n.**

– Apex of third tergite with more or less medio-apical divergent striation (Figs 4, 6–8, 10, 62); mesopleuron behind prepectal carina brownish yellow or dark brown (Figs 28, 51, 59, 66, 73), if not, hypopygium dark brown basally (Fig. 41) or first-second metasomal tergites mainly dark brown (Figs 54, 76) **7**

7 Propodeum entirely dark brown or black, without pale area medially; outer side of hind femur and of hind coxa yellow; side of pronotum dark brown dorsally (Fig. 45)... ***C. parallelus*** **sp. n.**

– Propodeum with yellowish longitudinal area medially (Figs 52, 74) and remainder brown or dark brown; outer side of hind femur more or less dark brown subapically; colour of hind coxa variable; side of pronotum ivory or pale yellow dorsally (Figs 51, 59, 73) **8**

8 Clypeus shallowly concave medially; ventral rim differentiated and slightly protruding (Fig. 51); [first metasomal tergite 1.7–1.9 times as long as wide apically and parallel-sided apically (Fig. 54)]..................... ***C. robberti*** **sp. n.**

– Clypeus flat medially or slightly convex; ventral rim absent (Figs 59, 73)....**9**

9 Third and fourth metasomal tergites with sub-transverse elements posteriorly (Fig. 8); apical width of first tergite 1.7–1.8 times its minimum subbasal width (Fig. 8); diameter of posterior ocellus about 1.4 times OOL; occipital carina evenly concave (Fig. 40) .... ***C. intermedius*** **sp. n.**

– Third and fourth tergites without sub-transverse elements posteriorly and only obliquely striate (Figs 62, 76); apical width of first tergite 1.5–1.6 times its minimum subbasal width (Figs 62, 76); diameter of posterior ocellus usually 2–3 times OOL (Figs 61, 75); occipital carina deeply concave (Fig. 75).... **10**

10 Area in front of prepectal carina pale yellow (Fig. 59); face yellow sublaterally (Fig. 58); ovipositor sheath mainly yellowish brown and only apically darkened (Fig. 64); temple narrow, eye in lateral view about 6 times as wide as temple (Fig. 59)..................................... ***C. spilonotus*** **(Cameron, 1905)**

– Area in front of prepectal carina dark brown (Fig. 73); head brown sublaterally (Fig. 72); ovipositor sheath mainly dark brown (Fig. 78); temple somewhat wider, eye in lateral view about 4.4 times as wide as temple (Fig. 73)... .... ***C. vuquangensis*** **sp. n.**

Descriptions

Canalirogas affinis sp. n.

http://zoobank.org/DC0F9921-0428-47A3-9DCA-75EF6AF7E505

Figs 9, 12–16

Material. Holotype, female (VNMN), 'Rog.639', "[NE Vietnam:] Phu Tho, Tan Son, Kiet Son, orchard, 21°10'N, 104°57E', 110 m, MT, 11-15.v.2009, KD Long, NH

Thao”. Paratypes (13 females; VNMN, RMNH): 1 female, ‘Rog.632’, id. but 6–10.vii.2009; 1 female, ‘Rog.636’, id. but 6–10.v.2009; 1 female, ‘Rog.637’, id. but 16–20.vi.2009; 1 female, ‘Rog.638’, id. but 20–26.vii.2009; 1 female, ‘Rog.640’, id. but 6–10.vi.2009; 1 female, ‘Rog.641’, id. but 26–30.vii.2009; 1 female, but ‘Rog.643’, id. 26–31.vii.2009; 1 female, ‘Rog.647’, id. but 1–5.vii.2009; 1 female, ‘Rog.648’, id. but 15–31.viii.2009; 1 female, ‘Rog.772’, “[NE Vietnam:] Phu Tho, Tan Son, Xuan Dai, 21°07'N, 105°00'E, 120 m, MT 11–15.iv.2009, KD Long; 1 female, ‘Rog.471’, “[NE Vietnam:] Vinh Phuc, Me Linh, Ngoc Thanh, forest, 21°23'N, 105°43'E, 280 m, MT, 1–13.viii.2000, KD Long”; 1 female, ‘Rog.663’, id. but MT 23.v.-7.vi.2001, KD Long; 1 female, ‘Rog.644’, id. but MT, 4–15.v.2001, KD Long.

Description. Holotype, female, body length 7.7 mm, fore wing length 5.7 mm.

Head. Antenna incomplete, with 45 segments remaining; middle segments 3.2 times longer than wide (8:2.5); third antennal segment 1.25 times fourth (10:8); width of face 0.8 times length of face and clypeus combined (18:22); malar space 0.7 times as long as mandible width (5:7); mandible width 0.7 times as long as hypoclypeal depression (7:10); malar suture present; distance between tentorial pits 3.3 times distance between pits and eyes (10:3) (Fig. 12); in dorsal view height of eye 5.0 times as long as temple (20:4); in lateral view width of eye 4.5 times longer than temple (18:4); ocelli large, POL:Od:OOL = 1:2:1; distance between front and hind ocelli as long as OOL (Fig. 14); face sparsely rugose; frons, vertex and temple smooth.

Mesosoma. Length of mesosoma 1.4 times longer than high (81:58); pronotal side smooth dorsally, crenulate medially, finely granulate ventrally; mesoscutum smooth; notauli rather shallow, flat posteriorly and smooth; precoxal sulcus short, nearly smooth; mesopleuron and metapleuron smooth (Fig. 13); scutellar sulcus 0.8 times as long as scutellum (7:9); scutellum smooth; propodeum rugose-punctate laterally, median areola with median transverse carinae.

Wings. Fore wing: pterostigma 5.2 times longer than wide (52:10); r:2-SR:3-SR:SR1=12:9:32:38; vein r arising little before middle of pterostigma; vein cu-a short and robust (Fig. 16), 1-CU1:cu-a:2-CU1:3-CU1=3:7:31:6; posterior length of second submarginal cell 2.7 times its apical width (40:15). Hind wing: vein M+CU:1-M: 1r-m=32:30:11.

Legs. Hind coxa shining with sparse fine punctures; length of hind femur:tibia:basitarsus: tarsus = 32:43:22:50; length of hind femur, tibia and basitarsus 5.3, 9.5 and 11.0 times as long as their width respectively; inner hind tibial spur 0.25 times as long as basitarsus (11:44).

Metasoma. First tergite 1.45 times as long as apical width (43:32) (Fig. 9); first-third tergites with parallel striation; fourth tergite with divergent striation; medial length of second tergite 1.5 times than third (33:22); second suture crenulate; ovipositor sheath truncate apically, 0.5 times as long as hind basitarsus (22:44); ovipositor stout (Fig. 15).

Colour. Pale yellow; antenna yellow; palpi whitish yellow; stemmaticum black; pronotum, mesopleuron, metapleuron pale yellow; hind coxa blackish dorsally and ventrally, yellow basally and ventrally; propodeum laterally, metasomal tergites 1-5 basally and tergite 6 entirely, black; wing subhyaline with brownish yellow veins, setae pale yellow; pterostigma dark brown medially, yellow basally and apically (Fig. 16).

Male. Unknown.

Variation. Paratypes, antenna with 44–52 segments; first tergite 1.35–1.45 times as long as apical width; medial length of metasomal second tergite 1.5–1.6 times as long as third tergite medially; body length 5.6–8.0 mm; fore wing length 4.6–5.9 mm.

Etymology. Named 'affinis' (Latin for 'related to'), because this species is close to *C. spilonotus* (Cameron).

Canalirogas cucphuongensis **sp. n.**

http://zoobank.org/C57127C0-6DF6-44CB-8167-54125B7E4EB0

Figs 11, 17–21

Material. Holotype, female (VNMN), 'Rog.202', "[NW Vietnam:] Hoa Binh, Yen Thuy, secondary forest close to Cuc Phuong NP, 20°28'N, 105°34'E, 315 m, M[alaise] T[rap], 10–20.vi.2002, KD Long".

Description. Holotype, female, body length 5.7 mm, fore wing length 4.0 mm, antenna 6.7 mm, ovipositor sheath 0.4 mm.

Head. Antenna with 47 segments, 1.2 times longer than body; third antennal segment 1.14 times fourth one (8:7); middle segments 3.0 times as long as wide (6:2), penultimate antennal segment 0.6 times apical segment; apical segment with spine; width of face 0.9 times length of face and clypeus combined (15:16); malar space 0.8 times as long as mandible width (4:5), mandible width 0.6 times as long as hypoclypeal depression (5:9); malar suture present; distance between tentorial pits 2.3 times distance between pits and eyes (7:3; Fig. 19); in dorsal view height of eye 3.5 times as long as temple (14:4); in lateral view width of eye 2.4 times as long as temple (12:5); ocelli in high triangle, POL:Od:OOL = 4:6:5, distance between front and hind ocelli as long as OOL (Fig. 20); face rugose laterally, smooth medially; frons, vertex and temple smooth.

Mesosoma. Length of mesosoma 1.4 times as long as high (57:41); pronotal trough smooth dorsally, crenulate medially, finely granulate ventrally; precoxal sulcus short, narrow and crenulate (Fig. 17); mesopleuron and metapleuron shiny and smooth; notauli deep and crenulate, united posteriorly in a deep groove; mesoscutum with sparse fine punctures; scutellum almost smooth; scutellar sulcus 0.9 times as long as scutellum (10:11); propodeum punctate basally, rugose apically, medial areola crenulate.

Wings. Fore wing: pterostigma 4.4 times as long as wide (35:8); r:2-SR:3-SR:SR1 = 7:9:21:36; vein r before middle of pterostigma; vein cu-a short and vertical, vein 1-CU1 quadrate; posterior length of second submarginal cell 3.3 times its apical width (30:9). Hind wing: vein M+CU:1-M:1r-m = 22:18:10.

Legs. Hind coxa smooth; length of hind femur:tibia:basitarsus:tarsus = 51:63:34:85; length of hind femur, tibia and basitarsus 5.7, 10.5 and 11.3 times their width, respectively; inner hind tibial spur 0.2 times as long as basitarsus (7:34).

Metasoma. First tergite 1.5 times longer than apical width (32:21) (Figs 11, 18); second suture more or less crenulate; medial length of metasomal second tergite 2.2 times as long as third tergite medially (29:13); second-third tergites with comparatively less divergent striation (Fig. 18); fourth-fifth tergites with curved striation; sixth tergite granulate; ovipositor sheath 0.8 times as long as hind basitarsus (28:34); ovipositor slightly curved (Fig. 21).

Colour. Brown; head and antenna yellow; palpi yellow; stemmaticum brown; fore and middle legs yellow; hind coxa, hind femur subapically and hind telotarsus brownish; metasoma ventrally yellow; wings subhyaline, with veins brownish, but parastigma yellow; mesosternum dark brown and mesopleuron dark or reddish brown (Fig. 17).

Male. Unknown.

Etymology. Named after the famous national park near its type locality: Cuc Phuong National Park.

Canalirogas curvinervis **sp. n.**

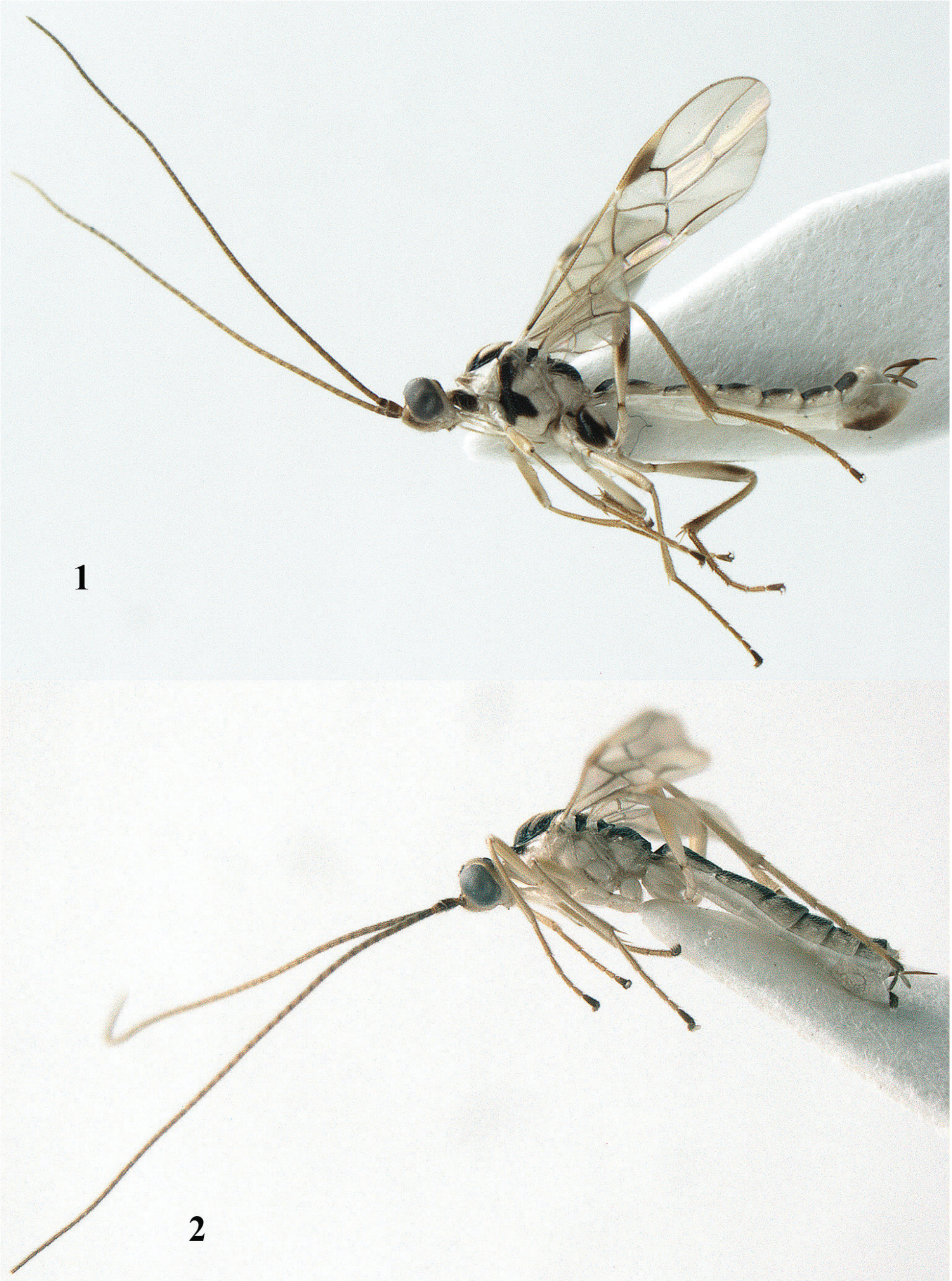
http://zoobank.org/B4C391B4-C285-4107-BD3D-BBDB62661254
Figs 2, 3, 22–26

Material. Holotype, female (RMNH) "[C Vietnam:] Thua Thien-Hue, Phong Dien N.R., 15 km W. Phong My, 80–210 m, 23.iii.-6.iv.2001, Mal. trap, C. v. Achterberg & R. de Vries, RMNH'01". Paratypes (5 females): 1 female (IEBR), "[NE Vietnam:] Viet Tri, nr Thanh Son, Thuong Cuu, 20°59'N, 105°8'E , 350–400 m, 11–16.x.1999, Mal. trap, R. de Vries, RMNH'99"; 1 female (RMNH), 'Rog.662', "[NE Vietnam:] Vinh Phuc, Tam Dao NP, 200 m, MT, 23.v.-7.vi.2001, KD Long"; 1 female (RMNH), "[NC Vietnam:] Ha Tinh, Vu Quang NP, 94 m, 18°17'43"N, 105°25'49"E, 5.iii.–15.iv.2011, Mal. trap 13, C. v. Achterberg, RMNH'11"; 1 female (VNMN), 'Rog.690', "[NC Vietnam:] Ha Tinh, Vu Quang NP, 6.x.2009, KD Long"; 1 female (RMNH), "[S Vietnam:] Dông Nai, Cát Tiên N.P., Bird trail, Mal. trap[s] 9–12, c. 100 m, 1–9.x.2005, C. v. Achterberg & R. de Vries, RMNH'05".

Description. Holotype, female, body length 7.2 mm, fore wing length 5.3 mm.

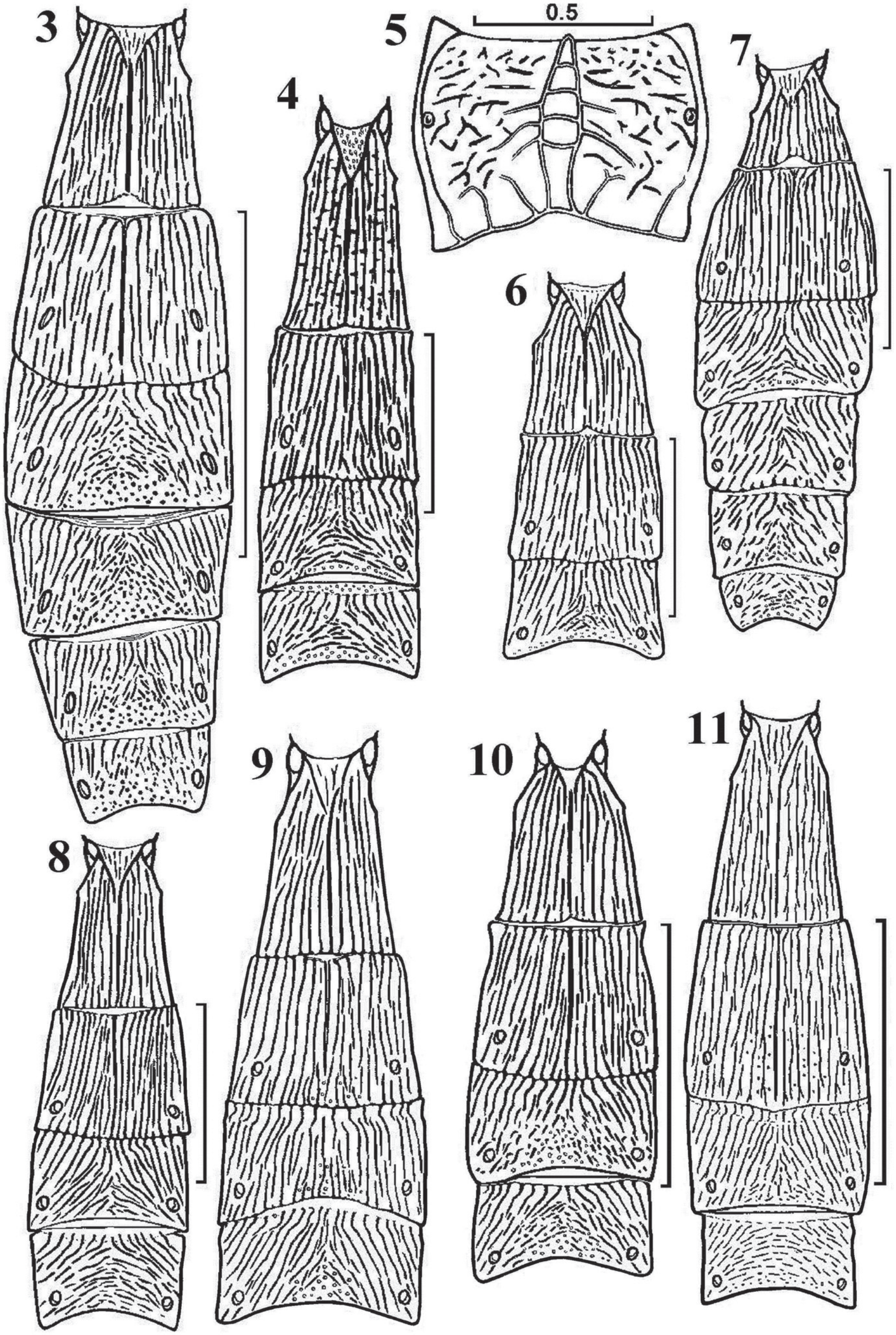
Head. Antenna with 28 segments remaining; third antennal segment 1.1 times fourth one (10:9); middle segments 2.3 times its width (7:3); width of face 0.9 times length of face and clypeus combined (19:21); malar space as long as mandible width; mandible width 0.6 times as long as hypoclypeal depression (6:10); malar suture present; distance between tentorial pits 5.0 times distance between pits and eyes (10:2; Fig. 22); in dorsal view height of eye 5.8 times as long as temple (23:4); in lateral view width of eye 3.2 times as long as temple (19:6); ocelli in high triangle, POL:Od:OOL = 3:6:4; distance between front and hind ocelli:OOL = 3:4 (Fig. 24); face rugose; frons, vertex and temple smooth.

Mesosoma. Length of mesosoma 1.5 times as long as high (90:60); pronotal side smooth dorsally, crenulate anteriorly, finely granulate ventrally; precoxal sulcus long, deep and crenulate (Fig. 23); mesopleuron smooth; mesoscutum smooth; notauli deep and crenulate; propodeum mainly rugose and without distinct medial areola.

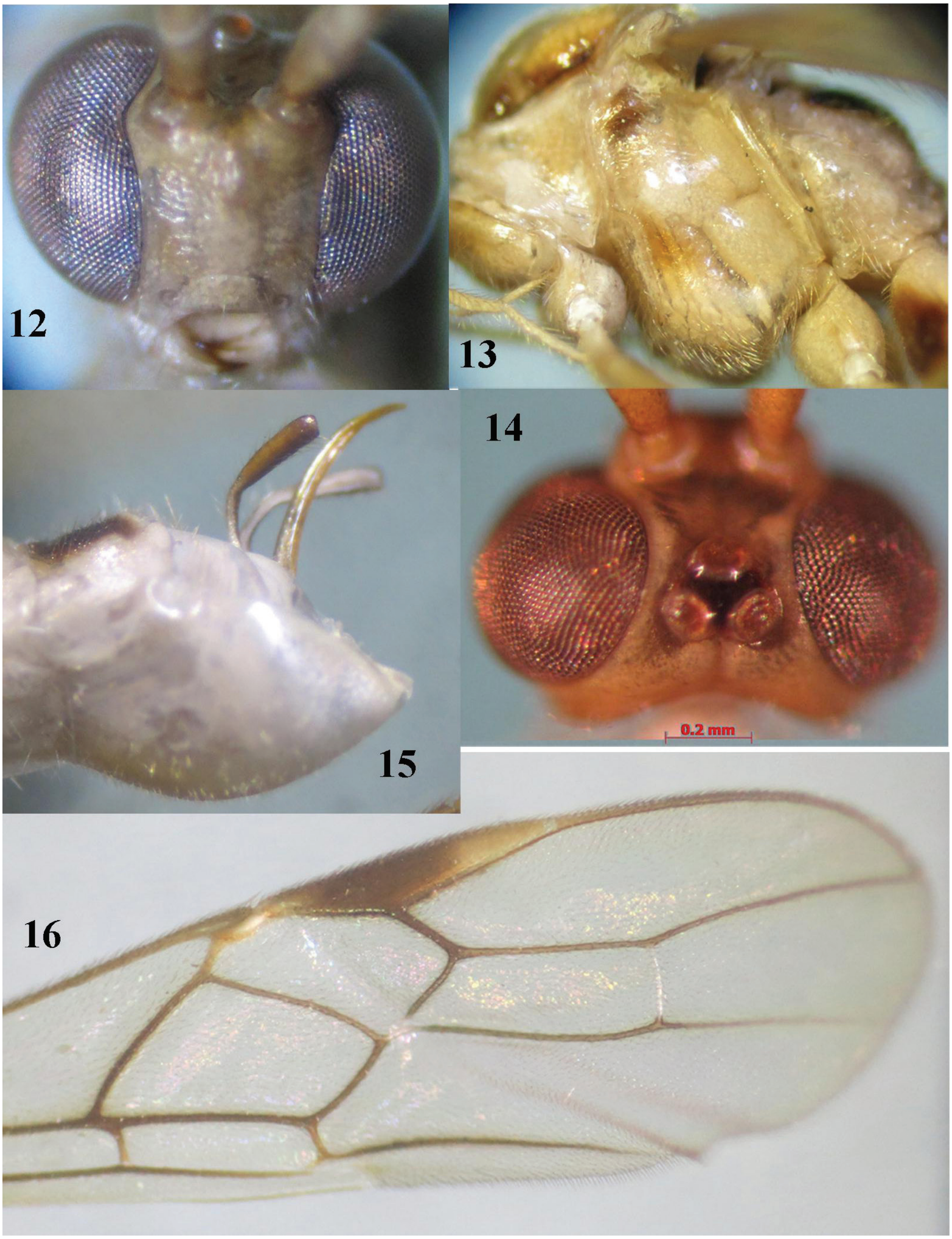


Figures 1–2. *Canalirogas vuquangensis* sp. n. (**1** holotype, female) and *C. curvinervis* sp. n. (**2** paratype, female), habitus lateral.

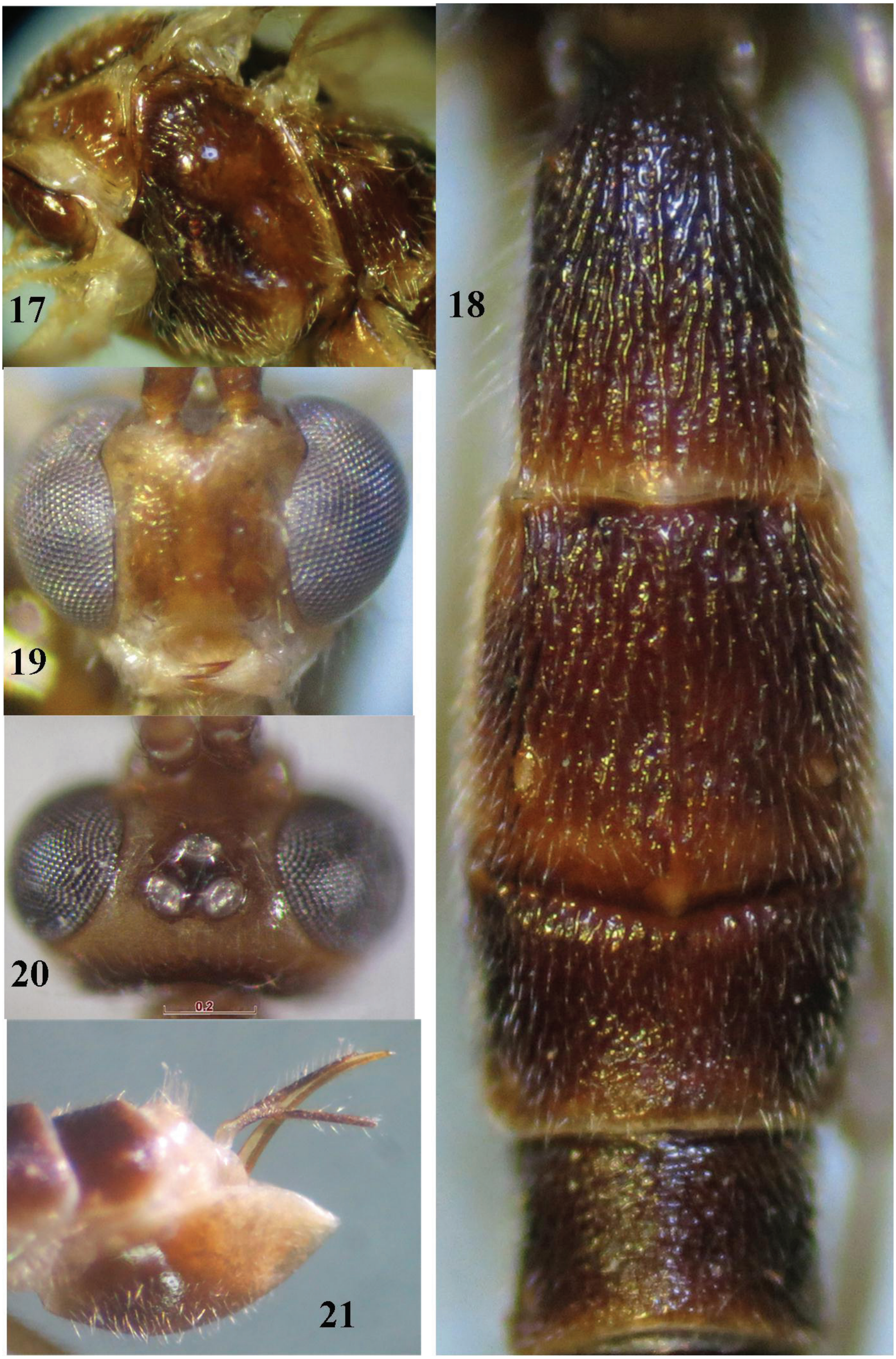
Wings. Fore wing: pterostigma 4.8 times as long as wide; r:2-SR:3-SR:SR1=10:18:28:50; vein r arising submedially from pterostigma (Fig. 28); vein 1-CU1 quadrate; vein cu-a perpendicular; posterior length of second submarginal cell



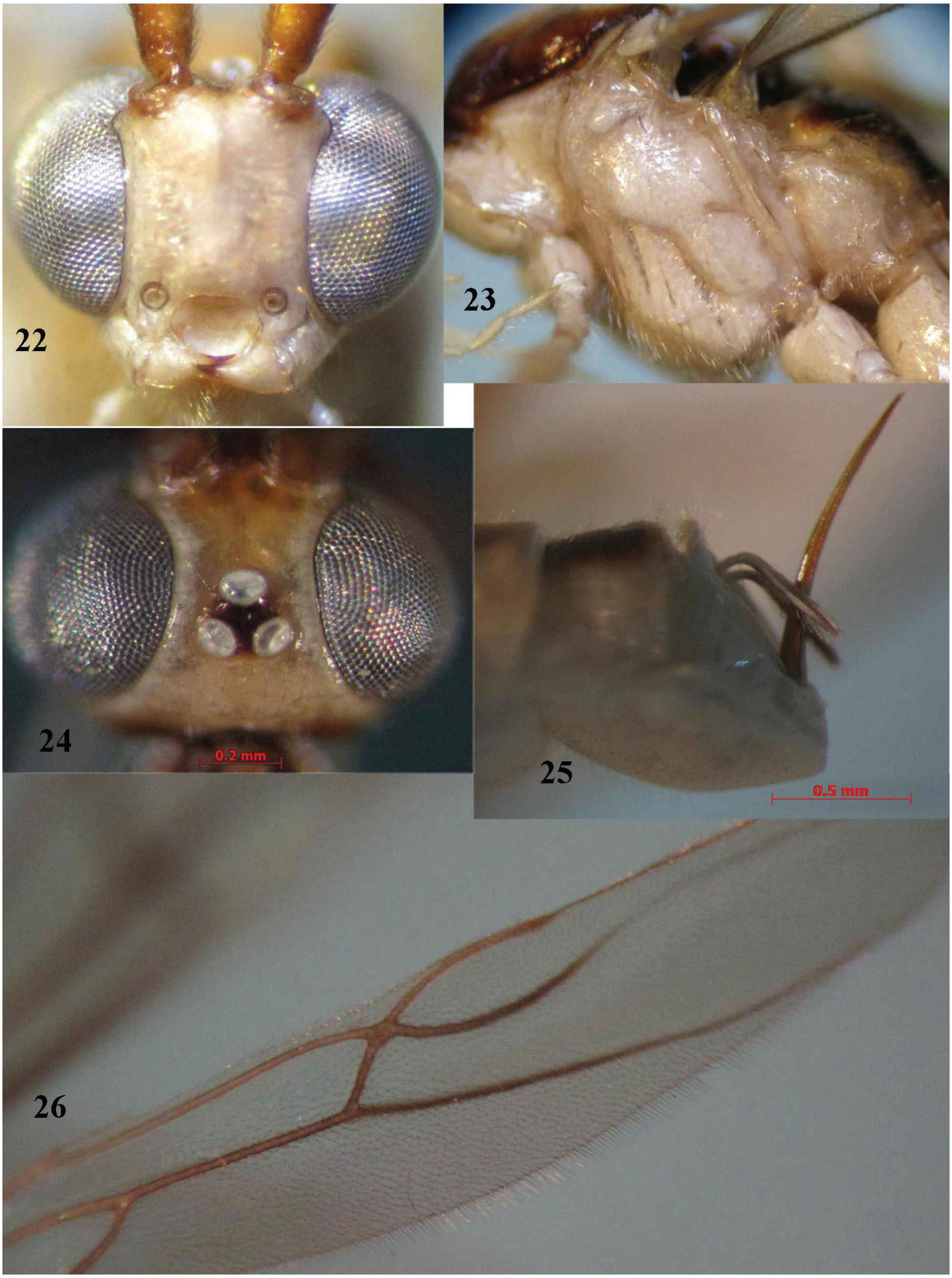
Figures 3–11. *Canalirogas* spp.: basal metasomal segments dorsal, but 5 propodeum dorsal. **3** *C. curvinervis* sp. n. **4, 5** *C. parallelus* sp. n. **6** *C. hoabinhicus* sp. n. **7** *C. vittatus* sp. n. **8** *C. intermedius* sp. n. **9** *C. affinis* sp. n. **10** *C. eurycerus* **11** *C. cucphuongensis* sp. n.



Figures 12–16. *Canalirogas affinis* sp. n., female, holotype. **12** head anterior **13** mesosoma lateral **14** head dorsal **15** hypopygium lateral **16** apical part of fore wing.



Figures 17–21. *Canalirogas cucphuongensis* sp. n., female, holotype. **17** mesosoma lateral **18** first-fourth tergites dorsal **19** head anterior **20** head dorsal **21** hypopygium lateral.



Figures 22–26. *Canalirogas curvinervis* sp. n., female, holotype. **22** head anterior **23** mesosoma lateral **24** head dorsal **25** hypopygium lateral **26** hind wing.

3.2 times its width (38:12). Hind wing: vein M+CU as long as vein 1-M and 3.5 times vein 1r-m = 35:10 (Fig. 26).

Legs. Hind coxa smooth; length of hind femur:tibia:basitarsus:tarsus = 71:92:13:43; length of hind femur, tibia and basitarsus 5.9, 10.2 and 10.75 times their width, respectively.

Metasoma. First-second tergites with median carinae and parallel striae; first tergite 1.2 times as long as its apical width (Fig. 3); medial length of second tergite 1.6 times third (42:27); third-fifth tergites basally with divergent striation, granulate medio-apically; sixth tergite mainly granulate; ovipositor sheath pointed apically (0.5 mm), 0.4 times as long as hind basitarsus (20:46); ovipositor slender, nearly straight, enlarged basally (Fig. 25).

Colour. Yellow; antenna yellowish, but darkened basally; palpi pale yellow; stemmaticum black; pronotum dorsally, notauli and mesonotum laterally, side of scutellum and axilla, propodeum medially blackish-brown or black; first-sixth tergites black medially, pale yellow laterally; wings subhyaline.

Male. Unknown

Variation. Antenna with 45(1) and 49(1) segments and 1.4 times as long as body; first tergite 1.1–1.3 times as long as apical width; medial length of metasomal second tergite 1.7–1.8 times as long as third tergite medially; body length 5.2–5.9 mm; fore wing length 4.3–4.5 mm.

Etymology. From 'curvus' (Latin for bend), because of the curved vein SR of hind wing.

***Canalirogas eurycerus* sp. n.**

http://zoobank.org/494603D1-0CE9-45EA-9DE1-968E8821E318

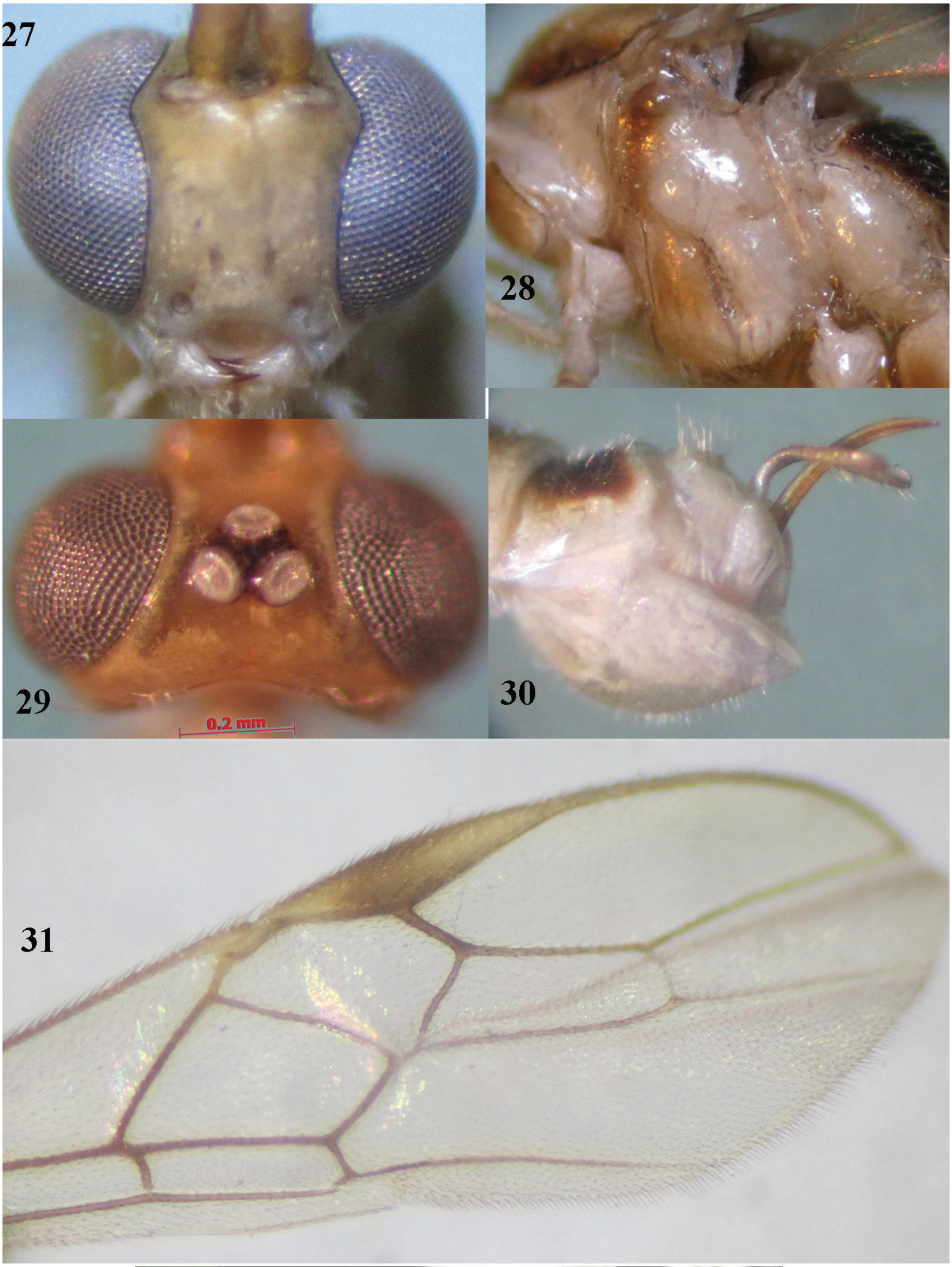
Figs 10, 27–31

Material. Holotype, female (VNMN), 'Rog.469', "[C Vietnam:] Thua Thien-Hue, Nam Dong, MT, 2–6.v.2005, NQ Truong". Paratypes (2 females): 1 female (VNMN), 'Rog.076', "[C Vietnam:] Ha Tinh, Huong Son 18°22'N, 105°13'E, 200 m, 15.v.1998, MT, AMNH, K Long"; 1 female (RMNH), 'Rog.642', "[NE Vietnam:] Phu Tho, Tan Son, 21°14'N, 104°57'E, 140 m, MT, 16–20.vii.2009, NH Thao".

Description. Holotype, female, body length 5.4 mm, fore wing length 3.9 mm.

Head. Antenna incomplete, with 37 segments remaining; third antennal segment as long as fourth; middle segments 2.8 times its width; width of face 0.8 times length of face and clypeus combined (13:16); malar space 0.8 times as long as mandible width (4:8); mandible width 0.7 times as long as hypoclypeal depression (5:7); malar suture present; distance between tentorial pits 3.5 times distance between pits and eyes (7:2; Fig. 27); in dorsal view height of eye 5.3 times as long as temple (16:3); temple narrow, in lateral view width of eye 4.7 times as long as temple (14:3); ocelli large, POL:Od:OOL=3:7:4 (Fig. 29); distance between front and hind ocelli:OOL = 3:4; face mostly smooth with sparse fine punctures; frons, vertex and temple smooth.

Mesosoma. Length of mesosoma 1.2 times as long as high (47:38); pronotal trough mainly smooth, sparsely crenulate anteriorly; precoxal sulcus short, deep and smooth;



Figures 27–31. *Canalirogas eurycerus* sp. n., female, holotype. **27** head anterior **28** mesosoma lateral **29** head dorsal **30** hypopygium lateral **31** apical part of fore wing.

mesopleuron and metapleuron smooth (Fig. 28); mesoscutum and scutellum smooth; notauli short, crenulate anteriorly, flat and smooth posteriorly; propodeum rugose laterally with medial areola crenulate.

Wings. Fore wing: pterostigma 4.4 times as long as wide; r:2-SR:3-SR:SR1 = 8:11:22:31; vein r arising before middle of pterostigma (Fig. 31); 1-CU1:cu-a:2-CU1:3-CU1 = 2:4:21:4; posterior length of second submarginal cell 3.0 times its width (30:10). Hind wing: vein M+CU 1.1 times vein 1-M (24:22) and 3.0 times vein 1r-m (24:8).

Legs. Hind coxa smooth; length of hind femur:tibia:basitarsus:tarsus = 44:55:28:68; length of hind femur, tibia and basitarsus 4.9, 9.2 and 14.0 times their width, respectively; inner hind tibial spur 0.2 times as long as basitarsus (3:14).

Metasoma. First-second with median carinae; first tergite 1.2 times as long as apical width (28:22); medial length of second tergite 1.7 times third (25:15; Fig. 10); second suture crenulate; third and fourth with basal striation, granulate apically; ovipositor sheath 2.5 times inner hind spur (15:6); ovipositor rather slender, gradually curved (Fig. 30).

Colour. Yellow; antenna yellow, medial and subapical segments with medial pale band; palpi pale yellow; stemmaticum black; side of scutellum and axilla brown; metasoma yellow except first tergite basally and sixth tergite medially brown; propodeum dark brown but yellow medially; wings subhyaline.

Male. Unknown.

Variation. Antennal segments 44(1); first tergite 1.1–1.2 times as long as apical width; medial length of metasomal second tergite 1.6–1.7 times as long as third tergite medially; body length 4.4–5.6 mm; fore wing length 3.4–4.3 mm.

Etymology. From ‘eurys’, Greek for ‘widespread’.

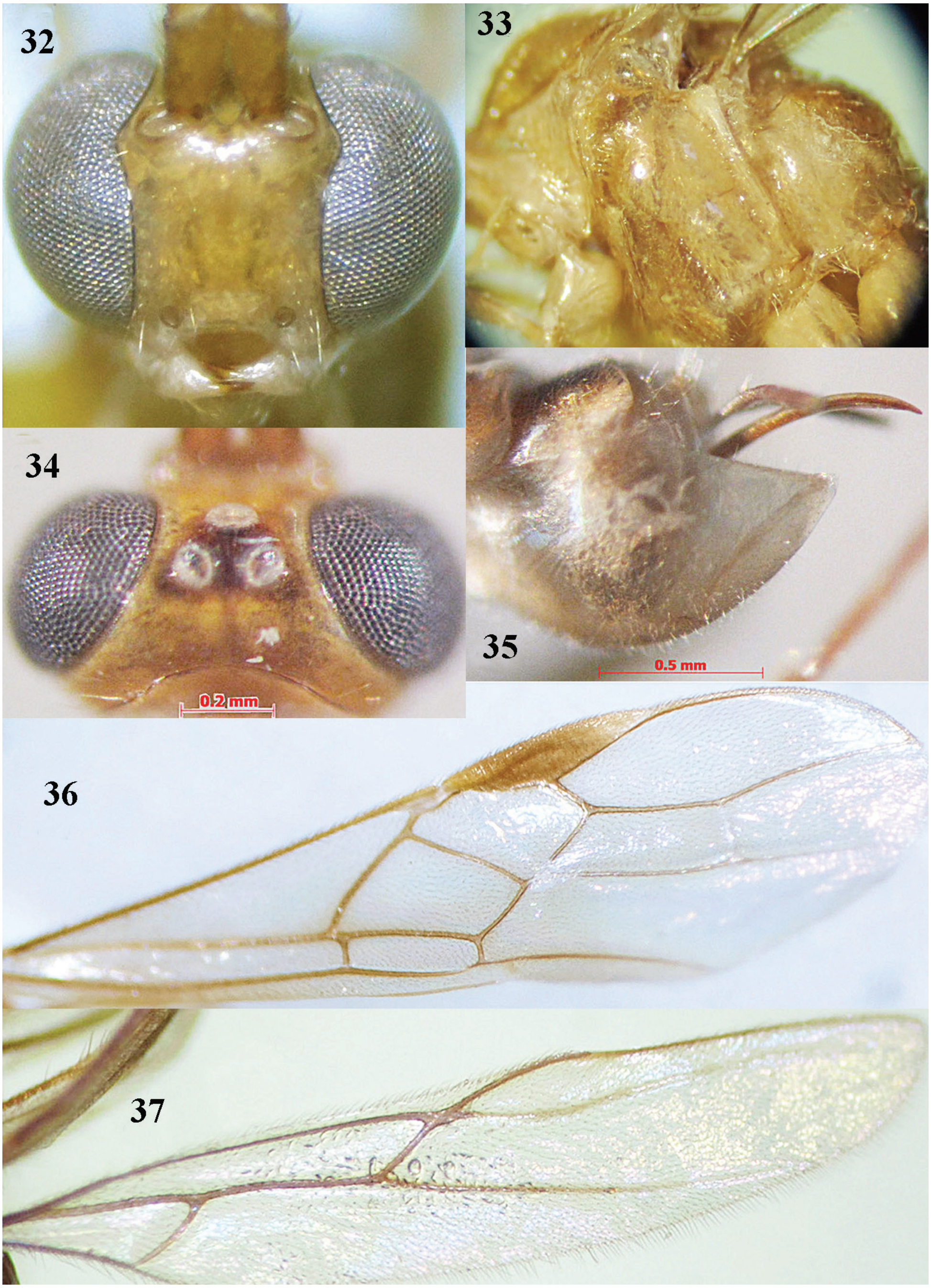
Canalirogas hoabinhicus **sp. n.**

http://zoobank.org/2AFF74EC-92C5-48B0-84A1-D12C17EB2C3F
Figs 6, 32–37

Material. Holotype, female (VNMN), ‘Rog.281’, “[NW Vietnam:] Hoa Binh, Yen Thuy, secondary forest, 20°23'N, 105°34'E, 315 m, MT, 20–30.viii.2002, KD Long”. Paratypes (3 females): 1 female (RMNH), ‘Rog.016’, id. but 5.v.2002; 1 female (VNMN), ‘Rog.692’, “[NW Vietnam:] Hoa Binh, Mai Chau, Tan Son, garden, 20°43'N, 105°59'E, 650 m, MT, 1–5.v.2010, KD Long”; 1 female (VNMN), ‘Rog.694’, id. but 20–25.viii.2010, KD Long.

Description. Holotype, female, body length 6.4 mm, fore wing length 4.5 mm.

Head. Antenna incomplete, with 26 segments remaining; third segment 1.1 times fourth segment (9:8); middle segments 2.4 times longer than wide (6:2.5); width of face as long as length of face and clypeus combined; malar space 0.7 times as long as mandible width (4:6), mandible width 0.75 times as long as hypoclypeal depression (6:8); malar suture present; distance between tentorial pits 3.4 times distance between pits and eyes (17:5; Fig. 32); in dorsal view height of eye 3.3 times as long as temple (13:4); in lateral view width of eye about 3.0 times as long as temple (15:5); ocelli small, POL:Od:OOL = 4:5:3 (Fig. 34); distance between front and hind ocelli as long as OOL; face punctate; face shiny and sparsely punctate; frons, vertex and temple smooth.



Figures 32–37. *Canalirogas hoabinhicus* sp. n., female, holotype. **32** head anterior **33** mesosoma lateral **34** head dorsal **35** hypopygium lateral **36** fore wing **37** hind wing.

Mesosoma. Length of mesosoma 1.32 times as long as high (33:25); pronotal trough mainly crenulate medially, finely granulate ventrally; precoxal sulcus narrow, rather long, crenulate; mesopleuron smooth dorsally, sparsely punctate ventrally (Fig. 33); metapleuron dull; mesoscutum dull because of irregular punctures; scutellar sulcus 0.6 times as long as scutellum (6:10); propodeum mainly rugose laterally and medial areola crenulate.

Wings. Fore wing: pterostigma 4.6 times as long as wide (41:9); r:2-SR:3-SR:SR1 = 8:14:23:37 (Fig. 36); vein r arising submedially from pterostigma; 1-CU1:cu-a:2-CU1:3-CU1 = 3:6:24:4; posterior length of second submarginal cell 2.8 times its apical width (37:13; Fig. 36). Hind wing: vein M+CU:1-M:1r-m = 31:26:10 (Fig. 37).

Legs. Hind coxa with sparse fine punctures; length of hind femur:tibia:basitarsus:tarsus = 57:74:35:87; length of hind femur, tibia and basitarsus 6.3, 9.3 and 11.7 times their width, respectively; inner hind tibial spur 0.3 times as long as basitarsus (10:35).

Metasoma. First tergite 1.3 times as long as apical width (35:27); medial length of second tergite 1.6 times third (31:19) (Fig. 6); second suture crenulate; third metasomal tergites obliquely striate, striation diverging posteriorly; fourth-sixth metasomal tergites obliquely striate basally, rugose-punctate apically; ovipositor sheath 0.7 times as long as hind basitarsus (23:35), ovipositor weakly curved and slender (Fig. 35).

Colour. Yellow; antenna and palpi yellow; stemmaticum dark brown; propodeum brown laterally; all legs yellow, but telotarsi brown; all metasomal tergites yellow, but first-second tergites basally and sixth tergite brown and hypopygium somewhat infuscate (Fig. 35); wings subhyaline.

Male. Unknown.

Variation. Antennal segments 52(1); first tergite 1.3–1.4 times as long as apical width; medial length of metasomal second tergite 1.5–1.7 times as long as third tergite medially; body length 6.0–7.5 mm; fore wing length 4.3–5.0 mm.

Etymology. Named after its type locality: the province of Hoa Binh.

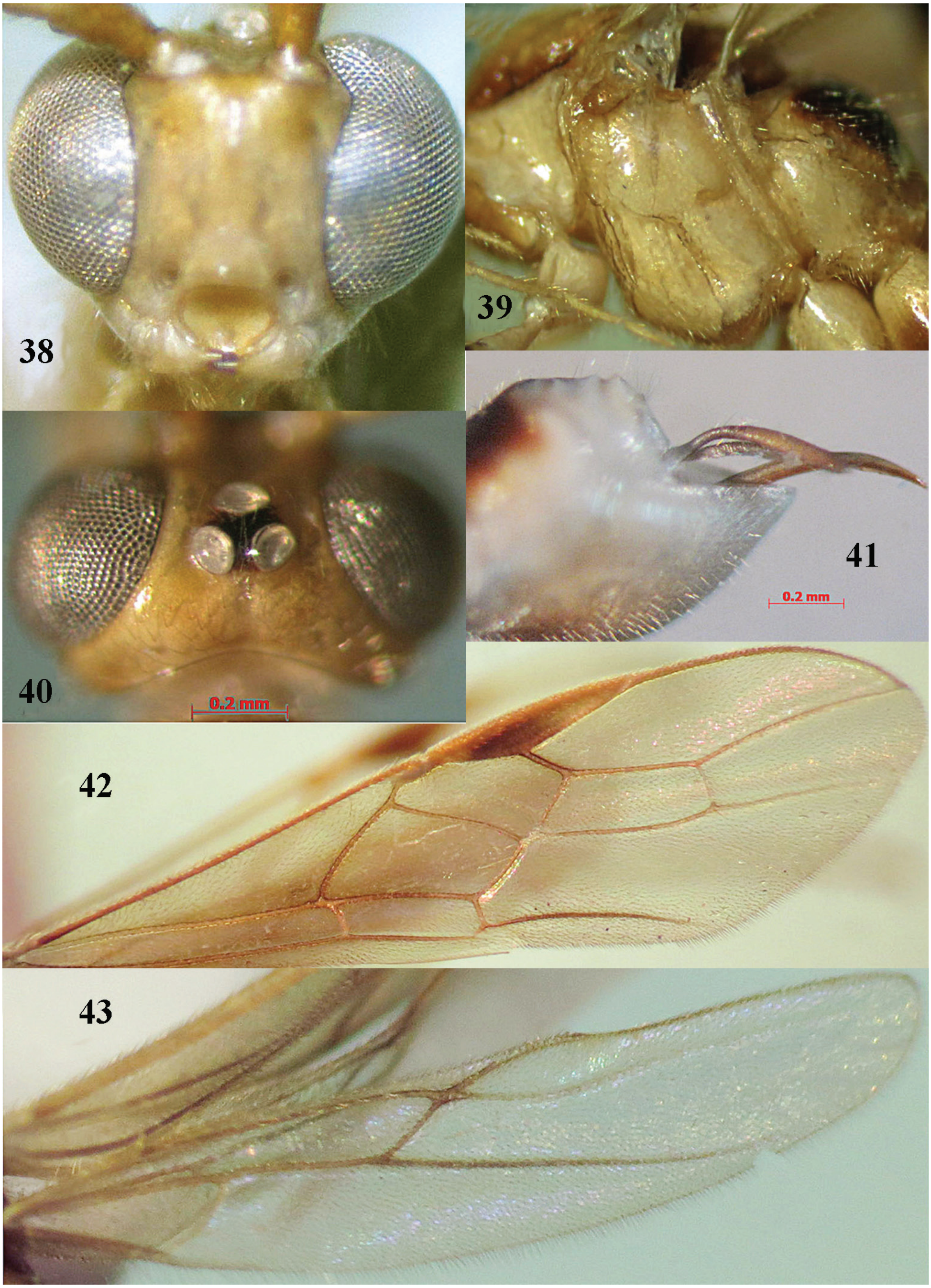
***Canalirogas intermedius* sp. n.**

http://zoobank.org/945FE282-E2D7-4127-99E3-40DCA68C2211
Figs 8, 38–43

Material. Holotype, female (VNMN) 'Rog.589', "[C Vietnam:] Thua Thien-Hue, Bach Ma NP, secondary forest, 300 m, 18.v.2007, KD Long".

Description. Holotype, female, body length 6.4 mm, fore wing length 4.8 mm, antenna 7.4 mm.

Head. Antenna with 51 segments, 1.2 times longer than body; third segment 1.3 times fourth segment (10:8); middle segments 3.5 times longer than wide (7:2), penultimate antennal segment as long as apical segment; apical segment with spine; width of face 0.9 times length of face and clypeus combined (16:18); malar space 0.5 times as long as mandible width (3:6), mandible width about 0.9 times as long



Figures 38–43. *Canalirogas intermedius* sp. n., female, holotype. **38** head anterior **39** mesosoma lateral **40** head dorsal **41** hypopygium lateral **42** fore wing **43** hind wing.

as hypoclypeal depression (6:7); malar suture present; distance between tentorial pits 4.0 times distance between pits and eyes (8:2; Fig. 38); in dorsal view height of eye 4.5 times as long as temple (18:4); in lateral view width of eye 4.0 times as long as temple (16:4) ocelli large, POL:Od:OOL = 3:6:4 (Fig. 40); distance between front and hind ocelli 0.75 times OOL (3:4); face sparsely and finely punctate; frons, vertex and temple smooth.

Mesosoma. Length of mesosoma 1.5 times as long as high (66:45); pronotal side smooth dorsally and posteriorly, crenulate medio-anteriorly, finely granulate ventrally; precoxal sulcus narrow and sparsely crenulate; mesopleuron shiny and smooth; metapleuron smooth with sparse fine punctures (Fig. 39); notauli wide and crenulate anteriorly, flat and smooth posteriorly; scutellar sulcus 0.9 times scutellum (6:7); mesoscutum smooth; propodeum rugose laterally, with medial crenulate areola.

Wings. Fore wing: pterostigma 4.9 times as long as wide (44:9); r:2-SR:3-SR:SR1 = 9:12:25:40; vein r arising before middle of pterostigma (Fig. 42); vein 1-CU1 rather short, 1-CU1:cu-a:2-CU1:3-CU1 = 2:5.5:27:5; posterior length of second submarginal cell 3.1 times its apical width (Fig. 42). Hind wing: vein M+CU:1-M: 1r-m = 32:23:12 (Fig. 43).

Legs. Hind coxa with sparse fine punctures; length of hind femur:tibia:basitarsus:tarsus = 57:73:35:85; length of hind femur, tibia and basitarsus 6.3, 10.4 and 10.0 times as long as their width, respectively; inner hind tibial spur 0.3 times as long as basitarsus.

Metasoma. First tergite 1.4 times as long as apical width (30:19); medial length of second tergite 1.8 times as long as third (30:17; Fig. 8); third-fifth metasomal tergites with divergent striation; sixth tergite rugose-punctate; ovipositor sheath 0.5 times as long as hind basitarsus (19:35; Fig. 41).

Colour. Yellow; antenna and palpi yellow; stemmaticum black; propodeum blackish brown laterally, yellow medially and posteriorly; first metasomal tergite brown, but yellow apically; second-sixth metasomal tergites brown, but lateral corners yellow; fore wing yellow with veins 1-M, 2-CU1 and CU1a medially, veins r and 2-SR brown; pterostigma brown medially, yellow basally and apically; pronotum, mesopleuron and metapleuron ivory; middle and lateral lobes of mesoscutum and side of scutellum yellow; outer side of hind coxa and hind femur subapically dark yellow.

Male. Unknown.

Etymology. From ‘inter’ (Latin for ‘between’), because this species is intermediate between *C. parallelus* sp. n. and *C. spilonotus* (Cameron), but differs from these species by having larger occelli (diameter of posterior ocellus 3.0 times as long as POL and 1.5 times as long as OOL). This species is close to *C. spilonotus*, but differs by having the mesopleuron antero-dorsally and below the precoxal sulcus pale yellow (dark brown antero-dorsally and more or less brownish below precoxal sulcus in *C. spilonotus*), the ovipositor sheath entirely brown (only apically dark brown) and the third and fourth metasomal tergites with nearly transverse striation apically (absent).

Canalirogas parallelus **sp. n.**

http://zoobank.org/FCCA8CAC-7D22-480E-B361-47C54D49AE88

Figs 4, 5, 44–48

Material. Holotype, female (RMNH), "[S Vietnam:] Kon Tum, Chu Mom Ray NP, Mal. traps, 700–900 m, 26.ix–5.x.2006, Mai Phu Quy & Nguyen Thanh Manh, RMNH'07". Paratype, 1 female (VNMN), 'Rog.520', "[NE Vietnam:] Ha Giang, Vi Xuyen, Cao Bo, forest, 300 m, 11.v.2007, KD Long".

Excluded from type series a female from Central Vietnam (missing its metasoma; IEBR) 'Rog.590', 'C. Vietnam: Thua Thien-Hue, Bach Ma NP, secondary forest 300 m, 20.v.2007, KD Long' with the precoxal area dark brown.

Description. Holotype, female, body length 7.2 mm, fore wing length 5.2 mm, antenna 10.2 mm.

Head. Antenna with 57 segments, 1.4 times longer than body; third segment 1.1 fourth segment (9:8); middle segment 2.7 times as long as wide (8:3), penultimate antennal segment 0.75 times apical segment (6:8); apical segment with spine; width of face 0.9 times length of face and clypeus combined (28:21); malar space 0.7 times as long as mandible width (4:6); basal width of mandible 0.7 times as long as hypoclypeal depression (6:9); malar suture present; distance between tentorial pits 3.0 times distance between pits and eyes (9:3; Fig. 44); in dorsal view height of eye 5.0 times as high as temple (20:4); in lateral view width of eye 3.4 times as long as temple (17:5); ocelli in high triangle, POL:Od:OOL = 4:6:4 (Fig. 46); distance between front and hind ocelli as long as OOL; face rugose-punctate; frons, vertex and temple smooth.

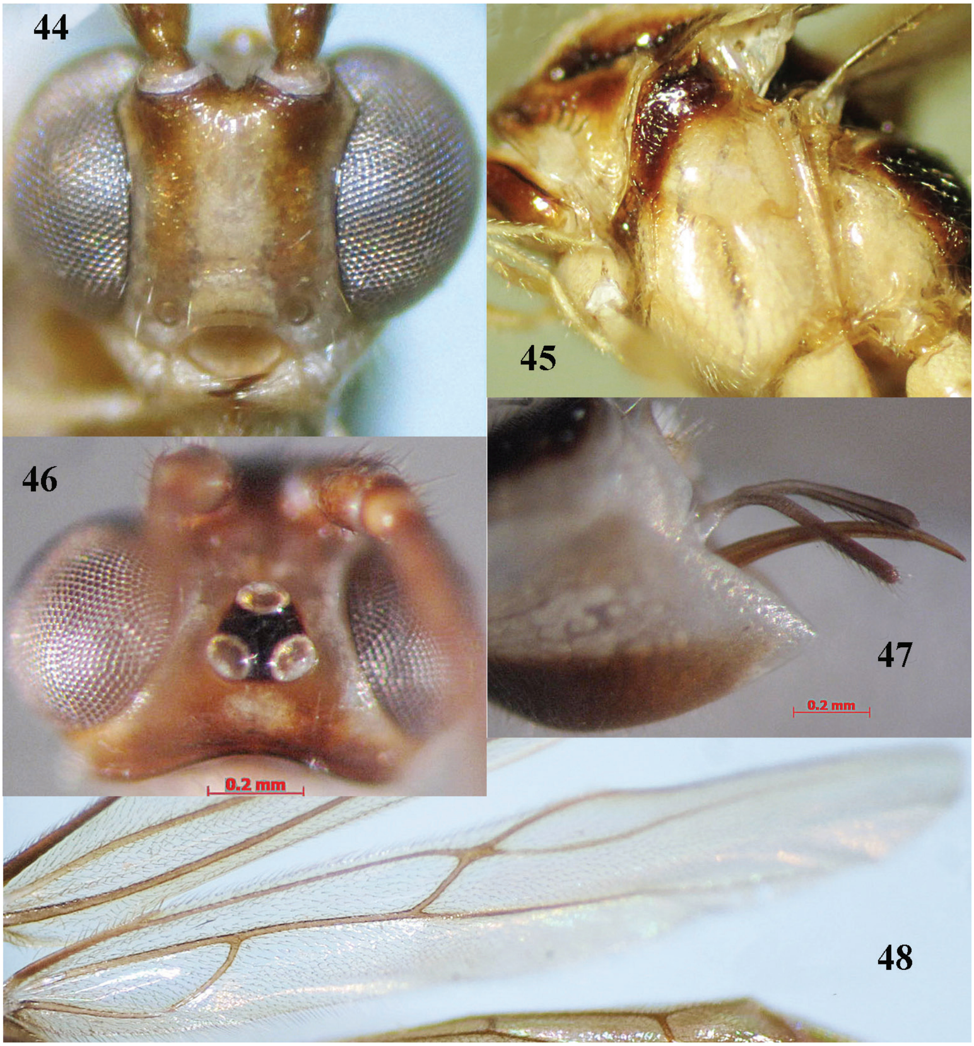
Mesosoma. Length of mesosoma 1.45 times as long as high (77:54); pronotal side mainly crenulate medially smooth dorsally, finely granulate ventrally; notauli deep and long, punctate; scutellar sulcus 0.55 times as long as scutellum; mesopleuron and metapleuron smooth; precoxal sulcus rather wide and crenulate (Fig. 45); propodeum mainly rugose laterally and medial areola crenulate (Fig. 5).

Wings. Fore wing: pterostigma 4.8 times as long as wide; r:2-SR:3-SR:SR1 = 9:14:27:43; vein r arising before middle of pterostigma; 1-CU1:cu-a:2-CU1:3-CU1=4:7:27:5; posterior length of second submarginal cell 2.5 times its apical width (33:13). Hind wing: vein M+CU:1-M:1r-m = 35:24:11 (Fig. 48).

Legs. Hind coxa almost smooth; length of hind femur:tibia:basitarsus:tarsus = 62:85:44:108; length of hind femur, tibia and basitarsus 6.2, 10.6 and 11.0 times as long as their width, respectively; inner hind tibial spur 0.25 times as long as basitarsus (11:44).

Metasoma. First tergite 1.7 times as long as apical width (45:27; Fig. 4); medial length of second tergite 1.6 times as long as third (34:21); second suture crenulate; second metasomal tergite obliquely and longitudinally striate; basal area of third-fifth metasomal tergites with divergent striation, apex of third-fifth metasomal tergites with curved striation mixing with punctures (Fig. 4); ovipositor sheath 0.5 times as long as hind basitarsus (1:2; Fig. 47).

Colour. Pale yellow; antenna yellowish brown, basal antennal segments with medial pale band; palpi yellow; stemmaticum black; propleuron, mesopleuron anteriorly,

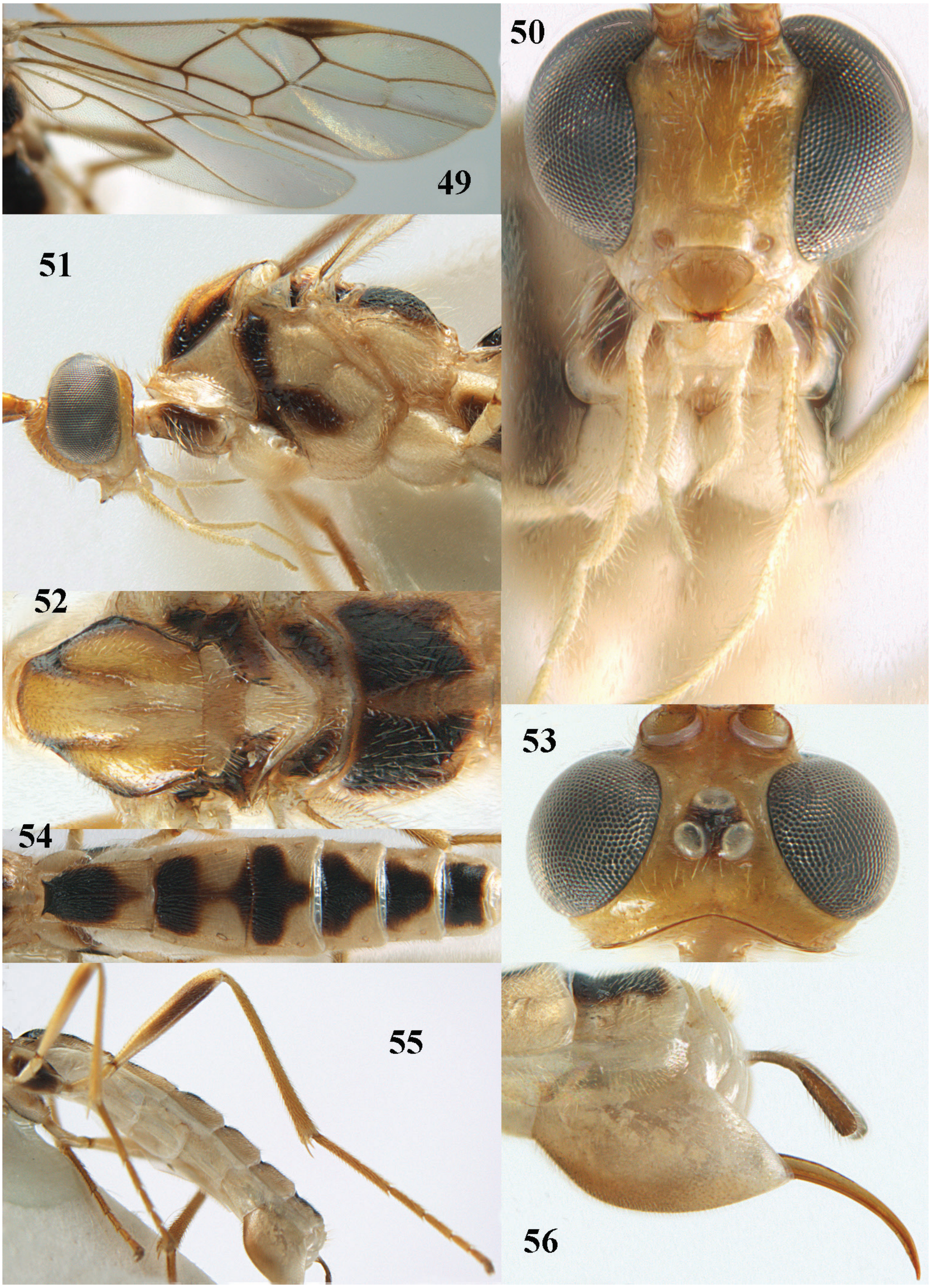


Figures 44–48. *Canalirogas parallelus* sp. n., female, holotype. **44** head anterior **45** mesosoma lateral **46** head dorsal **47** hypopygium lateral **48** hind wing.

side of scutellum and axilla, metanotum and propodeum entirely black; second-sixth metasomal segments black, yellow laterally; hypopygium yellow, brownish ventrally; all legs yellow, but hind coxa yellowish brown ventrally; wings subhyaline with veins brownish yellow; parastigma yellow; pterostigma mainly brown, yellow subapically.

Male. Unknown.

Etymology. Named ‘parallelus’, because of the nearly parallel-sided first metasomal tergite.



Figures 49–56. *Canalirogas robberti* sp. n., female, holotype. **49** wings **50** head anterior **51** head and mesosoma lateral **52** mesosoma dorsal **53** head dorsal **54** first-sixth tergites dorsal **55** hind leg lateral **56** hypopygium lateral.

Canalirogas robberti sp. n.

http://zoobank.org/CC50053B-5145-4724-B6CE-670BAD92E6FF
Figs 49–56

Material. Holotype, female (RMNH), "[S Vietnam:] Dông Nai, Cát Tiên NP, *Ficus* trail, Mal. trap[s] 1-8, c. 100 m, 1-9.x.2005, C. v. Achterberg & R. de Vries, RMNH'05".

Description. Holotype, female, body length 7.7 mm, fore wing length 5.4 mm.

Head. Antenna with 52 segments, 1.8 times as long as fore wing; middle and subapical segments 2.6 and 2.5 times longer than wide, respectively; third antennal segment 1.1 times as long as fourth segment; width of face 0.8 times length of face and clypeus combined; clypeus concave medially in lateral view, with distinct ventral rim (Fig. 51); malar space 0.6 times as long as basal width of mandible; basal width of mandible 0.7 times as long as width of hypoclypeal depression; malar suture deep; distance between tentorial pits 3.4 times distance between pits and eyes (Fig. 50); length of eye in dorsal view 5.5 times as long as temple (Fig. 53); width of eye in lateral view 3.8 times as long as temple; ocelli large, POL:Od:OOL = 1:3:1; distance between front and hind ocelli as long as OOL (Fig. 53); face with some distinct punctures laterally, with some indistinct rugae sublaterally, remainder of face, frons, vertex and temple smooth.

Mesosoma. Length of mesosoma 1.3 times as long as high; pronotal side smooth dorsally, coarsely crenulate medially and superficially granulate and with some rugae ventrally; precoxal sulcus only posteriorly absent and finely crenulate (Fig. 51); mesopleuron and metapleuron mainly smooth; mesoscutum smooth, except some punctulation; notauli narrow, shallow posteriorly and finely crenulate; scutellar sulcus 0.5 times as long as scutellum and with one long crenula (Fig. 52); scutellum smooth except some striae posteriorly; propodeum rugulose-granulate dorsally, except carinate median areola and some coarse rugae posteriorly (Fig. 52).

Wings. Fore wing: pterostigma 4.8 times as long as wide; r:2-SR:3-SR:SR1 = 5:8:14:22; vein r emerging before middle of pterostigma; vein cu-a slender (Fig. 49), 1-CU1:cu-a:2-CU1:3-CU1 = 3:10:38:8; posterior length of second submarginal cell 3.1 times its apical width. Hind wing: vein M+CU:1-M: 1r-m = 15:12:6; vein SR unsclerotised.

Legs. Hind coxa shiny and with sparse fine punctures; length of hind femur:tibia:basitarsus: tarsus = 60:81:38:94; length of hind femur, tibia and basitarsus 6.0, 10.0 and 9.6 times as long as their width, respectively (Fig. 55); inner hind tibial spur 0.3 times as long as basitarsus.

Metasoma. First tergite 1.7 times as long as apical width and slightly widened posteriorly (Fig. 54); first-second tergites with costate and somewhat oblique striation; third-fifth tergites with finer and more divergent striation and sixth tergite finely rugulose; medial length of second tergite 1.7 times than third segment; second suture coarsely crenulate; ovipositor sheath truncate apically and half as long as hind basitarsus; ovipositor stout (Fig. 56).

Colour. Pale yellow or ivory; antennal segments pale brown with faint yellowish transverse bands; stemmaticum, propleuron partly, mesopleuron antero-dorsally, antero-ventrally and below precoxal sulcus, mesoscutum laterally, scutellum and metanotum laterally, propodeum (except areola and posteriorly), inner and outer side of hind coxa, outer and inner side of hind femur mainly (except basally), metasomal tergites 1-5 basally and medio-posteriorly, tergite 6 nearly entirely dorsally (Fig. 54) and ovipositor sheath (except basally), dark brown; telotarsi and hypopygium baso-ventrally brown; wings mainly slightly infuscate; veins mainly (but of apical third of wing brownish yellow) and pterostigma medially dark brown; remainder of pterostigma and parastigma yellow.

Male. Unknown.

Etymology. Named after one of the collectors of the holotype, Mr. Rob de Vries (Leiden); for his excellent collaboration.

Canalirogas spilonotus **(Cameron, 1905)**

Figs 57–64

Troporhogas spilonotus Cameron, 1905: 93. Lectotype female (BMNH: Hym. Type 3c.222 from Sri Lanka) examined and here designated.

Canalirogas spilonotus Quicke & Shaw, 2005: 3531.

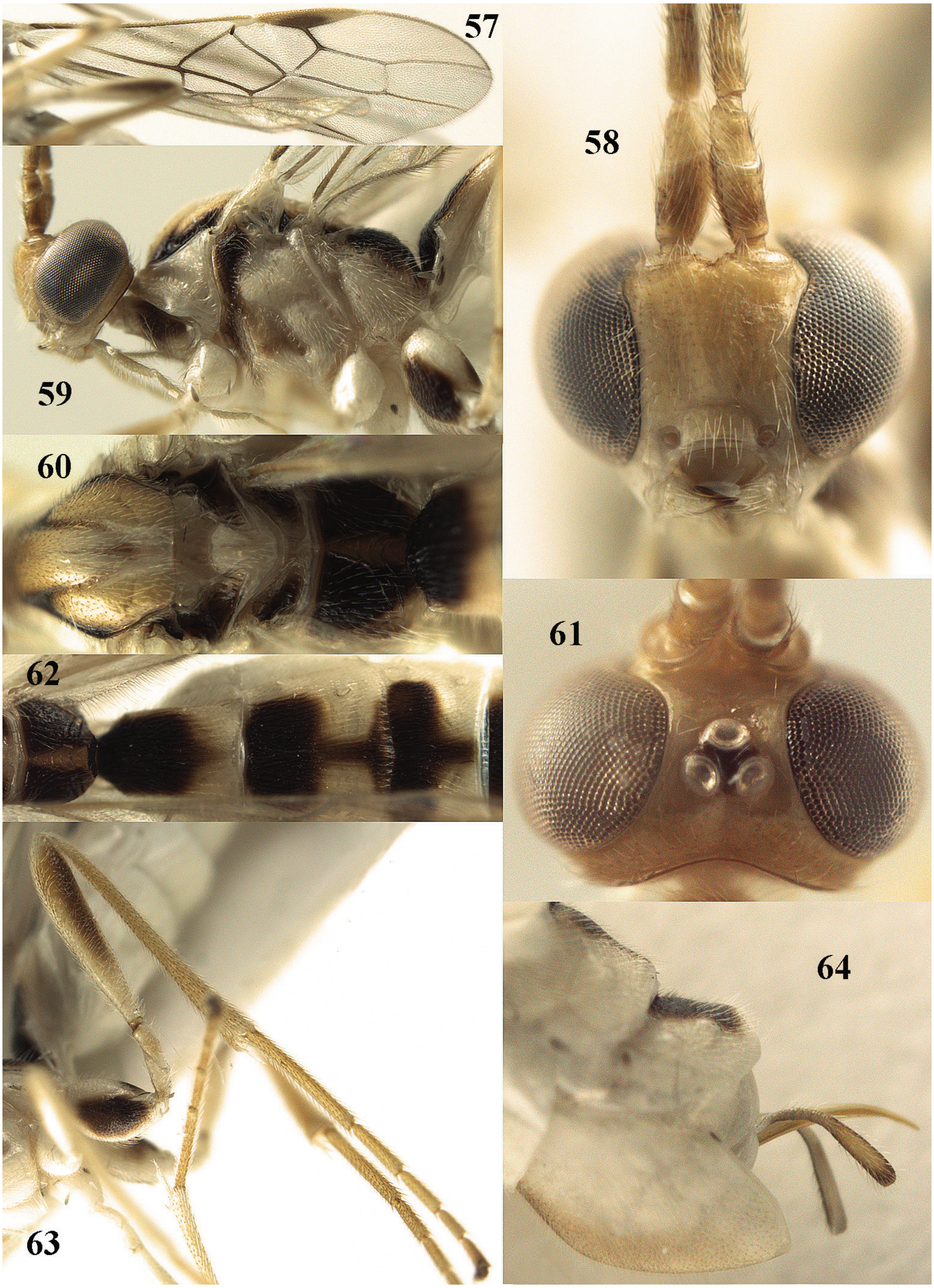
C. balgooyi van Achterberg & Chen, 1996: 70–73 (description). **Syn. n.**

Material. Specimens examined from North and North Central and South Vietnam (IEBR, RMNH and VNMN): Ha Giang (Vi Xuyen), Hoa Binh (Mai Chau, Yen Thuy), Ninh Binh (Cuc Phuong NP), Ha Tinh (Huong Son, Vu Quang NP), Phu Tho (Tan Son), Vinh Phuc (Me Linh; Tam Dao NP), Dông Nai (Cat Tien NP).

Description. Figured female from Cát Tiên National Park, body length 7.1 mm, fore wing length 5.5 mm.

Head. Antenna with 51 segments, 1.7 times as long as fore wing; middle and subapical segments 2.6 and 2.5 times longer than wide, respectively; third antennal segment 1.3 times as long as fourth segment; width of face 0.8 times length of face and clypeus combined; clypeus flat in lateral view (Fig. 59); malar space 0.6 times as long as basal width of mandible; basal width of mandible 0.7 times as long as width of hypoclypeal depression; malar suture deep; distance between tentorial pits 3.9 times distance between pits and eyes (Fig. 58); length of eye in dorsal view 7.8 times as long as temple (Fig. 61); width of eye in lateral view 5.6 times as long as temple; ocelli large, POL:Od:OOL = 5:14:5; distance between front and hind ocelli as long as OOL (Fig. 61); face weakly rugose sublaterally, remainder of face, frons, vertex and temple smooth.

Mesosoma. Length of mesosoma 1.3 times as long as high; pronotal side smooth dorsally, coarsely crenulate medially and superficially granulate ventrally; precoxal sulcus only posteriorly absent and finely crenulate (Fig. 59); mesopleuron and metapleuron largely smooth; mesoscutum smooth, except some punctulation; notauli narrow, shallow posteriorly and finely crenulate; scutellar sulcus 0.6 times as long as scutellum and with 3 long crenulae (Fig. 60); scutellum smooth except some striae posteriorly;



Figures 57–64. *Canalirogas spilonotus* (Cameron), female, Vietnam. **57** fore wing **58** head anterior **59** head and mesosoma lateral **60** mesosoma dorsal **61** head dorsal **62** propodeum and first-third tergites dorsal **63** hind leg lateral **64** hypopygium lateral.

propodeum densely finely punctate dorsally, except carinate median areola and laterally rugose (Figs 60, 62).

Wings. Fore wing: pterostigma 4.9 times as long as wide; r:2-SR:3-SR:SR1 = 10:14:18:43; vein r emerging little before middle of pterostigma; vein cu-a short and slender (Fig. 57), 1-CU1:cu-a:2-CU1:3-CU1 = 1:5:24:4; posterior length of second submarginal cell 3.4 times its apical width. Hind wing: vein M+CU:1-M: 1r-m = 30:26:16; vein SR unsclerotised.

Legs. Hind coxa shiny and with sparse fine punctures; length of hind femur:tibia:basitarsus: tarsus = 50:64:31:78; length of hind femur, tibia and basitarsus 6.2, 11.4 and 11.6 times as long as their width, respectively (Fig. 63); inner hind tibial spur 0.3 times as long as basitarsus.

Metasoma. First tergite 1.5 times as long as apical width and slightly widened posteriorly (Fig. 62); first-third tergites with costate and somewhat oblique striation; fourth-fifth tergites with more divergent striation; medial length of second tergite 1.6 times than third segment; second suture crenulate; ovipositor sheath truncate apically and half as long as hind basitarsus; ovipositor rather stout (Fig. 64).

Colour. Pale yellow or ivory; antennal segments pale brown with yellow transverse bands (Fig. 58); stemmaticum, propleuron partly, mesopleuron antero-dorsally, mesoscutum laterally, metanotum partly laterally, propodeum (except areola, narrowly posteriorly and partly latero-posteriorly), inner and outer side of hind coxa, metasomal tergites 1-5 basally and medio-posteriorly (but of third-fifth tergites partly brown antero-laterally), tergite 6 entirely dorsally (Fig. 57) and apex of ovipositor sheath narrowly dark brown (Fig. 64); telotarsi brown; wings largely slightly infuscate; veins (but of apical third of wing unpigmented) and pterostigma medially dark brown; remainder of pterostigma and parastigma yellow.

Male. Unknown.

Variation. Antennal segments of female 44(1), 48(1), 50(1) or 51(1); first tergite 1.2–1.5 times as long as apical width (Fig. 57); medial length of second tergite 1.5–1.6 times as long as third tergite medially; body length 6.2–7.1 mm; fore wing length 4.6–5.5 mm.

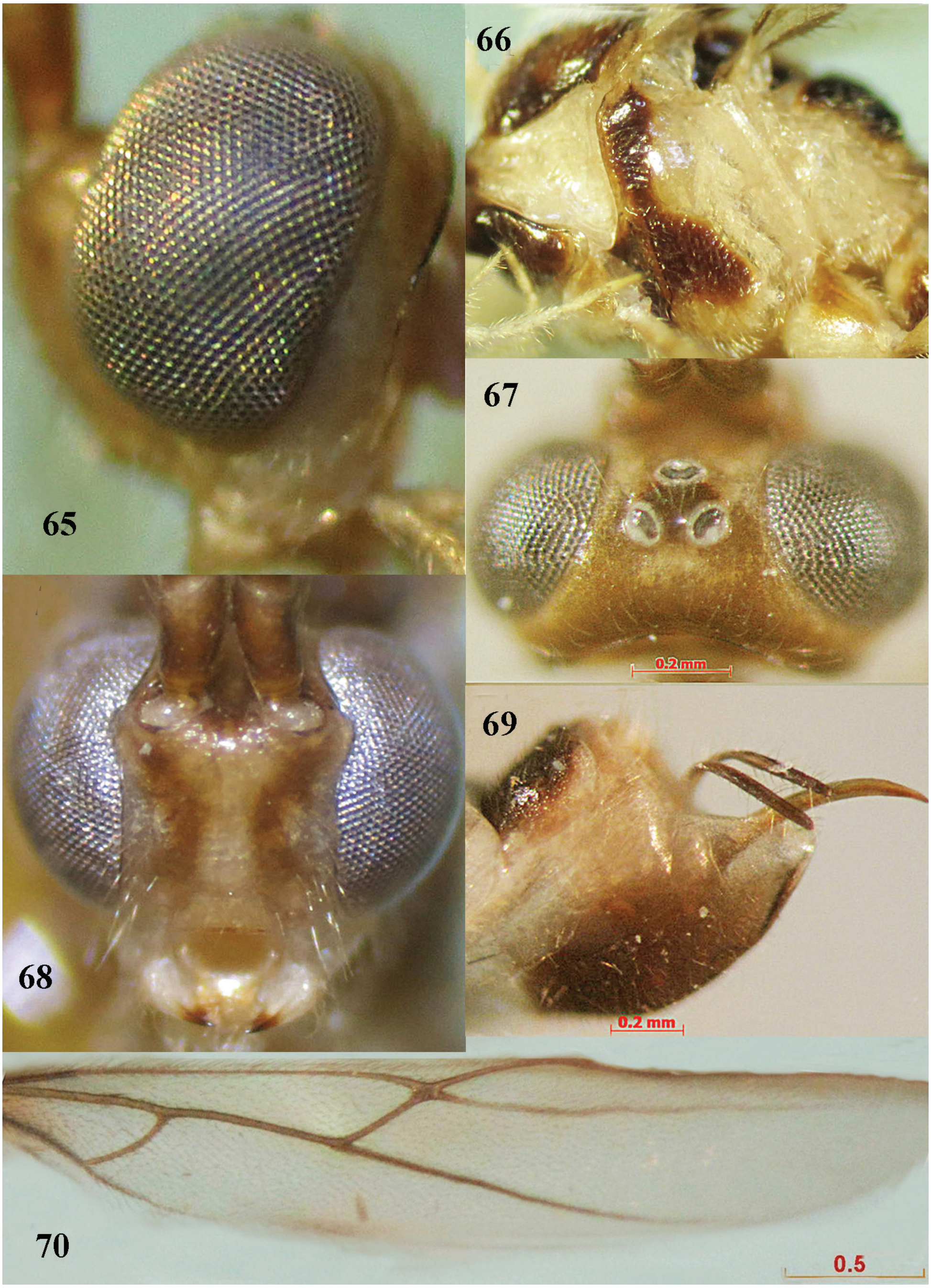
Notes. This conspicuous species has the eyes in dorsal view 6–8 times longer than temple (Fig. 61) and in lateral view width of eye about 3.8 times temple (15:4; Fig. 59); ovipositor stout (Fig. 64). The lectotype of *C. spilonotus* (Cameron) designated in this paper falls within the (rather wide) variation limits of *C. balgooyi* and is, therefore, considered to be a senior synonym of the latter.

Canalirogas vittatus sp. n.

http://zoobank.org/3D065D35-E536-4EBB-AE82-48F81FD46775

Figs 7, 65–70

Material. Holotype, female (VNMN) 'Rog.014', "[NE Vietnam:] Ninh Binh, Cuc Phuong NP, 7–9.v.2002, KD Long". Paratypes, 2 females (RMNH, VNMN), 'Rog.013' & 'Rog.005', topotypic and same date.



Figures 65–70. *Canalirogas vittatus* sp. n., female, holotype. **65** head lateral **66** mesosoma lateral **67** head dorsal **68** head anterior **69** hypopygium lateral **70** hind wing.

Description. Holotype, female, body length 5.9 mm, fore wing length 5.0 mm, antenna 8.0 mm.

Head. Antenna with 47 segments, 1.4 times longer than body; third segment 1.1 times fourth; middle segments 2.8 times longer than wide (7:2.5); penultimate antennal segment 0.9 times apical segment; apical segment with spine; width of face slightly less than length of face and clypeus combined (18:19); malar space 0.7 times as long as mandible width (5:7); basal width of mandible 0.8 times as long as hypoclypeal depression (7:9); malar suture absent; distance between tentorial pits 3.0 times distance between pits and eyes (9:3; Fig. 68); in dorsal view height of eye 3.2 times as high as temple (16:5); in lateral view width of eye 2.5 times as long as temple (10:4; Fig. 65); ocelli rather small and in high triangle, POL:Od:OOL = 4:5.5 (Fig. 67); distance between front and hind ocelli 0.8 times OOL (4:5); face rugose-punctate; frons, vertex and temple smooth.

Mesosoma. Length of mesosoma 1.35 times longer than high (69:51); pronotal side mainly crenulate medially, granulate ventrally; precoxal sulcus wide and punctate-crenulate (Fig. 66); mesopleuron smooth dorsally and punctate ventrally, punctures merged into mesosternum; scutellum smooth; mesopleuron smooth, rugose anteriorly; notauli deep, crenulate; mesoscutum with sparse fine punctures; scutellar sulcus 0.7 times as long as scutellum (6:9); propodeum mainly rugose laterally and its medial areola crenulate.

Wings. Fore wing: pterostigma 4.7 times as long as wide (42:9); r:2-SR:3-SR:SR1 = 9:15:29:44; vein r arising before middle of pterostigma; 1-CU1:cu-a:2-CU1:3-CU1 = 4:7:27:5; ventral length of second submarginal cell 3.4 times its apical width (41:12). Hind wing: vein M+CU:1-M:1r-m = 31:26:23 (Fig. 70).

Legs. Hind coxa shiny with sparse fine punctures; length of hind femur:tibia:basitarsus:tarsus = 55:74:38:89; length of hind femur, tibia and basitarsus 5.5, 9.25 and 9.5 times as long as their width, respectively; inner hind tibial spur 0.24 times as long as basitarsus (9:38).

Metasoma. First tergite subequal to apical width; medial length of second tergite 1.6 times third (30:19; Fig. 7); second suture crenulate; second tergite with parallel striation; third-fifth tergites mainly rugose medially; sixth tergite with curved fine striation mixed with granulation; ovipositor sheath 0.5 times as long as hind basitarsus (18:38; Fig. 69).

Colour. Yellow; antennal segments brown with medial pale band; palpi pale yellow; stemmaticum black; occipital carina brown; propleuron, mesopleuron anteriorly, precoxal sulcus, notauli, mesonotum laterally, side of scutellum and axilla black; propodeum black, but pale yelllow medially; fore and middle legs yellow, except middle femur subapically and tarsus darker than tibia; hind coxa blackish brown, except yellow dorso-basally; hind trochantellus, most part of hind femur and hind tarsus brown; hind tibia dirty yellow; wings dirty subhyaline with pterostigma and veins brown, except veins 3-SR, SR1, 3-M and r-m yellow; first-fifth metasomal tergites black, yellow laterally and at posterior corners; sixth tergite entirely black.

Male. Unknown.

Variation. Length of first metasomal tergite 1.0–1.2 times as long as apical width; medial length of metasomal second tergite 1.6–1.7 times as long as third tergite medially; body length 5.1–6.2 mm; fore wing length 4.0–5.1 mm.

Etymology. From 'vitta' (Latin for 'ribbon, band'), because of the pale band of the antennal segments.

Canalirogas vuquangensis **sp. n.**

http://zoobank.org/99337E9B-C176-4967-A419-6A0352BF4BA4

Figs 1, 71–78

Material. Holotype, female (RMNH), "[C Vietnam:] Ha Tinh, Vu Quang NP, 66 m, 18°19'47"N, 105°26'28"E, Mal. trap 9, 4.iii–15.iv.2011, C. v. Achterberg, RMNH'11".

Description. Holotype, female, body length 6.6 mm, fore wing length 4.8 mm.

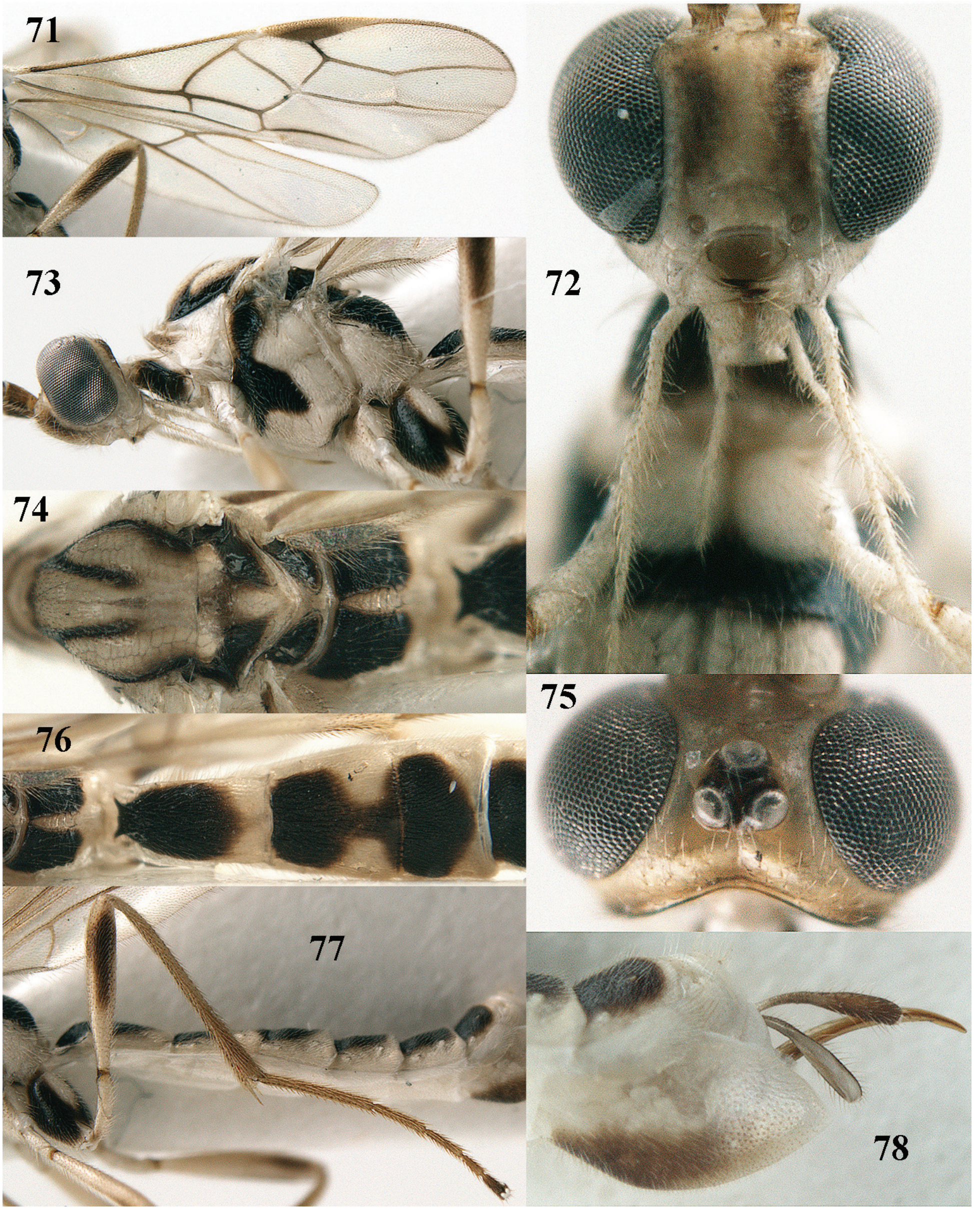
Head. Antenna with 44 segments, 1.6 times as long as fore wing; middle and subapical segments 3.3 and 2.7 times longer than wide, respectively; third antennal segment 1.4 times as long as fourth segment; width of face 0.8 times length of face and clypeus combined; clypeus flat in lateral view and ventral rim not differentiated from clypeus (Fig. 73); malar space 0.7 times as long as basal width of mandible; basal width of mandible 0.7 times as long as width of hypoclypeal depression; malar suture deep; distance between tentorial pits 2.9 times distance between pits and eyes (Fig. 72); length of eye in dorsal view 8.3 times as long as temple (Fig. 75); width of eye in lateral view 4.4 times as long as temple; ocelli large, POL:Od:OOL = 2:6:3; distance between front and hind ocelli as long as OOL (Fig. 72); face distinctly granulate submedially and orbita sparsely punctate, remainder of face superficially coriaceous; frons, vertex and temple smooth.

Mesosoma. Length of mesosoma 1.4 times as long as high; pronotal side smooth dorsally, moderately crenulate medially and granulate ventrally; precoxal sulcus only medially distinctly impressed and finely crenulate; mesopleuron mainly smooth; metapleuron superficially granulate (Fig. 73); mesoscutum smooth, except some punctulation; notauli narrow, shallow posteriorly and smooth; scutellar sulcus 0.5 times as long as scutellum and with one long crenula; scutellum smooth except some striae posteriorly; propodeum distinctly granulate dorsally, except carinate median areola, rugose medially and superficially granulate posteriorly (Figs 73, 74).

Wings. Fore wing: pterostigma 4.9 times as long as wide; r:2-SR:3-SR:SR1 = 5:9:15:26; vein r emerging before middle of pterostigma; vein cu-a slender (Fig. 71), 1-CU1:cu-a:2-CU1:3-CU1 = 3:8:34:7; posterior length of second submarginal cell 3.1 times its apical width. Hind wing: vein M+CU:1-M: 1r-m = 15:13:7; vein SR unsclerotised.

Legs. Hind coxa with satin sheen, superficially coriaceous and punctulate; length of hind femur:tibia:basitarsus:tarsus = 50:74:33:78; length of hind femur, tibia and basitarsus 6.0, 10.3 and 11.6 times as long as their width, respectively (Fig. 77); inner hind tibial spur 0.3 times as long as basitarsus.

Metasoma. First tergite 1.9 times as long as apical width and slightly widened posteriorly (Fig. 76); first-second tergites with rather coarse and somewhat oblique rugae;



Figures 71–78. *Canalirogas vuquangensis* sp. n., female, holotype. **71** wings **72** head anterior **73** head and mesosoma lateral **74** mesosoma dorsal **75** head dorsal **76** propodeum and first-third tergites dorsal **77** hind leg lateral **78** hypopygium lateral.

third-fifth tergites with more divergent rugulae and sixth tergite mainly coriaceous; medial length of second tergite 1.7 times longer than of third segment; second suture moderately crenulate; ovipositor sheath truncate apically and 0.6 times as long as hind basitarsus; ovipositor moderately stout (Fig. 78).

Colour. Pale yellow or ivory; antennal segments brown with yellowish transverse bands (Fig. 1); stemmaticum and face sublaterally pale brown; scapus, pedicellus, telotarsi, inner side of hind coxa, patch on outer side and inner side of hind femur, ovipositor sheath (except basally) and hypopygium baso-ventrally dark brown; propleuron partly, mesopleuron antero-dorsally, antero-ventrally and below precoxal sulcus, mesoscutum laterally, notaulic courses, scutellum and metanotum laterally, propodeum (except areola and posteriorly), outer side of hind coxa, metasomal tergites 1–3 basally and medio-posteriorly and tergites 4–6 nearly entirely dorsally (Figs 1, 76) blackish brown; wings largely slightly infuscate; veins mainly (but of apical third of wing brownish yellow) and pterostigma medially and subbasally dark brown; remainder of pterostigma and parastigma yellow.

Male. Unknown.

Etymology. Named after the type locality in Central Vietnam.

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Subgenera of *Charidotella* Weise with description of a new subgenus and species from Brazil (Coleoptera, Chrysomelidae, Cassidinae, Cassidini)

Lukáš Sekerka[1,2], Lech Borowiec[3]

1 *Department of Entomology, National Museum, Cirkusová 1740, CZ-193 00 Praha 9, Czech Republic* **2** *Department of Zoology, Faculty of Science, University of South Bohemia, Branišovská 31, CZ-370 05 České Budějovice, Czech Republic* **3** *Department of Biodiversity and Evolutionary Taxonomy, University of Wrocław, Przybyszewskiego 63/77, 51-148 Wrocław, Poland*

Corresponding author: *Lukáš Sekerka* (sagrinae@seznam.cz)

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Abstract

A new subgenus and species, *Charidotella* (*Chapadacassis* **subgen. n.**) *paradoxa* **sp. n.** is described and figured from the Chapada plateau in Mato Grosso, Brazil. Subgenera of *Charidotella* Weise, 1896 are listed, supplemented with basic data, diagnostic table, and a key is proposed. Based on a study of respective type material following new combinations are proposed: *Charidotella* (*Philaspis*) *stulta* (Boheman, 1855), **comb. n.**, *Charidotella* (*Xenocassis*) *amoenula* (Boheman, 1855), **comb. n.**, *Ch.* (*X.*) *cyclographa* (Boheman, 1855), **comb. n.**, *Ch.* (*X.*) *discoidalis* (Boheman, 1855), **comb. n.**, *Ch.* (*X.*) *incerta* (Boheman, 1855), **comb. n.**, *Ch.* (*X.*) *purpurea* (Linnaeus, 1758), **comb. n.**, *Ch.* (*X.*) *myops* (Boheman, 1855), **comb. n.** (all previously placed in the nominotypical subgenus), and *Plagiometriona cingulata* (Boheman, 1862), **comb. n.** (from *Charidotella* (*Xenocassis*)).

Keywords

Entomology, taxonomy, new subgenus, new species, new combination, Neotropical Region, Brazil

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Introduction

New World Cassidini comprises currently 726 species in 46 genera. Brazil is the country with richest fauna represented by 402 species, 252 of them so far known only from Brazil (Borowiec and Świętojańska 2015). Most likely the number of endemic taxa will be much lower as many species occur also in neighbouring countries. Particularly Bolivia and Venezuela are quite poorly explored regarding Cassidinae fauna and our recent research indicates that many species so far known only from Brazil are present in these countries too (Windsor and Sekerka, unpubl. data).

Dry regions of Southern America are poorly collected and many species are known only from small areas while their range is in fact large. This is particularly true for western Bolivia and central-west Brazil (Windsor and Sekerka, unpubl. data). The Chapada plateau in Mato Grosso is perhaps one of the most interesting areas in this part of Southern America and probably hides numerous undescribed taxa. Several cassidines were described recently by Świętojańska and Borowiec (1995, 1996, 1999) and Borowiec (2004). In the material studied recently we found a new species belonging to an undescribed peculiar subgenus of *Charidotella* Weise, 1896 characterized by completely irregular punctation of the elytra, a very rare morphological feature in New World Cassidini.

Weise (1896) proposed *Charidotella* for a single species, *Ch. zona* (Fabricius, 1801), while he also created *Metriona* Weise, 1896 where he placed most species currently classified in *Charidotella*. Spaeth (1914) downgraded *Charidotella* to subgenus of *Metriona* and designated *M. elatior* (Klug, 1829) as the type species of the latter. He also included six more species in *Charidotella*, all having pattern on the ventral side of the elytral disc. Spaeth (1942) raised *Charidotella* to genus rank and listed eleven species in it. Meantime, Spaeth described several genera (*Philaspis* Spaeth, 1913, *Xenocassis* Spaeth, 1936 and *Metrionaspis* Spaeth, 1942) for species previously classified in *Coptocycla* Chevrolat, 1836 or *Metriona*. Subsequently Hincks (1952) placed them as subgenera of *Charidotella* and validated one more subgenus *Charerocassis* Spaeth in Hincks, 1952 following Spaeth's unpublished manuscript for Wytsman's Genera Insectorum. Borowiec (1989) placed *Metrionaspis* as subgenus of *Charidotella*, proposed a key to the subgenera and the first catalogue of the genus. Most recently, Windsor et al. (1992) considered *Xenocassis* as a separate genus, however, this change was not accepted and *Xenocassis* remained as subgenus of *Charidotella* (e.g. Borowiec 1999).

Currently *Charidotella* comprises 100 species divided in five subgenera (Borowiec and Świętojańska 2015). Identification of subgenera was established mainly on the basis of structure of tarsal claws (simple vs. appendiculate) by Spaeth (1936) and followed by Borowiec (1989). General body shape, convexity of the elytra, and punctation provide good characters too, however, in many cases they are hard to describe to be clearly and easily understood. The structure of tarsal claws proved as yet not fully understood and at least some species have intraspecific variability in presence or absence of the basal tooth on respective claw (e.g. Riley 1982, 1986). Besides the key we provide also a diagnostic table (Table 1) to help to recognize subgenera of *Charidotella*.

Table 1. Summarizing most important morphological differences among subgenera of *Charidotella* Weise, 1896. Numbers in parentheses indicate number of species possessing particular character when variable within one subgenus.

subgenus / character	***Chapadacassis* subgen. n.**	***Philaspis* Spaeth, 1913**	***Metrionaspis* Spaeth, 1942**	***Chaerocassis* Spaeth in Hincks, 1952**	***Xenocassis* Spaeth, 1936**	***Charidotella* s. str. Weise, 1896**
body shape	oval and parallelsided	oval and parallelsided	subtriangular to subcircular	subcircular (3) or oval (3)	circular	variable, mostl subcircular to subtriangular
convexity of elytra	irregular and subgibose	regular and weak	irregular with postscutellar hump	regular and weak	regular and moderate	from regular and low to tuberculate
punctation of elytra	irregular	regular	regular	regular	regular	regular
explanate margin of elytra	densely punctate	sparsely punctate (4) or impunctate (6)	sparsely punctate in humeral area	impunctate (4) or punctate in humeral area (2)	impunctate	impunctate
pattern on underside of elytra	absent	present (6) or absent (4)	absent	absent	absent	present (at least in 32 species) or absent
pattern on disc of elytra	absent	absent	disc uniformly red	disc uniformly red or yellow	usually with ring, rarely yellow	usually yellow
spots on explanate margin of elytra	absent	absent	present	present (5) or absent (1)	absent	absent (61) or present (7)
sides of pronotum	rounded	subangulate	rounded	rounded	rounded	rounded (66) or subangulate (1)
size of eye	large, occupying almost whole side	large, occupying almost whole side	large, occupying almost whole side	large, occupying almost whole side	moderately large occupying 2/3 of side, gena well visible	large, occupying almost whole side, gena sometimes visible but very narrow
antennae	5 basal slim shiny antennomeres + 6 dull and broad	6 basal slim shiny antennomeres + 5 dull and broad	5 basal slim shiny antennomeres + 6 dull and broad	6 basal slim shiny antennomeres + 5 dull and broad	6 basal slim shiny antennomeres + 5 dull and broad	6 basal slim shiny antennomeres + 5 dull and broad
antennomeres II–IV	II and III subequal, IV approx. 1/4 longer than either II and III	II distinctly shorter than III, III and IV subequal	II and III subequal, IV as long as II and III combined	III longer than II and IV longer than III	variable	variable
proclaws	both with small basal tooth	both with large basal tooth	both with large basal tooth	both with large basal tooth	both with small to large basal tooth	both with moderate to large basal tooth

subgenus **character**	***Chapadacassis* subgen. n.**	***Philaspis* Spaeth, 1913**	***Metrionaspis* Spaeth, 1942**	***Chaerocassis* Spaeth in Hincks, 1952**	***Xenocassis* Spaeth, 1936**	***Charidotella* s. str. Weise, 1896**
mesoclaws	outer simple, inner with small tooth	outer simple (♂) or with small tooth (♀), inner with large tooth	both simple (♀) or outer with large basal tooth (♂)	♂: both or only inner simple; ♀: all with large tooth or one simple	inner with small to large basal tooth, outer simple or both simple	outer simple (♂) or both with small to large tooth (♀)
metaclaws	both with small basal tooth	both with large basal tooth	inner simple, outer with large basal tooth	♂: inner simple; ♀: both with large tooth or one simple	inner with small to large basal tooth, outer simple or both simple or both with large tooth	both with moderate to large basal tooth

The genus *Charidotella* can be characterized by at least some tarsal claws with a basal tooth, venter of the pronotum without antennal grooves, the clypeus flat or impressed and without distinct grooves, and a broad prosternal process with the apex not strongly expanded laterally. *Charidotella* species are mostly associated with the plant family Convolvulaceae, mainly with the diverse genus *Ipomoea*, however at least one species is associated with Asteraceae (Windsor and Sekerka, unpubl. data).

Label data from the type specimens are cited as they appeared on the labels. Individual labels are separated by a double vertical bar "||" and rows within the label by a single vertical bar "|".

Overview of subgenera of *Charidotella*

Charidotella (s. str.) Weise, 1896

Figs 8–9

Charidotella Weise, 1896: 13.

Type species. *Cassida zona* Fabricius, 1801 by monotypy.

Number of species. 67 (Borowiec and Świętojańska 2015, present paper).

Key to species. Borowiec (2007) proposed a key covering 23 species with pattern on the ventral part of the elytral disc.

Range. Canada to Argentina.

Distinguishing characters. Species of the nominotypical subgenus can be separated by all tarsal claws with a basal tooth of variable size, or in males the outer claw of mesotarsi is with small tooth or simple. They also have subcircular to subtriangular body and are more convex in comparison to most other subgenera except *Metrionaspis* and *Chapadacassis* subgen. n. Otherwise the nominotypical subgenus is polymorphic displaying greater variability and some species externally reminds other subgenera. Most species are yellow with or without pattern on the ventral side of the elytral disc which can be variable. After revising most species of *Charidotella* there is no species in the nominotypical subgenus with dark annulus on the upper side of the elytra and all such coloured species are here transferred to *Xenocassis*.

Chaerocassis Spaeth in Hincks, 1952

Figs 10–11

Charidotella subgen. *Chaerocassis* Spaeth in Hincks, 1952: 350.

Type species. *Coptocycla marculenta* Boheman, 1855 by original designation.

Number of species. 6 (Borowiec and Świętojańska 2015).

Key to species. Not yet proposed.

Range. USA to Panama.

Distinguishing characters. *Chaerocassis* species have subcircular or oval body outline, regularly convex elytra, the base of the elytra distinctly wider than the pronotum and humeral angles moderately projecting anterad. Four species have explanate margin of the elytra with basal and posterolateral spots. One species has outer margin of the elytra black and the type species is uniformly yellow. Males have the outer claw of meso- and metatarsi, or both claws of meso- and the outer claw of metatarsi simple. Females have all claws appendiculate or one of the meso- and metatarsi simple. They are externally close to the nominotypical subgenus but can be easily separated by one of the metaclaws simple and elytra always without pattern on uderside.

Metrionaspis Spaeth, 1942

Figs 16–17

Metrionaspis Spaeth, 1942: 39; Borowiec 1989: 204 (as subgenus of *Charidotella*).

Type species. *Aspidomorpha rubicunda* Guérin-Méneville, 1844 by monotypy.

Number of species. 2 (Borowiec and Świętojańska 2015).

Key to species. Not yet proposed.

Range. *Charidotella rubicunda* is widely distributed through South America from Colombia to Argentina while *Ch. santaremi* Borowiec, 1995 is so far known only from the state of Pará in Brazil.

Distinguishing characters. The two *Metrionaspis* species have a broadly oval to subtriangular body outline, base of the elytra distinctly wider than pronotum with humeral angles projecting anterad, explanate margin of the elytra with humeral and posterolateral spots, and the elytra with a postscutellar tubercle. Externally both species are very similar to two *Charidotella* s. str. species, *Ch. tuberculata* (Fabricius, 1775) and *Ch. ventricosa* (Boheman, 1855), but they can be separated by an impunctate explanate margin of the elytra and claws of the metatarsi in both sexes with a basal tooth. While *Metrionaspis* species have humeral area of the explanate margin punctate and the inner claw of the metatarsi simple in both sexes.

Philaspis Spaeth, 1913

Figs 14–15

Philaspis Spaeth, 1913: 142; Hincks 1952: 342 (as subgenus of *Charidotella*).

Type species. *Odontionycha seriatopunctata* Spaeth, 1901 designated by Hincks (1952).

Number of species. 10 (Borowiec 2004, present paper).

Key to species. Spaeth (1936) covered eight species, Borowiec (2004) covered nine species.

Range. One species in Mexico and Costa Rica, remaining in the southern part of South America.

Distinguishing characters. *Philaspis* species are at first glance easily distinguished by the parallel-sided elytra in combination with subangulate sides of the pronotum. All species are uniformly yellow or have a small black spot in the middle of each elytron.

Remarks. *Charidotella stulta* (Boheman, 1855) was previously classified in the nominotypical subgenus. We recently examined its holotype, preserved in Museum für Naturkunde, Berlin, and found that it belongs to the subgenus *Philaspis* near *Ch.* (*P.*) *inculta* (Boheman, 1855).

***Xenocassis* Spaeth, 1936**

Figs 12–13

Xenocassis Spaeth, 1936: 260; Hincks 1952: 342 (as subgenus of *Charidotella*).

Type species. *Coptocycla amoena* Boheman, 1855 by original designation.

Number of species. 15 (present paper).

Key to species. Not yet proposed.

Range. Mexico to Peru with most species in the Central America.

Distinguishing characters. *Xenocassis* species can be easily separated from other subgenera by the small eyes covering only 2/3 of lateral sides of the head thus gena is well visible while all other subgenera have large eyes. In addition *Xenocassis* has nearly regularly circular body outline, weakly convex elytra with coarser punctation on lateral slope, and dorsum with ring pattern on the upper side. In extreme cases the ring can form a large discal spot or can be completely vanished thus whole dorsum is uniformly yellow.

Remarks. So far *Xenocassis* was separated from other genera on the basis of the tarsal claws and general body shape. Windsor et al. (1992) were the first who noticed that all species have also small eyes in comparison to other *Chardotella* species. As a result they raised *Xenocassis* to genus in the provided key but unfortunately made no additional comments and their change was not accepted later (e.g. Borowiec 1999). We agree with them that the small size of the eye is diagnostic for *Xenocassis* and found that five species currently classified in the nominotypical subgenus should be transferred to *Xenocassis* based on this character. In addition we found that *Xenocassis* species are very variable regarding the size and presence of tarsal appendages. The genus was based by Spaeth (1936) on the outer claws of the metatarsi simple in both sexes, however, examination of extensive material revealed that even the type species, *C. amoena*, could have the outer claws of the metatarsi with a large basal tooth. Similar situation was found in two other species we had extensive material to study – *Ch.* (*X.*) *ambita* (Champion, 1894) and *Ch.* (*X.*) *puella* (Boheman, 1855). In both the basal teeth showed variable size even within one population. While the size of the eye is constant. Some species of other subgenera have slightly smaller eyes than others thus they have gena visible but always very narrow while species of *Xenocassis* have gena covering approximately basal third of lateral side of the head.

We consider *Xenocassis* as subgenus of *Charidotella* as the size of the eye is found variable also in some other new world Cassidini genera, e.g. *Charidotis* Boheman, 1855 and *Plagiometriona* Spaeth, 1899.

Last catalogue, Borowiec (1999) listed 10 species in the subgenus *Xenocassis*. We have recently examined types of all species and found that one was wrongly assigned to *Xenocassis*. *Coptocycla cingulata* Boheman, 1862 (type seen in the Natural History Museum, London) was unknown to most authors and have been tentatively placed in *Charidotella* based on the original description (Boheman 1862) and notes published by Champion (1894) in the Cassidinae volume of the Biologia Centrali Americana (Borowiec 1989). It posses all characters of the genus *Plagiometriona* and is here transferred to it as *Plagiometriona cingulata* (Boheman, 1862), comb. n.

During examination of species placed in the nominotypical subgenus we found four which had small eyes and are here transferred to *Xenocassis*: *Ch.* (*X.*) *discoidalis* (Boheman, 1855), comb. n., *Ch.* (*X.*) *incerta* (Boheman, 1855), comb. n., *Ch.* (*X.*) *purpurea* (Linnaeus, 1758), comb. n., and *Ch.* (*X.*) *myops* (Boheman, 1855), comb. n. Types of all, with exception of *Ch. purpurea*, were examined and are preserved in the Naturhistoriska Riksmuseet, Stockholm, Sweden. In addition Boheman (1855) described two more species in the same groups as abovementioned ones and we have strong feeling that they belong to *Xenocassis* too: *Ch.* (*X.*) *amoenula* (Boheman, 1855), comb. n. and *Ch.* (*X.*) *cyclographa* (Boheman, 1855), comb. n. Unfortunately, we were not able to locate their type specimens thus the transfer is tentative, based on primary descriptions according to which the species should have the circular body shape, the annulus on upper side of the elytra, and coarser punctation on the lateral slope of elytral disc like other *Xenocassis* species.

***Chapadacassis* subgen. n.**

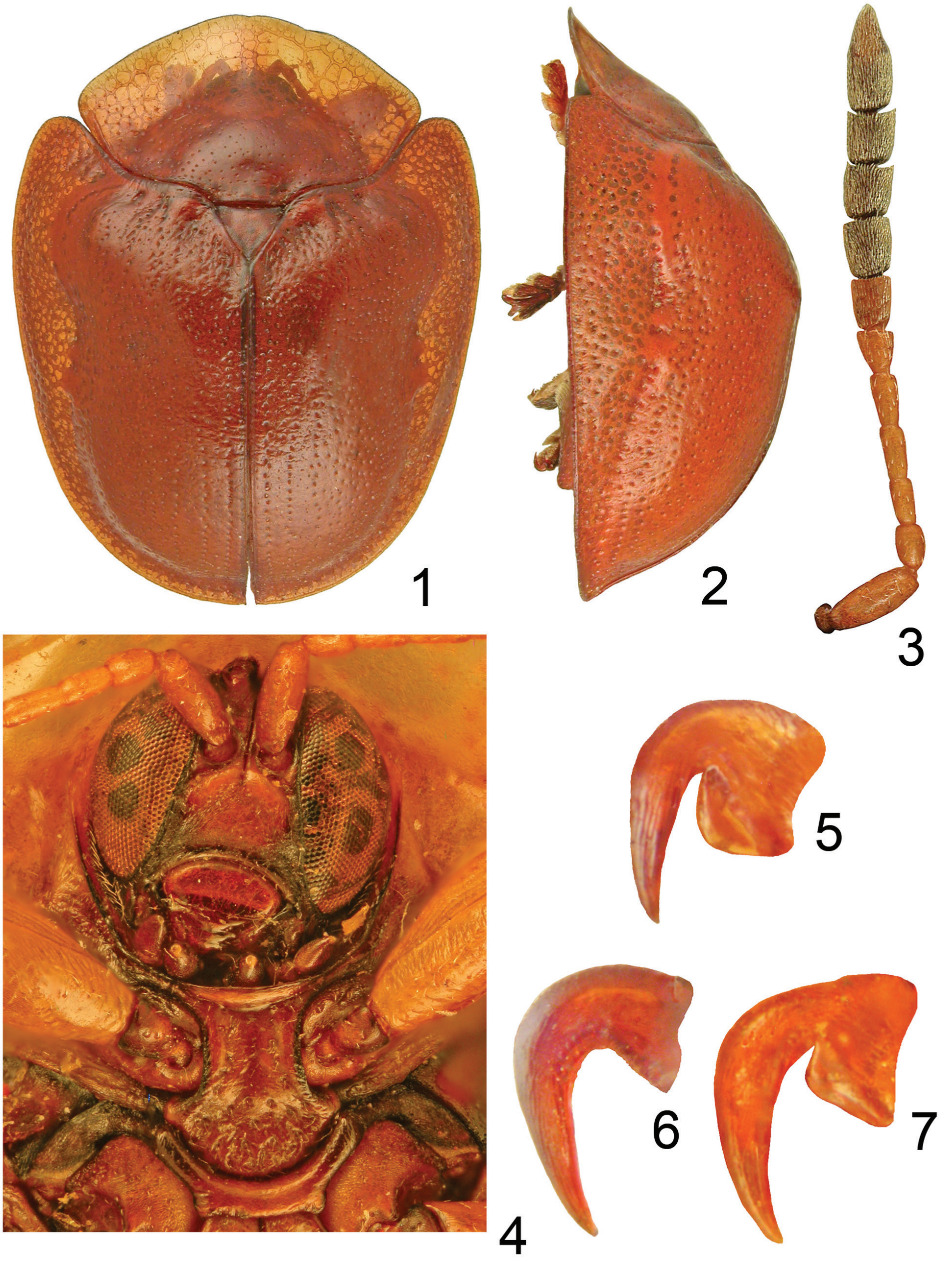
http://zoobank.org/2BC3A84F-44A2-48C0-A888-14EB4101B789
Figs 1–7

Type species. *Charidotella* (*Chapadacassis*) *paradoxa* sp. n. here designated.

Etymology. The genus name is a combination of its type locality, the Chapada plateau and the genus name *Cassida*, gender feminine.

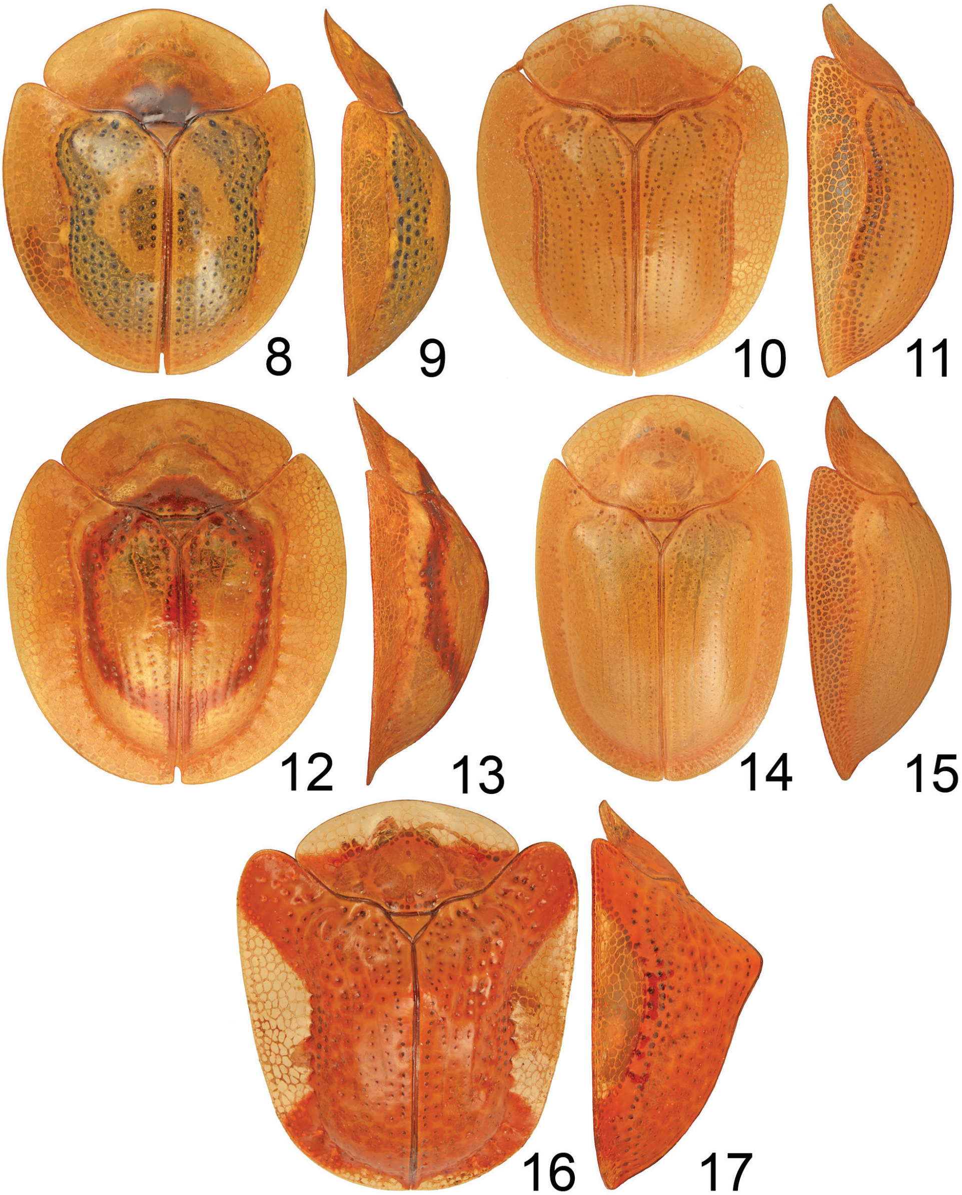
Diagnosis. *Chapadacassis* subgen. n. is well characterized by completely irregular punctation of the elytra, only apical two thirds of sutural row appear more or less regular, while all other *Charidotella* species have mostly regular punctation of the elytra. Mostly or completely irregular punctation of the elytra is generally a rare feature in Neotropical Cassidini present only in a few taxa (e.g. *Metriona elatior* (Klug, 1829) or *Scaeocassis turbulenta* (Boheman, 1862)).

Externally, *Chapadacassis* subgen. n. is reminiscent of *Philaspis* because of the body shape, but *Philaspis* species have moderately and regularly convex elytra without any impressions while *Chapadacassis* subgen. n. has strongly convex elytra with moderate scutellar impressions thus elytral profile is distinctly broken (Fig. 2). *Chapadacassis* subgen. n. also differs in having lateral sides of pronotum rounded (angulate in *Philaspis*), tarsal



Figures 1–7. *Charidotella* (*Chapadacassis*) *paradoxa* sp. n. **1** body dorsal **2** body lateral **3** antenna **4** head and prosternum **5** outer claw of protarsus **6** inner claw of mesotarsus **7** inner claw of metatarsus.

claws with small tooth (large in *Philaspis*), antennae with five basal shiny and slim antennomeres (six in *Philaspis*), and antennomeres II and III subequal in length and IV longer than either (III and IV subequal in length and II distinctly shorter than either one).



Figures 8–17. Type species for subgenera of *Charidotella*. **8–9** *Charidotella* (s. str.) *zona* (Fabricius, 1801) **10–11** *Charidotella* (*Chaerocassis*) *marculenta* (Boheman, 1855) **12–13** *Charidotella* (*Xenocassis*) *amoena* (Boheman, 1855) **14–15** *Charidotella* (*Philaspis*) *seriatopunctata* (Spaeth, 1901) **16–17** *Charidotella* (*Metrionaspis*) *rubicunda* (Guérin-Méneville, 1844).

Description. Body 7.6 mm long and 5.9 mm wide, broadly oval and strongly convex (Figs 1–2). Pronotum subpentagonal, 1.9 times wider than long, widest slightly before midlength with obtuse lateral sides. Disc indistinctly separated from explanate margin, whole surface of pronotum sparsely and coarsely punctate. Scutellum triangular, smooth, dull, micro-reticulate. Elytral base distinctly wider than base of pronotum, humeral angles strongly protruding anterad and rounded. Disc strongly convex, moderately impresed on each side of scutellum, thus lateral profile broken (Fig. 2). Punctation of elytra overall coarse, mostly irregular only first two rows more or less regular in apical half. Marginal row distinct, interrupted by large callosity around midlength, its punctures approximately twice coarser than those on disc. Explanate margin broad, almost as broad as half width of disc, strongly declivous, sparsely and coarsely punctate. Extreme outer margin swollen.

Eyes large, gena not visible. Clypeus transverse, impunctate and shiny, anterior margin micro-rugose and slightly elevated (Fig. 4). Antennae slim, antennomeres I–V slim, glabrous and shiny, antennomere V intermediate, VI–XI broad and densely pubescent (Fig. 3). Labrum oval, not emarginate. Mandible with three large teeth. Prosternal collar slightly expanded towards mouth. Prosternal process broad with moderately expanded apex. Metepisterna coarsely punctate and dull. Mesepimera and mesepisterna micro-reticulate and dull. Metaventrite smooth, shiny and sparsely punctate. Abdominal ventrites I–IV smooth and shiny, V shiny and sparsely punctate, each puncture with long seta. Legs normal, slim, tarsal claws divergent. Both pro- and metaclaws appendiculate with small tooth. Outer mesoclaw claw simple (Fig. 6), inner with small tooth.

***Charidotella* (*Chapadacassis*) *paradoxa* sp. n.**

http://zoobank.org/2F581A64-5A62-4D6C-BDBA-0570F65417EA

Type locality. The type locality most likely refers to Chapada dos Guimarães (approximately 15°10'–15°30'S, 55°40'–56°00'W), Mato Grosso, Brazil.

Type material. Holotype, pinned: “BRAZIL, Mato Grosso | Chapada Plateau | XI 1965 | native collector [white, printed and cardboard label]” (preserved at Department of Biodiversity and Evolutionary Taxonomy, Wrocław, Poland). Paratype, pinned: same data as holotype (preserved in collection of L. Sekerka, Prague, Czech Republic). Both specimens are provided with an additional red, printed and cardboard label: “HOLOTYPUS [or PARATYPUS respectively] | Charidotella | Chapadacassis sgen. n. | paradoxa sp. n. | L. Sekerka & | L. Borowiec des. 2014”.

Description. Body 7.6 × 5.9 mm, broadly oval and strongly convex (Figs 1–2).

Dorsum uniformly reddish-yellow. Margins of thoracic segments, trochanters, head, central parts of abdominal ventrites, and tarsi infuscate. Remaining ventral parts yellow. Five terminal antennomeres black, remaining yellow.

Pronotum subpentagonal, 1.9 times wider than long, widest slightly before midlength with obtuse lateral sides. Disc indistinctly separated from explanate margin, strongly convex, without impressions, sparsely and coarsely punctate, punctures laterobasally gradually coarser. Interspaces smooth and shiny, 1–4 times wider than puncture diameter. Explanate margin broad, lateral sides coarsely and sparsely punctate, transparent, smooth, and shiny, and with honeycomb structure. Anterior margin regularly convex.

Scutellum triangular, smooth, dull, micro-reticulate.

Elytra widest in basal third, then slowly tapering posteriorly. Elytral base distinctly broader than base of pronotum, humeral angles strongly protruding anterad and rounded. Disc strongly convex, with moderate impression on each side of scutellum, thus profile broken in lateral view (Fig. 2). Punctation of elytra overall coarse, mostly irregular only first two rows more or less regular in apical half. Punctures gradually coarser from top of disc to lateral sides. Interspaces 1–5 times wider than puncture diameter, finely micro-reticulate and appear shiny. Marginal row distinct, interrupted by large callosity around midlength, its punctures approximately twice coarser than those on disc (Fig. 2). Explanate margin broad, almost as broad as half width of disc, strongly declivous, sparsely and coarsely punctate, punctures gradually denser towards base and apex. Interspaces 1–5 times wider than puncture diameter, micro-reticulate and appear dull. Extreme outer margin swollen.

Clypeus 1.3 times broader than long, impunctate and shiny, anterior margin micro-rugose and slightly elevated. Antennae slim, length ratio of antennomeres: 100:46:49 :59:54:45:57:57:55:56:115. Antennomere III slightly longer than II, VII–X subequal in length and approximately as long as wide (Fig. 3). Labrum oval, its lower margin smooth, not emarginate. Prosternal collar slightly expanded towards mouth. Prosternal process broad with moderately expanded apex, its surface microreticulate, sparsely and coarsely punctate, each puncture with single long seta (Fig. 4).

Legs normal, slim, tarsal claws divergent. Both fore claws appendiculate (Fig. 5). Inner mid claw simple (Fig. 6), outer with small tooth. Inner hind claw with large tooth (Fig. 7), outer with small.

Diagnosis. At first glance *Ch.* (*C.*) *paradoxa* sp. n. reminds some species of the subgenus *Philaspis*. Particularly recently described, *Ch.* (*P.*) *marginepunctata* Borowiec, 2004 (also from Chapada in Mato Grosso) because of quite similar body shape and coarsely punctate explanate margin of elytra and pronotum. The latter distinctly differs in regularly punctate and less convex elytra without postscutellar impressions, subhorizontal explanate margin of the elytra, and the presence of a small black spot on each elytron.

Etymology. The species epithet from Latin "*paradoxus*" = peculiar or curious for its unusual combination of morphological characters for Neotropical Cassidini.

Distribution. Brazil (Mato Grosso).

Key to subgenera of *Charidotella* Weise, 1896

1 Eyes large covering whole sides of the head, gena very narrow or invisible **2**
– Eyes moderately sized, covering 2/3 of lateral sides of the head, gena well visible, covering the basal third ....***Xenocassis* Spaeth, 1936**
2 Punctation of elytra regular...**3**
– Punctation of elytra completely irregular ....***Chapadacassis* subgen. n.**

3 Body outline subcircular to subtriangular. Pronotal sides usually broadly rounded **4**

– Body outline oval, parallel-sided. Pronotal sides sub-angulate .... ***Philaspis* Spaeth, 1913**

4 At least in male one of the metaclaws simple **5**

– All claws in both sexes with basal tooth or in male external claw of mesotarsi simple .... ***Charidotella* s. str.**

5 Elytra regularly convex or slightly impressed around scutellum. Antennae with six shiny basal antennomeres and five dull and broad apical .... ***Chaerocassis* Spaeth in Hincks, 1952**

– Elytra with a large postscutellar gibbosity, thus lateral profile appears angulate. Antennae with five shiny basal antennomeres and six dull and broad apical .... ***Metrionaspis* Spaeth, 1942**

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RESEARCH ARTICLE

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Redescription of the Far Eastern brook lamprey *Lethenteron reissneri* (Dybowski, 1869) (Petromyzontidae)

Claude B. Renaud[1], Alexander M. Naseka[2]

[1] Research & Collections Division, Canadian Museum of Nature, P.O. Box 3443, Station D, Ottawa, ON K1P 6P4 Canada [2] *Faculty for Biology and Soil, St. Petersburg State University, Universitetskaya Emb. 7, St. Petersburg, 199034 Russia*

Corresponding author: *Claude B. Renaud* (crenaud@mus-nature.ca)

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Abstract

Nonparasitic *Lethenteron reissneri* (Dybowski) is redescribed based on four syntypes (two adults and two ammocoetes) from the Onon and Ingoda rivers, Russia, and 15 topotypic specimens (seven metamorphosing ammocoetes and eight ammocoetes) from the Onon River system, Russia and Mongolia. Posterial teeth were not mentioned in the original description, but Berg (1931) stated that they were sometimes absent, which he later (Berg 1948) changed to usually absent, based on material (some of which we have re-identified as parasitic *L. camtschaticum*) from far outside of the type locality. The latter view has been widely accepted by subsequent authors. Unfortunately, the poor condition of the two adult syntypes did not permit verification of this character. However, a row of posterials was clearly visible in six of the seven topotypic metamorphosing ammocoetes and indicates their usual presence in the species. The first full description of the ammocoetes, including pigmentation, is provided. The present study restricts the distribution of *L. reissneri* to the Shilka and Songhua river systems within the Amur River basin, until a more geographically comprehensive study is undertaken. Additionally, in this study, feeding versus non-feeding at the adult stage, are considered to be valid taxonomic characters at the species level.

Keywords

Amur River basin, morphology, nonparasitic, taxonomy

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Introduction

The Northern Hemisphere lamprey genus *Lethenteron* was originally erected as a subgenus of *Entosphenus* by Creaser and Hubbs (1922) and elevated to generic rank by Jordan et al. (1930), without justification. Vladykov and Follett (1967) accepted this action and defined members of *Lethenteron* as possessing posterial teeth in a single curved row and with the outer laterals (exolaterals) absent. Renaud (2011) recognized one parasitic species, *L. camtschaticum* (Tilesius, 1811) (i.e., the stem species) and six nonparasitic species, *L. alaskense* Vladykov & Kott, 1978, *L. appendix* (DeKay, 1842), *L. kessleri* (Anikin, 1905), *L. ninae* Naseka, Tuniyev & Renaud, 2009, *L. reissneri* (Dybowski, 1869), and *L. zanandreai* (Vladykov, 1955) (i.e., the satellite species) in the genus, along with two additional undescribed nonparasitic species from Japan, and noted that the taxonomic limits of the nonparasitic *L. reissneri* were unclear. Authors have either treated these satellites of *L. camtschaticum* as distinct species (e.g., Potter et al. 2015) or as synonyms of this species. For example, Artamonova et al. (2011a, 2011b) and Makhrov et al. (2013) have, respectively, suggested that *L. ninae*, *L. reissneri*, and *L. kessleri* are synonyms of *L. camtschaticum* and that mode of life (i.e., parasitism versus nonparasitism) is not a valid criterion for specific distinctiveness. This is not a new concept. McPhail and Lindsey (1970), in discussing *L. camtschaticum* (reported as *Lampetra japonica* (von Martens, 1868)) from the Northwest Territories, Yukon and Alaska, suggested that it may not be specifically distinct from *L. appendix* (reported as *L. lamottenii* (Lesueur, 1827)) from eastern North America, but preferred to retain them as distinct pending a review of all relevant species from both continents (i.e., North America and Eurasia). Renaud et al. (2009) proposed that the key to resolving the issue of whether parasitism or nonparasitism constitute valid taxonomic characters at the species level may be to conduct common garden experiments (i.e., rearing two putative species under the same conditions from the zygote to the adult stage) that seek to elucidate the triggering mechanism for trophic interactions, or the lack thereof, in the adult stage. In the absence of such experiments, however, we follow here conventional taxonomy and continue to recognize the above nonparasitic species as distinct. Additionally, prior to synonymizing species, it is critical to compare any extant type material as well as the original descriptions, and, unfortunately, this has not been done on a consistent basis by authors. The original description by Dybowski (1869) of *Petromyzon reissneri* was very short, incomplete and based on material from the upper Amur River basin, Russia (type locality: Onon and Ingoda rivers). A number of authors conducted morphological studies on what they referred to as *Lampetra reissneri* and anadromous *L. japonica* (= *Lethenteron camtschaticum*) from the lower Amur River basin (Berg 1931, 1948, Nikol'sky 1956, Abakumov 1960, Hensel 1963). However, we are aware of only two studies since the original description, to have examined lamprey material, which they treated as a single species, from the upper Amur (Karasev 1987, Yamazaki et al. 2006). The Amur River basin is divided into five or six well-defined zoogeographic districts (Bogutskaya et al. 2008) or ecoregions (Abell et al.

2008), respectively, based on the distributional disparities of freshwater fish species along its 4,370–4,510 km length. Thus, it is critical to examine lamprey material from the upper rather than lower Amur, to objectively evaluate the characteristics of *L. reissneri* and prevent the inclusion of another species in the redescription. Karasev (1987) studied 52 adult lamprey from the Ingoda and the Shilka rivers, but only reported a few morphometric characters and the tooth formula of the infraoral lamina. Yamazaki et al. (2006) studied 26 ammocoetes from the Onon and 29 from the Ingoda rivers and determined that they possessed 65–73 trunk myomeres, but made no mention of their body pigmentation. Yamazaki et al. (2006) examined an adult syntype of *L. reissneri* (Museum für Naturkunde, Berlin; ZMB 7118) and determined it had 69 trunk myomeres, but made no mention of its dentition. Although Berg (1931) reported that *L. reissneri* possessed 56–67 trunk myomeres, that range was taken from Jordan and Hubbs (1925) based on Japanese material (Himeji and Lake Biwa, Honshu Island and Sapporo, Hokkaido Island), which they identified as *Entosphenus mitsukurii* (Hatta 1901). Berg (1931) further stated that the lower labial teeth (= posterial teeth) were sometimes absent in *L. reissneri*. He subsequently (Berg 1948) changed this to usually absent based on material from the Asian Pacific coast between the Anadyr estuary and the Shangshi River, distant from the type locality. Hubbs and Potter (1971) highlighted the inconsistency between Berg's (1948) statement of usually no lower labial teeth and their observations. Nevertheless, Reshetnikov (2002) repeated Berg's (1948) statement in the widely cited Atlas of freshwater fishes of Russia. The purpose of this study is to provide a full description of the species based on the examination of type and topotypic material of ammocoetes, metamorphosing ammocoetes and adults, and in view of the inconsistency between the observations of Berg (1931, 1948) and Hubbs and Potter (1971), re-examine material that Berg studied to determine how often posterials are absent.

Materials and methods

Material was examined from the Academy of Natural Sciences, Philadelphia (ANSP), Natural History Museum, London (BMNH), Canadian Museum of Nature Fish Collection, Ottawa (CMNFI), Naturhistorisches Museum Wien, Vienna (NMW), Zoological Institute, Russian Academy of Sciences, St. Petersburg (ZIN), and Museum für Naturkunde, Berlin (ZMB). Note that collection dates for ZIN collections use the Gregorian rather than the Julian calendar. The characters examined in the ammocoetes and adults follow the method of Renaud (2011). Evaluation of the lateral line neuromast pigmentation in both ammocoetes and adults was made on the dorsal aspect of the branchial region. We additionally examined in ammocoetes the pigment pattern of the posterior fleshy part of the tail as in Richards et al. (1982); their caudal ridge, and the pigmentation in adults of the gular region and apex of the second dorsal fin following Vladykov and Kott (1978). TL, total length.

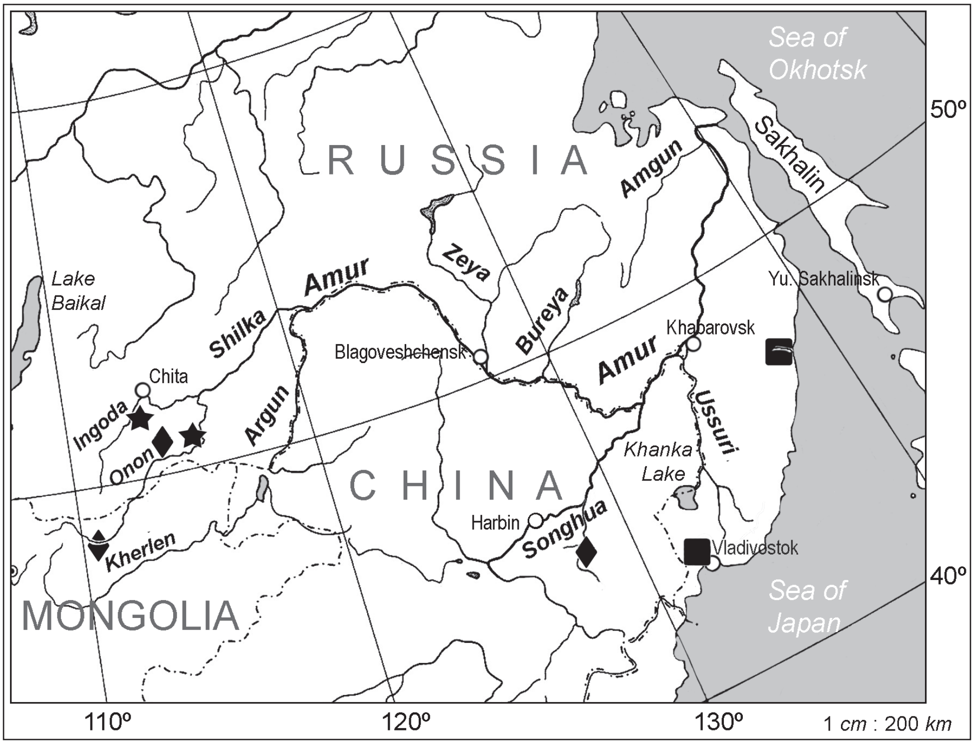

Figure 1. Geographic distribution of *Lethenteron reissneri* and material identified by Berg (1931) as *L. reissneri* without posterials. Approximate location of the type locality of *L. reissneri*, Amur River basin, Russia (solid star), topotypic localities in Russia and Mongolia (solid diamonds) and localities of material identified by Berg (1931) as *L. reissneri*: Shangshi River, Amur River basin, People's Republic of China (solid diamond), Sedanka River, Sea of Japan basin, Russia (solid square), and Samarga River, Sea of Japan basin, Russia (solid square). The Sedanka and Samarga River specimens were re-identified as *L. camtschaticum*.

Syntypes (for locality see also map in Fig. 1)

BMNH 1871.7.19.37, 1 adult, reported as 120 mm TL in Regan (1911), but only 90+ mm when measured by CBR in 2010, Russia: Onon River, Transbaikalia (also known as Dauria), purchased from Museum Godeffroy (Museum Godeffroy, Hamburg, Germany, existed 1861 to 1885); ZMB 7118, 1 adult, 117.1 mm TL, Russia: Onon River, B.N. Dybowski; NMW 78112, 2 ammocoetes, 106.5–122.2 mm TL, Russia: Onon and Ingoda rivers, upper Amur River basin, received from B.N. Dybowski on 1 Feb. 1870.

Topotypic non-type material (for localities see also map in Fig. 1)

ANSP 185410, 2 ammocoetes, 83–151 mm TL, 6 metamorphosing ammocoetes, 139.5–151.5 mm TL, Mongolia: Barh River, tributary to Onon River, upper Amur River basin, about 5 km E of town of Barh at crossing of road N to Bathshireet,

Figure 2. Syntype (adult) of *Petromyzon reissneri* Dybowski, 1869, ZMB 7118, 117.1 mm TL, Onon River.

Khentii Province, altitude 1,111 m, 48°36.20'N; 110°12.00'E, 21 Aug. 2006; CMNFI 2008–58, 1 metamorphosing ammocoete, 164 mm TL, Russia: Ilya River, tributary to Onon River, upper Amur River basin, upstream from Dul'durga, 50°43.18'N; 113°35.42'E, 24–26 Aug. 2004; ZIN uncatalogued, 6 ammocoetes, 129.5–171 mm TL, Russia: Ilya River, tributary to Onon River, upper Amur River basin, upstream from Dul'durga, 50°43.18'N; 113°35.42'E, 24–26 Aug. 2004.

Specimens identified by Berg (1931) as *L. reissneri* (for localities see also map in Fig. 1)

ZIN 14457, 1 adult female, 146 mm TL, 1 ammocoete, 221.5 mm TL, People's Republic of China: Shanshi (= Shangshi) River, Sungari (= Songhua) River system, at Khandaokhetszy railway station, near Shangzhi, Manchuria, April 1908; ZIN 15078, 1 adult re-identified as *L. camtschaticum*, 178+ mm TL (very dessicated), Russia: Samarga River, near Sufren Cape, near coast, in brackish water, 28 Sept. 1910; ZIN 15747, 1 adult female re-identified as *L. camtschaticum*, 161.5 mm TL, Russia: Sedanka River, near Vladivostok, 6 March 1912.

Results

Adults (Tables 1 and 2)

Adult syntype (BMNH 1871.7.19.37) extremely dessicated and TL could not be accurately determined. Approximate TL 90+ mm. Eye length 2.5 mm. Confirmed as adult because of oral disc about 3.5 mm in length. Supraoral lamina with two cusps separated by broad toothless bridge. Two dorsal fins. No other counts or measurements feasible. Second adult syntype (ZMB 7118, Fig. 2) in much better condition and all morphometrics determined (Table 1) plus additional characteristics of dentition and trunk myomeres (Table 2). 70 trunk myomeres in syntype (69 reported by Yamazaki et al. (2006) for same specimen).

Metamorphosing ammocoetes

Seven topotypic metamorphosing ammocoetes from two tributaries to the Onon River examined: six from Barh River, Mongolia (ANSP 185410) and one from Ilya River,

Table 1. Morphometrics re-examined in adult *Lethenteron reissneri* and *Lethenteron camtschaticum* (identified by Berg (1931) as *Lethenteron reissneri*). The syntypes and non types of *L. reissneri* are from upper Amur River basin.

	Lethenteron reissneri **syntype†** **BMNH 1871.7.19.37** **Onon River**	***Lethenteron reissneri*** **syntype ZMB 7118 Onon River**	***Lethenteron reissneri*** **non types (from Karasev 1987) Ingoda and Shilka rivers n = 52**	***Lethenteron reissneri***	***Lethenteron camtschaticum*** **specimens identified by Berg (1931) as *Lethenteron reissneri***	
				ZIN 14457 Shangshi River	**ZIN 15747 Sedanka River**	**ZIN 15078 Samarga River**
Total length (TL, mm)	90.0+	117.1	137–182	146.0	161.5	178.0+
%TL Prebranchial length	undetermined	11.1	7.9–15.0	11.0	9.9	10.4
Branchial length	undetermined	10.9	8.9–11.2	10.3	9.3	9.6
Trunk length	undetermined	50.5	undetermined	47.9	52.0	49.4
Cloacal slit length	undetermined	1.2	undetermined	0.7	0.9	1.1
Tail length	undetermined	26.9	undetermined	28.8	28.2	27.8
Disc length	3.9	5.1	undetermined	4.8	4.3	4.8
Snout length	undetermined	6.1	4.0–9.3	6.8	5.0	5.9
Eye length	2.8	1.5	1.2–2.2	2.1	2.5	1.7
Postocular length	undetermined	3.5	2.2–3.9	2.7	2.5	2.2
Interbranchial opening length	undetermined	1.5	undetermined	1.7	1.2	1.1
Prenostril length	undetermined	4.9	undetermined	5.1	4.6	5.1
Interocular width	undetermined	3.0	2.2–3.9	3.8	3.1	2.2
Urogenital papilla length	undetermined	0.9	undetermined	0.7	0.6	undetermined

†Extremely dessicated and contorted specimen; total length cannot be determined accurately.

Table 2. Characteristics re-examined in adults of *Lethenteron reissneri* (syntypes) and those identified by Berg (1931) as that species. Pigmentation coverage as follows: - < 1%; +++ ≥ 75%. b, bicuspid; u, unicuspid.

	Lethenteron reissneri **syntype BMNH 1871.7.19.37 Onon River**	***Lethenteron reissneri*** **syntype ZMB 7118 Onon River**	***Lethenteron reissneri***	***Lethenteron camtschaticum*** **specimens identified by Berg (1931) as *Lethenteron reissneri***	
			ZIN 14457 Shangshi River	**ZIN 15747 Sedanka River**	**ZIN 15078 Samarga River**
Trunk myomeres	undetermined	70	72	72	77
Supraoral lamina	1u–1u	1u–1u	1u–1u	1u–1u	1u–1u
Endolaterals	undetermined	2–2–2	2–2–2	2–2–2	2–2–2
Infraoral lamina	undetermined	1b5u	1b4u1b	1b4u1b	6u1b
Rows of anterials	undetermined	undetermined	3	2	2
Rows of exolaterals	undetermined	undetermined	0†	0	0§
Rows of posterials	undetermined	undetermined	2	1	1
First anterial row	undetermined	undetermined	5u	5u	4u
First posterial row	undetermined	undetermined	24u	18u	18u1b3u
Transverse lingual lamina	undetermined	undetermined	2u–I–2u	4u–I–4u	4u–I–4u
Longitudinal lingual laminae	undetermined	undetermined	undetermined	undetermined	undetermined
Oral papillae	undetermined	undetermined	undetermined	21	≈18
Oral fimbriae	undetermined	undetermined	≈104	92	91
Caudal fin shape	undetermined	undetermined	spade-like	spade-like	undetermined
Pigmentation					
- Caudal fin	undetermined	undetermined	+++	+++	+++
- Second dorsal fin	undetermined	undetermined	no blotch	with blotch	undetermined
- Lateral line neuromasts	undetermined	undetermined	unpigmented	unpigmented	undetermined
- Gular	undetermined	undetermined	-	-	-

† Left side has two exolateral teeth; one between first and second and other between second and third endolaterals.

§ Right side with exolateral tooth between first and second endolaterals.

Figure 3. Syntypes (ammocoetes) of *Petromyzon reissneri* Dybowski, NMW 78112, 106.5 mm (below); 122.2 mm TL (above). Arrows point to dark midline streak on tail.

Russia (CMNFI 2008–58). Five of Mongolian specimens (139.5–151.5 mm TL) had remnants of oral cirrhi, whereas none present in the other Mongolian (147 mm) or the Russian (164 mm) specimens. Furrow linking all branchial openings present in all specimens except only partially present in one Mongolian specimen (146.5 mm). All specimens with both well-developed supraoral lamina bearing two cusps separated by wide bridge and faint dark blotch near apex of their second dorsal fin. Row of posterial teeth discernible in six specimens; although exact numbers could not be determined. This character not assessed in 139.5 mm Mongolian specimen because of presence of remnants of oral cirrhi on posterior field. Enlarged median cusp present on transverse lingual lamina in all specimens.

Ammocoetes (Table 3)

Morphometrics and number of trunk myomeres were determined in two syntypic ammocoetes (NMW 78112, Fig. 3), but specimens extremely faded with virtually no pigmentation. Both possessed prominent streak of dark pigmentation along midline of tail region (Fig. 3). This limited information was augmented by the study of eight topotypic ammocoetes (ANSP 185410 and ZIN uncatalogued) in which virtually all characters studied were recorded.

Discussion

In the original description of *Petromyzon reissneri* written in German, Dybowski (1869) did not give the number of adults examined and the diagnosis was: 120–140 mm in TL; supraoral lamina with one blunt tooth at each end; infraoral lamina with six blunt teeth, the lateralmost being bicuspid; second dorsal fin almost three times higher than the first dorsal fin and higher than the body depth; dorsal body surface dark and lower surface whitish. Additional information was that spawning occurs in June and that ammocoetes are widespread and abundant, while adults are extremely rare. The small size of adults, the very high second versus first dorsal fins, and the strong bicoloration of the body points to the diagnosis being based on spawning individuals.

Absence vs. presence of posterials in *Lethenteron reissneri*

Dybowski (1869) did not mention posterials in his brief original description of *L. reissneri*. Regan (1911) examined a 120 mm adult syntype from the Onon River (BMNH 1871.7.19.37) and identified it as *Lampetra planeri* (Bloch, 1784), a species that does not possess posterial teeth according to the key he provided in the same publication. Unfortunately, the condition of this syntype, as well as the one in Berlin (ZMB 7118), was such that the presence or absence of posterials could not be ascertained by us. However, the presence of a row of posterials in all topotypic metamorphosing ammocoetes in which this character was discernible, albeit of uncertain numbers, showed that posterials are the predominant if not constant characteristic of this species. This contrasts with the assumption in the recent literature (e.g., Reshetnikov 2002) that posterials in *L. reissneri* are sometimes (Berg 1931) or usually (Berg 1948) absent.

Berg (1931) did not examine any material from the type locality, but recognized *L. reissneri* as a distinct species. He stated that in this species, the posterial teeth (he called them lower labial or infralabial teeth) were either entirely absent or present as a complete row and he provided drawings of the oral disc, showing these respective conditions [Berg (1931): Pl. VI, Fig. 2, ZIN 15747 and Pl. VI, Fig. 3, ZIN 15734] in two specimens from the Sedanka River, Russia. He documented five cases of *L. reissneri* without posterials (ZIN 14457, 15078, 15547, 15747, and an uncatalogued male from the Anadyr River). We were able to locate three of these specimens (ZIN 14457, 15078, 15747). Our re-examination revealed the following counts of posterials in a complete row: 24 unicuspid teeth (Fig. 4a); 18 unicuspid, 3 bicuspid, 1 unicuspid teeth (Fig. 4b); and 18 unicuspid teeth (Table 2). In fact, ZIN 14457 (Shangshi River, People's Republic of China) possessed two rows of posterials (Fig. 4a). It is unknown why these numerous posterial teeth were overlooked by Berg; however, it is clear that an absence of posterials in the drawings of the oral disc [Berg (1931): Pl. VII, Fig. 1, ZIN 14457 and Pl. VI, Fig. 2, ZIN 15747] is incorrect. Berg (1948) partially corrected his 1931 comment by stating that non-keratinized posterials could be seen on the left side of the oral disc of specimen ZIN 14457 at 20× magnification. Based on its September collection date, strong dentition with nine teeth on the transverse lingual lamina and the fact that it was collected from brackish waters, ZIN 15078 (Fig. 4b) from the Samarga River, Russia was re-identified as a young adult *L. camtschaticum* on its feeding migration to the sea. The specimen from the Sedanka River (ZIN 15747) was likewise re-identified as *L. camtschaticum* based on the presence of nine strong teeth on its transverse lingual lamina. However, we agree with Berg (1931) that the adult from the Shangshi River, Songhua River system (ZIN 14457) is *L. reissneri* on the basis of its weaker dentition and lower number of teeth (i.e., five) on its transverse lingual lamina. Additionally, the *L. reissneri* specimen from the Shangshi River has an unpigmented second dorsal fin whereas the *L. camtschaticum* from the Sedanka River has a blotch on this fin (Table 2).

Karasev (1987) reported on seven morphometric characters comparable to those we examined (Table 1) along with the tooth formula of the infraoral lamina in 52

Table 3. Characteristics in ammocoetes of *Lethenteron reissneri* from upper Amur River basin and Shangshi River. Pigmentation coverage is as follows: -, absent to trace; +, 1% to < 25%; ++, 25% to < 75%; +++, ≥ 75%. The number in parentheses indicates the number of specimens with this condition.

	syntypes NMW 78112 n = 2	**topotypes ANSP 185410 n = 2**	**topotypes ZIN uncatalogued n = 6**	**Shangshi River ZIN 14457 n = 1**
Total length (TL, mm)	106.5–122.2	83.0–151.0	129.5–171.0	221.5
Prebranchial length (% TL)	6.3–6.9	7.0–8.4	5.8–7.3	5.0
Branchial length (% TL)	10.5–11.1	11.9–12.7	11.1–13.1	10.8
Trunk length (% TL)	55.9–57.7	50.6–53.6	49.8–53.3	53.7
Cloacal slit length (% TL)	0.5–0.7	0.6–1.0	0.6–1.9	1.4
Tail length (% TL)	24.0–24.5	26.5–29.1	27.5–28.8	29.1
Prenostril length (% TL)	1.6–2.1	2.0–2.4	1.7–2.4	1.8
Interbranchial opening length (% TL)	1.3–1.6	2.0–2.4	1.7–2.3	1.4
Trunk myomeres	67–69	67–69	66–70	≈70
Caudal fin shape	spade-like(2)	spade-like(2)	spade-like(6)	spade-like
Pigmentation				
- Upper lip	undetermined	+(2)	+(6)	-
- Lower lip	undetermined	++(2)	+(4), ++(2)	-
- Between upper lip and cheek	undetermined	+++(2)	+++(6)	+++
- Cheek	undetermined	+++(2)	+++(6)	++
- Subocular	undetermined	-, +	-, +(4), ++	-
- Upper prebranchial	undetermined	++(2)	+, ++, +++(4)	-
- Lower prebranchial	undetermined	-, +	-(3), +(3)	-
- Upper branchial	undetermined	++(2)	++(5), +++	++
- Lower branchial	undetermined	-(2)	-(6)	-
- Ventral branchial	undetermined	-(2)	-(6)	-
- Caudal fin	undetermined	++(2)	+(2), ++(4)	++

	syntypes NMW 78112 n = 2	**topotypes ANSP 185410 n = 2**	**topotypes ZIN uncatalogued n = 6**	**Shangshi River ZIN 14457 n = 1**
- Posterior fleshy part of tail	dark midline streak(2)	dark midline streak(2)	undetermined	dark midline streak
- Predorsal	undetermined	+, ++	+++(6)	++
- Lateral line neuromasts	undetermined	unpigmented(1), undetermined(1)	unpigmented(6)	unpigmented
Middle prong of tongue precursor				
- shape	undetermined	undetermined	undetermined	bulbous
- pigmentation	undetermined	undetermined	undetermined	++
Areas lateral to elastic ridge pigmentation	undetermined	undetermined	undetermined	-

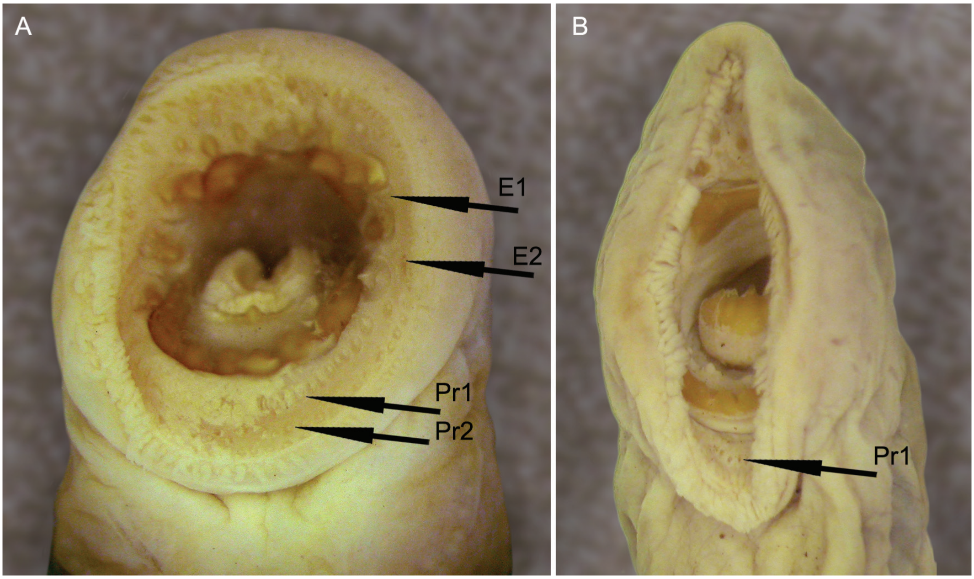

Figure 4. Oral disc of lampreys identified by Berg (1931) as *Lethenteron reissneri* without row of posterials. **A** ZIN 14457, Shangshi River, Songhua (Sungari) River system, People's Republic of China, 146 mm TL with complete posterial row comprising 24 unicuspid teeth (Pr1; only few of these teeth visible in photo). Note second row of posterials (Pr2). Two exolateral teeth additionally present on left side, one between first and second (E1) and other between second and third endolaterals (E2) **B** ZIN 15078 (re-identified as *L. camtschaticum*), Samarga River, near Sufren Cape, Russia, 178.0+ mm TL with complete posterial row comprising 18 unicuspid, 3 bicuspid, 1 unicuspid teeth (only few of these teeth visible in photo). Exolateral tooth present on right side between first and second endolaterals not visible because oral disc not fully open.

adults from the Ingoda and Shilka rivers in the upper Amur River basin. His morphometric data are informative in encompassing a range of adult total lengths (137–182 mm). The values recorded in the six morphometric characters that were expressed as percentages of TL for the best preserved syntype (ZMN 7118, 117.1 mm, Table 1) fall within the ranges reported by Karasev (1987). Unfortunately, it is unclear from the reported infraoral lamina counts (i.e., 1–4–1 and 1–5–1) whether the lateralmost teeth were enlarged relative to the internal ones. Regardless, the total number of teeth (6–7) is very similar to the only infraoral lamina count (6) in a syntype (ZMB 7118, Table 2). Karasev (1987) observed two lampreys attached to specimens of *Leuciscus waleckii* (Dybowski, 1869) in the Olengui River (tributary to the Ingoda River) in June 1960 and noted these were the only cases of lamprey attacking fishes in rivers of Transbaikalia observed over a period of years and that an unspecified number of examined adults had empty intestines. We do not consider these observations evidence of lamprey parasitism because attachment does not necessarily lead to feeding and especially since June, as noted above, is the spawning period in the upper Amur River basin and lampreys do not feed during this period (Potter et al. 2014). We believe additionally, that the small size difference between the largest ammocoetes (ZIN uncatalogued, 171 mm TL, Table 3) and adults [182 mm TL, Karasev (1987)] from the upper Amur River system is not conclusive evidence that *L. reissneri* feeds post metamorphosis and we presume that ammocoetes exceeding 182 mm TL exist. In fact, the 221.5 mm TL ammocoete and 146 mm TL spawning female from the Shangshi River, Songhua River system (ZIN 14457, Tables 1 and 3), that we identify as *L. reissneri* as did Berg (1931), indicate as in nonparasitic species that ammocoete total lengths exceed those of adults, even allowing for shrinkage in spawning individuals (Vladykov and Kott 1978: fig. 12). The total lengths reported by Dybowski (1869) for the spawning adults (120–140 mm) from the upper Amur are similar to that of the spawning female from the Shangshi River (146 mm) and indicate narrow variation across a wide distributional range (Fig. 1). The absolute fecundity in 15 females collected from the Ingoda River in April–May 1969 and 1970 was estimated to be 1,720–3,360 eggs/female and the egg diameter varied between 0.68 and 0.84 mm (Karasev 1987); a low fecundity expected in a nonparasitic species (Potter et al. 2014).

The number of trunk myomeres reported for 18 adults of *L. reissneri* from Japan and Sakhalin Island by Vladykov and Kott (1978) was 57–63. This is clearly different from the counts of 70–72 based on adult specimens from the upper Amur River system (syntype) and Songhua River system (Shangshi River, Table 2) and may refer to another species. Therefore, we restrict the distribution of *L. reissneri* to the Shilka and Songhua river systems, within the Amur River basin (Fig. 1) until a more geographically comprehensive study is undertaken. Yamazaki et al. (2006) gave counts of 65–73 trunk myomeres for 55 topotypic ammocoetes from the Onon and Ingoda rivers. This is similar to the counts of 66–70 reported here (Table 3) based on two syntypes and eight topotypes.

The presence of a dark midline streak on the posterior fleshy part of the tail in ammocoetes of *L. reissneri* was distinct from the pigmentation patterns reported by Richards et al. (1982) for ammocoetes of *Entosphenus macrostomus* (Beamish, 1982), *E. tridentatus* (Gairdner in Richardson, 1836), *Lampetra ayresii* (Günther, 1870), and *L. richardsoni* Vladykov & Follett, 1965. The same pattern of dark midline streak appears in Fig. 7b in Vladykov (1950) depicting the tail region of *Lethenteron appendix* (reported as *Entosphenus lamottenii*) and in Fig. 2 in Naseka et al. (2009) depicting the tail region of *L. ninae*. Additionally, Renaud et al. (in press) found the same pigmentation pattern in ammocoetes of *L. alaskense* and *L. camtschaticum*. This dark midline streak appears therefore to be a diagnostic characteristic of *Lethenteron*, but its presence still requires confirmation in *L. kessleri*.

Diagnosis

Lethenteron reissneri is distinguished from parasitic *L. camtschaticum* by not feeding as an adult, reaching 182 mm compared to 625 mm TL, 5 versus 9–18 teeth on the transverse lingual lamina. It possesses 70–72 trunk myomeres in adults compared to 54–60 in *L. zanandreai* (this species has been re-assigned to the genus *Lampetra*; see

Potter et al. (2015) for justification) and 58–62 in *L. ninae*; absence of pigmentation in the gular region in adults compared to presence of pigmentation in *L. appendix*; 6–7 infraoral teeth compared to 6–11 (mean 8.6) in *L. alaskense*.

Lethenteron kessleri (type locality: Tom' River and tributary, Kirgizka River, Ob' River basin, near Tomsk, Russia) is poorly defined and may be a junior synonym of *L. reissneri* as suggested by Yamazaki et al. (2006) on the basis of similarities in their number of trunk myomeres, allozyme alleles, and mtDNA genes CO I and cyt *b* sequences in larval material from the type localities (although only in a very general sense in the case of *L. kessleri*, as the material was from the upper Ob' River basin, in the Irtysh and Uba rivers, Kazakhstan). This synonymy will require corroboration using adults and a re-examination of the former's type material, which these authors did not conduct. It is the present authors' intention to do so in the near future. The two undescribed *Lethenteron* spp. from Japan are distinguished from *L. reissneri* on the basis of trunk myomeres (Yamazaki et al. 2006): 49–62 (*Lethenteron* sp. S) and 51–66 (*Lethenteron* sp. N).

Synonymy of *Lethenteron reissneri* (Dybowski, 1869) Far Eastern brook lamprey

Petromyzon Reissneri Dybowski, 1869: 948, 958 [original description, Onon and Ingoda rivers]

Lampetra planeri (non Bloch, 1784) – Berg 1906: 180 [Onon and Ingoda rivers]; Regan 1911: 203–204 [Onon River]

Lampetra planeri reissneri – Berg 1911: 36, 42–44 [in part, common name: Siberian brook lamprey; Siberia, Amur River basin including Sungari (Songhua) River system, Japan and eastern U. S. A.]; Berg 1916: 7 [in part, Asia and Atlantic coast of North America]

Lampetra (*Lampetra*) *reissneri* – Berg 1931: 103–105 [in part, common name: Pacific brook lamprey; Amur River basin, Pacific Ocean basin from Vladivostok to Anadyr, on Hondo (Honshu) and Hokkaido islands, Japan, possibly Pacific coast of North America]; Berg 1948: 41–43 [in part, common name: Far Eastern brook lamprey; distribution as in Berg (1931), plus Sakhalin and Iturup islands]

Lampetra reissneri – Nikol'sky 1956: 18–20 [in part, tributaries to upper and lower Amur River]; Abakumov 1960: 43 [in part, Amur River basin]; Hensel 1963: 85–86 [Mudan River, not Mutantiang River, tributary to Sungari (Songhua) River, People's Republic of China]

Lampetra (*Lethenteron*) *reissneri* – Hubbs and Potter 1971: 52 [in part, distribution restricted to Asian coasts of Pacific Ocean; question raised about inconsistency between Berg's (1948) report of usually no lower labial teeth and their observations]

Lethenteron reissneri – Vladykov and Kott 1978: 63 [in part, Amur River basin, Sakhalin Island and Japan, excluding Ryukyu Archipelago]; Vladykov and Kott 1979: 10, 19, 28 [in part, distribution as in Vladykov and Kott (1978)]; Kottelat 2006: 13–14 [Mongolia: Onon River system]; Yamazaki et al. 2006: 254 [Russia: Onon and Ingoda rivers, trunk myomeres in ammocoetes and adult syntype]; Bogutskaya et al. 2008: 313–314, Fig. 7 [in part, in smaller tributaries throughout Amur River basin; photograph of metamorphosing ammocoete]; Shishkin and Pavlov 2012: 429 [common name: Asiatic brook lamprey]

Lampetra japonica (non von Martens, 1868) – Karasev 1987: 16–18 [common name: Far Eastern brook lamprey; Ingoda, Onon, Shilka, and Argun rivers in upper Amur River basin]

Etymology

Dybowski (1869) did not specify, but this species was possibly named after Baltic German anatomist Ernst Reissner (1824–1878), as suggested by Scharpf and Lazara (2013).

Distribution

Shilka (Russia and Mongolia) and Songhua (People's Republic of China) river systems within the Amur River basin (Fig. 1).

Conclusion

This study establishes in *L. reissneri* the usual presence of a row of posterial teeth based on the examination of topotypic metamorphosing ammocoetes from the upper Amur River basin. The long and widely held perception that these teeth were either sometimes or usually absent in the species was based on the observations of Berg (1931, 1948). However, re-examination of material Berg (1931) reported to be without posterial teeth showed that these were in fact present as a complete row in the species.

Lethenteron reissneri possesses in adults an oral disc 3.9–5.1% of TL, a broad supraoral lamina with one cusp at either end, an endolateral tooth formula 2–2–2, an infraoral lamina with 6–7 teeth (one or both lateralmost teeth bicuspid and the rest unicuspid), 3 rows of anterials, no exolateral rows (but up to two exolateral teeth may be found on one side), 1–2 rows of posterials, the first has 24 unicuspid teeth, a transverse lingual lamina with an enlarged median cusp and two cusps on either side, a spade-like and strongly pigmented (i.e., +++) caudal fin, unpigmented (i.e., -) lateral line neuromasts and gular region, 70–72 trunk myomeres and reaches total lengths of 120–182 mm. The ammocoetes have a spade-like caudal fin, dark midline streak on the posterior fleshy part of the tail, unpigmented (i.e., -) lateral line neuromasts and lower and ventral branchial regions, weakly pigmented (i.e., +) upper lip, moderately pigmented (i.e., ++) upper branchial region, lower lip, and caudal fin, strongly pigmented (i.e., +++) cheek and area between the upper lip and cheek, a moderately pigmented (i.e., ++) bulbous middle prong of the tongue precursor and unpigmented (i.e., -) areas lateral to the elastic ridge, 65–73 trunk myomeres and reach 221.5 mm TL. It undergoes metamorphosis in August at 139.5–164 mm TL and spawns between April and June at 120–146 mm TL.

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RESEARCH ARTICLE

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Collembolan species diversity of calcareous canyons in the Republic of Moldova

Galina Buşmachiu[1], Anne Bedos[2], Louis Deharveng[2]

[1] Institute of Zoology of Academy of Sciences of Moldova, Academiei str.1, 2028 Chişinău, Moldova **2** *Institut de Systématique, Evolution, Biodiversité, ISYEB - UMR 7205 - CNRS, MNHN, UPMC, EPHE, Museum national d'Histoire naturelle, Sorbonne Universités, 45 rue Buffon (CP50), 75005 Paris, France*

Corresponding author: *Galina Buşmachiu* (bushmakiu@yahoo.com)

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Abstract

The study of collembolan communities from the Vîşcăuţi canyon in Moldova revealed 63 species belonging to 41 genera and 12 families, including four species new for the fauna of the Republic of Moldova. A checklist of collembolan species identified in the five calcareous canyons sampled so far in Moldova is included, with data on habitats, life form, occurrence and comments of distribution of most remarkable species. Of the 98 recognized species of these calcareous canyons, only 38 were shared by Vîşcăuţi and the other canyons. The richness of calcareous habitats together with the high heterogeneity in faunal composition suggests that further significant increase in the species richness of the region may be expected.

Keywords

Biodiversity, flotation method, checklist, life form

Introduction

Republic of Moldova has a rather small territory (33,760 km^2) but its heterogeneous natural conditions and its geographical position contributed to the formation of diverse types of soils, supporting high diversity of flora and fauna.

The largest river in the country is the Dniester. Its length within the territory of Moldova is 657 km, its catchment representing about 70% of the territory of

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country. The Dniester riverbed is sinuous in its upper course penetrating calcareous formations that emerge to the ground surface as cliffs and rocky banks. Along the course of water, petrophyte ecosystems are common and occupy a surface of 23 000 ha, being formed on the submarine coral reefs of Sarmatian Sea, emerged more than 10 million years ago.

The petrophyte ecosystems in calcareous canyons of Dniester River are characteristic elements of the landscape – unique in the north-western part of Black Sea basin.

The first result of the study concerning collembolan fauna of these canyons reported 56 species collected from five localities (Buşmachiu 2011a). The survey of Collembolan diversity on all riparian habitats of the Dniester revealed 138 species (Buşmachiu 2011b); however, it involved habitats such as natural steppe or natural flooded and xerothermic forests, which were not represented in Vîscăuți, the canyon object of the present study. Only 14 species were reported from Vîscăuți in our last paper.

The present study was part of collembolan fauna survey carried out in the calcareous canyons of the Dniester River and allowed us to identify one genus (*Appendisotoma*) and four species new for the fauna of the Republic of Moldova.

Material and methods

Study sites

The samples were taken in a calcareous canyon near the locality of Vîşcăuți situated close to the Dniester River in the central part of Moldova (47°43'N, 29°07'E, altitude 52 m). Canyon slopes are steep and covered with natural deciduous forest (Fig. 1). The trees trunks growing on limestone slopes and calcareous rocks are covered with moss and lichens. After each rain, water is drained from the surroundings into the canyon, where soils at the bottom are usually very wet and covered with moss.

Several types of habitats and microhabitats of the canyon were sampled for the study (Table 1). The samples were collected randomly in November 2009 (8 samples), May 2010 (4 samples) and January 2014 (13 samples), amounting to a total number of 25. Litter and soil were sampled by a metallic square frame of 25 cm^2 for 5 cm depth, each sample including 4 subsamples. Decaying wood, moss and lichens were taken additionally by hand. The winter 2013-2014 was very warm in Moldova and the first frosts began after our sampling within January, 2014, that could partly explain the richness of the collected fauna.

Extraction method and identification

The microarthropods were extracted from the soil using a modified flotation method (Fig. 2). A round plastic container of 1.8 litters and 22 cm in diameter was used for

Figure 1. Calcareous canyon on the bank of Dniester River near the locality of Vîșcăuți.

Table 1. The types of studied habitats and number of samples from the Vîşcăuți canyon.

Studied habitats	**Litter + soil**	**Soil**	**Litter**	**Lichen on wood**	**Moss on soil**	**Moss on rock**	**Barks of trees**	**Decaying wood**	**Number of samples**
	LS	S	L	LW	MS	MR	B	DW	
Bottom of the canyon	3	1		1	1	1			7
Forest on slopes	3	1				2	1	3	10
Trees above the canyon	2		3			1	1		7
Pasture		1							1
Number of samples	8	3	3	1	1	4	2	3	25

extraction. The container is compound of two elements with handles and a cap, the internal one being perforated by many holes (Fig. 2a). The sample to be extracted is put into the internal container and water is added in the containers (Fig. 2b) and they are covered with a cap (Fig. 2c). The soaking of the sample takes no more than 5–15 minutes depending on the soil structure (Fig. 2d) for getting Collembola out of the

Figure 2. Extraction of Collembola using flotation method (**a** plastic containers **b** filling the containers with sample and water **c** covering the containers **d** soaking the sample **e** collecting floating specimens under stereomicroscope).

substrate. Then container is shaken slowly several times and the sample is stirred with a spatula. This process done carefully allows the collembolan specimens to move up to the surface of the water. Neanuridae and Tullbergiidae need more time than others to break surface. The floating collembolan specimens are collected one by one by hand under binocular (Fig. 2e), using entomological needle or disposable syringe with the end of the needle curved.

Specimens were stored in 96% ethyl alcohol and counted. They were cleared in lactic acid and KOH and mounted on slides using Marc Andre II medium. Identification was mainly done with a phase contrast microscope LEICA 2500 equipped with camera Lucida, using the standard determination keys and recently published Synopses on Palaearctic Collembola (Bretfeld 1999; Potapov 2001; Thibaud et al. 2004; Dunger and Schlitt 2011; Jordana 2012).

Results and discussion

As a result of our survey, 63 species of Collembola belonging to 41 genera and 12 families were found in the Vîşcăuţi canyon. The family Entomobryidae was represented by 14 species, followed by the families Isotomidae – 13, Tullbergiidae – 9, Neanuridae – 8, Hypogastruridae – 6, Onychiuridae – 4, Neelidae and Odontellidae – 2 species, Tomoceridae, Arrhopalitidae, Katiannidae, Dicyrtomidae and Sminthurididae with one species each (Table 2). One genus – *Appendisotoma* Stach, 1947 and four species – *Jevania fageticola* Rusek, 1978, *Appendisotoma abiskoensis* (Ågrell, 1939), *Appendisotoma absoloni* Rusek, 1966 and *Folsomia volgensis* Martynova, 1967 are new for the Republic of Moldova.

The first study concerning collembolan fauna of calcareous canyons near the localities Lalova, Ţipova, Saharna, Vîşcăuţi and Butuceni with similar ecological settings recorded 56 species (Buşmachiu 2011a). One additional species was included in the next paper (Buşmachiu 2011b).

The present research increases the number of Collembola species revealed from the calcareous canyons of the Republic of Moldova from 57 to 98, which belong to 49 genera and 15 families. In Vîşcăuţi were recorded 63 species, in other four localities 73. Only 38 species were shared by Vîşcăuţi and the other canyons. Because none of the species of the canyons are considered local micro-endemics, this high divergence in faunal composition may result from important differences in sampled habitats.

The comparison with canyons of Lalova, Ţipova, Saharna and Butuceni (below named as "other canyons" – OC) revealed that contribution of the different Collembolan families to local biodiversity was similar, with the dominance of two families (Table 2): Entomobryidae with 21 species (14 species in Vîşcăuţi and 17 in OC) and Isotomidae with 17 species (13 and 11). They are followed by the families Tullbergiidae with 14 species (9 and 9), Neanuridae with 12 species (8 and 10), Hypogastruridae with 9 species (6 and 5) and Onychiuridae with 8 species (4 and 7). Two families comprised three species: Tomoceridae (1 and 2) and Katiannidae (1 and 3); four families – two species: Odontellidae (2 and 1), Neelidae (2 and 2), Dicyrtomidae (1 and 2) and Cyphoderidae (0 and 2); other three families, Sminthurididae, Sminthuridae and Arrhopalitidae were represented by one species each. The family Arrhopalitidae missed in the other canyons, while Cyphoderidae and Sminthuridae were not found in Vîşcăuţi (Table 2).

The distribution and ecology of the most interesting and rare taxa through the country is commented below.

Among the Collembola collected in the canyons, the family Hypogastruridae includes 9 species and 4 genera. In the Republic of Moldova the genus *Xenylla* is represented by seven species (Buşmachiu and Weiner 2008). Five of them were present in studied canyons. Populations of this genus are usually represented by numerous specimens in moss, litter and sometimes on the bark of trees. Though all species are largely distributed in Europe, their distribution among studied canyons differs greatly, with only one species shared by Vîşcăuţi and other canyons. This may point again to differences in sampled habitats.

The family Neanuridae was represented by 12 species from 7 genera. The most interesting and most diversified among them are Neanurinae, all linked to litter and decaying wood in Moldova, with two species probably endemic for the country (*Lathriopyga nistru* and *Neanura moldavica*), and one species originally described as endemic of Crimea (*Endonura gracilirostris*) (Buşmachiu and Deharveng 2008; Buşmachiu et

Table 2. Collembolan species found in the studied canyons. * – species new for the fauna of the Republic of Moldova; OC – other studied canyons; O – biogeographic occurrence (C – cosmopolitan, E – European, H – Holarctic, P – Palaearctic, M – Mediterranean, R – endemic); LF – life forms (e – epiedaphic, h – hemiedaphic, eu – euedaphic); abbreviations for habitats are given in Table 1.

Taxon	Number of specimens		Habitats	LF	O
	Vîscăuţi	OC			
Hypogastruridae					
Ceratophysella engadinensis (Gisin, 1949)	2 ex.	7 ex.	L	e	C
Ceratophysella sp. juv.	1 ex.		DW	e	-
Hypogastrura manubrialis (Tullberg, 1869)	2 ex.		L	e	C
Schoettella ununguiculata (Tullberg, 1869)		5 ex.	L	e	H
Xenylla boerneri (Axelson, 1905)	24 ex.		B, MR, DW	h	E
Xenylla brevisimilis brevisimilis Stach, 1949		23 ex.	L, LS, LW	h	E
Xenylla corticalis Börner, 1901	19 ex.		MS, DW	h	E
Xenylla maritima Tullberg, 1869	8 ex.	10 ex.	L, LS	h	C
Xenylla uniseta Gama, 1963		12 ex.	MR	h	M
Neanuridae					
Friesea mirabilis (Tullberg, 1871)		7 ex.	L	h	C
Deutonura albella (Stach, 1920)	1 ex.	5 ex.	DW	h	E
Deutonura stachi (Gisin, 1952)		4 ex.	L	h	E
Endonura gracilirostris Smolis, Skarżyński, Pomorski & Kaprus', 2007	2 ex.	1 ex.	DW	h	E
Lathriopyga nistru Buşmachiu, Deharveng & Weiner, 2010	3 ex.	10 ex.	L, DW	h	R
Neanura moldavica Buşmachiu & Deharveng, 2008	11 ex.	15 ex.	L, DW	h	R
Neanura minuta Gisin, 1963		1 ex.	DW	h	E
Neanura muscorum (Templeton, 1835)	2 ex.		L, DW	h	C
Micranurida pygmaea Börner, 1901	7 ex.	4 ex.	L, MS, MR, DW	eu	C
Pseudachorutes parvulus Börner, 1903	35 ex.		L	e	E
Pseudachorutes pratensis Rusek, 1973		1 ex.	L	e	E
Pseudachorutes subcrassus Tullberg, 1871	5 ex.	6 ex.	L, MR, DW	e	P
Odontellidae					
Axenyllodes bayeri Kseneman, 1935	3 ex.		S	eu	E
Superodontella montemaceli Arbea & Weiner, 1992	1 ex.	1 ex.	L	h	E
Onychiuridae					
Dimorphaphorura irinae (Thibaud & Taraschuk, 1997)	3 ex.		S	eu	E
Kalaphorura paradoxa (Schäffer, 1900)		~ 47 ex.	L, S	eu	E
Micraphorura uralica (Khanislamova, 1986)	13 ex.	25 ex.	L, S	eu	P
Protaphorura armata (Tullberg, 1869)		7 ex.	S	eu	C
Protaphorura pannonica (Haybach, 1960)		3 ex.	S	eu	E

Taxon	**Number of specimens**		**Habitats**	**LF**	**O**
	Vîscăuți	**OC**			
Protaphorura sakatoi (Yosii, 1966)	79 ex.	~ 37 ex.	S, L, MS	eu	E
Protaphorura subarmata (Gisin, 1957)	103 ex.	~ 59 ex.	S, L, MS	eu	E
Thalassaphorura tovtrensis (Kaprus' & Weiner, 1994)		81 ex.	L, S	eu	E
Tullbergiidae					
Doutnacia xerophila Rusek, 1974	4 ex.	6 ex.	S	eu	E
**Jevania fageticola* Rusek, 1978	3 ex.		S	eu	E
Jevania weinerae Rusek, 1978		3 ex.	L	eu	E
Karlstejnia rusekiana Weiner, 1983	1 ex.		S	eu	E
Mesaphorura critica Ellis, 1976	21 ex.	5 ex.	S, LW	eu	P
Mesaphorura florae Simón, Ruiz, Martin & Luciáñez, 1994	6 ex.		S	eu	E
Mesaphorura jarmilae Rusek, 1982	1 ex.		S	eu	E
Mesaphorura hylophila Rusek, 1982	4 ex.	9 ex.	S	eu	P
Mesaphorura italica (Rusek, 1971)		2 ex.	S	eu	P
Mesaphorura krausbaueri Börner, 1901		7 ex.	S	eu	P
Mesaphorura macrochaeta Rusek, 1976	1 ex.		S	eu	C
Mesaphorura sylvatica (Rusek, 1971)		2 ex.	S	eu	P
Mesaphorura yosii (Rusek, 1967)		6 ex.	S	eu	C
Metaphorura affinis (Börner, 1902)	1 ex.	2 ex.	S	eu	P
Isotomidae					
**Appendisotoma abiskoensis* (Ågrell, 1939)	24 ex.		L	e	E
**Appendisotoma absoloni* Rusek, 1966 juv.	15 ex.		L	e	E
Folsomia quadrioculata (Tullberg, 1871)	11 ex.	~ 26 ex.	L	h	H
Folsomia manolachei Bagnall, 1939	7 ex.	7 ex.	L	h	P
Folsomia penicula Bagnall, 1939		11 ex.	L, MR	h	P
**Folsomia volgensis* Martynova, 1967	27 ex.		L	h	P
Folsomides angularis (Axelson, 1905)		7 ex.	LS	h	H
Folsomides marchicus (Frenzel, 1941)		37 ex.	LS	h	E
Folsomides parvulus Stach, 1922	3 ex.	~75 ex.	LS	h	C
Desoria olivacea (Tullberg, 1871)	1 ex.		L	e	H
Isotoma riparia (Nicolet, 1842)	1 ex.		B	e	E
Isotoma viridis Bourlet, 1839	14 ex.	18 ex.	L, MR	e	H
Isotomiella minor (Schäffer, 1896)	9 ex.	13 ex.	L, MS, DW	eu	H
Isotomodes productus (Axelson, 1906)	1 ex.	12 ex.	LS	eu	C
Parisotoma notabilis (Schäffer, 1896)	58 ex.	~124 ex.	LS, MR, MS, DW	h	C
Proisotomodes bipunctatus (Axelson, 1903)		~ 23 ex.	DW	h	E
Vertagopus sp.	2 ex.		L	e	-

Taxon	**Number of specimens**		**Habitats**	**LF**	**O**
	Vîscăuți	**OC**			
Entomobryidae					
Heteromurus major (Moniez, 1889)	5 ex.	~ 15 ex.	L	e	M
Heteromurus nitidus (Templeton, 1835)		3 ex.	MR	e	C
Entomobrya nigrocincta Denis, 1923		2 ex.	L	e	E
Entomobrya marginata Tullberg, 1871	21 ex.		MS, L, B	e	E
Entomobrya multifasciata (Tullberg, 1871)	2 ex.	5 ex.	M	e	H
Entomobrya nivalis (Linnaeus, 1758)	2 ex.		Moss	e	C
Lepidocyrtus curvicollis Bourlet, 1839	1 ex.		L	e	H
Lepidocyrtus gr. *lignorum* (Fabricius, 1775)	56 ex.	~ 38 ex.	L	e	H
Lepidocyrtus paradoxus Uzel, 1890		4 ex.	L, MR	e	H
Lepidocyrtus violaceus Lubbock, 1873		7 ex.	L	e	H
Orchesella cincta (Linnaeus, 1758)		1 ex.	L	e	H
Orchesella maculosa Ionesco, 1915	7 ex.	3 ex.	MR	e	E
Orchesella multifasciata Stscherbakow, 1898	2 ex.	4 ex.	L, MR	e	E
Orchesella orientalis Stach, 1960		2 ex.	MR	e	E
Orchesella pseudobifasciata Stach, 1960	37 ex.	4 ex.	M, L	e	E
Orchesella xerothermica Stach, 1960	4 ex.		L, MR	e	E
Pseudosinella horaki Rusek, 1985	24 ex.	~ 32 ex.	L, MS, DW	h	E
Pseudosinella imparipunctata Gisin, 1953	1 ex.	11 ex.	L	h	E
Pseudosinella moldavica Gama & Buşmachiu, 2002	3 ex.	28 ex.	L	h	E
Pseudosinella octopunctata Börner, 1901		18 ex.	L	h	C
Seira domestica (Nicolet, 1842)	1 ex.	1 ex.	L	e	E
Tomoceridae					
Pogonognathellus flavescens (Tullberg, 1871)		5 ex.	DW	h	H
Tomocerus minor (Lubbock, 1862)		2 ex.	L	h	C
Tomocerus vulgaris (Tullberg, 1871)	2 ex.		DW	h	C
Cyphoderidae					
Cyphoderus albinus Nicolet, 1842		3 ex.	L	eu	P
Cyphoderus bidenticulatus Parona, 1888		7 ex.	S, L	eu	M
Neelidae					
Megalothorax minimus Willem, 1900	8 ex.	12 ex.	L, S	eu	C
Neelus murinus Folsom, 1896	6 ex.	6 ex.	L, S	eu	C
Sminthurididae					
Sphaeridia pumilis (Krausbauer, 1898)	1 ex.	~21 ex.	L, MR	h	C
Arrhopalitidae					
Pygmarrhopalites sp.	3 ex.		DW	eu	-
Katiannidae					

Taxon	**Number of specimens**		**Habitats**	**LF**	**O**
	Vîscăuți	**OC**			
Sminthurinus aureus (Lubbock, 1862)	7 ex.	2 ex.	L	e	P
Sminthurinus elegans (Fitch, 1863)		4 ex.	L	e	E
Sminthurinus niger (Lubbock, 1868)		5 ex.	L	e	P
Sminthuridae					
Caprainea marginata (Schott, 1893)		2 ex.	L	e	P
Dicyrtomidae					
Dicyrtoma minuta (Fabricius, 1763)	1 ex.	1 ex.	L, MR	e	E
Ptenothrix leucostrigata Stach, 1957		2 ex.	L	e	E
Total number of species: 98	**63**	**73**			

al. 2010; Smolis et al. 2007). These three species are frequent in all or most of the canyons. All are typical species for calcareous soils situated along the Dniester River, but are also present in the natural forest and under lower shrubs throughout the country (Buşmachiu 2008). *Neanura minuta*, of much larger distribution in Europe, is a very rare species in Moldova, only found in low number in the litter of the Saharna canyon (Buşmachiu 2011b).

In the calcareous canyons the family Onychiuridae was represented by 8 species from 5 genera. The species typical for calcareous soil – *Kalaphorura paradoxa* was found in every canyon covered with natural forest or rare lower shrubs except Vîşcăuți. Pomorski (1998) cited it as living in humid litter of mountains, under stones and pieces of wood: this is a rather different ecology, and suggests that two forms may be included under this species name. *Thalassaphorura tovtrensis* was found along a streamlet in Butuceni, i.e. in same ecological conditions as its occurrence outside Moldova (Kaprus' and Weiner 1994; Thibaud et al. 1999). The species *Micraphorura uralica* is widespread from Bashkiria in the south part of Ural Mountain (Khanislamova 1986) to Ukraine, and inhabits forest litter and moss on stone (Kaprus' and Weiner 1994, Kaprus' et al. 2002).

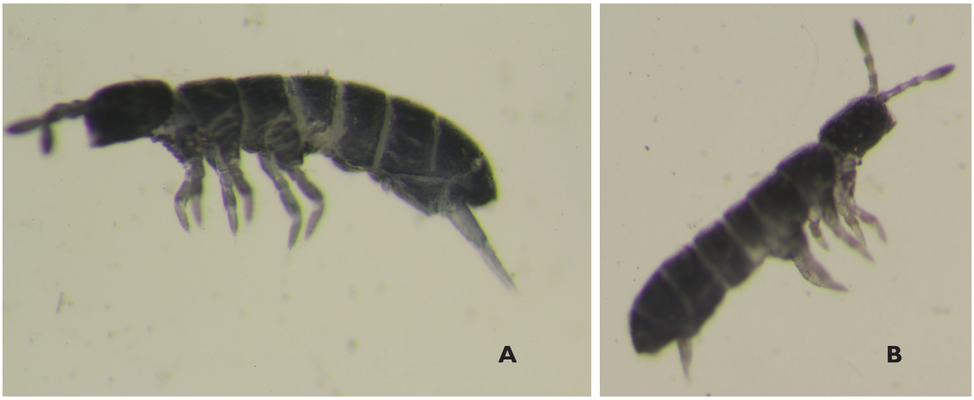
The smallest species of Poduromorpha belong to Tullbergiidae, which are well diversified in European soils. In Moldavian calcareous canyons, 14 species and 5 genera were collected. Among them, 5 species are only present in Vîşcăuți, while 5 are absent from this canyon, pointing once again to the originality of its faunal composition. Few species (4 out of 14) were present in Vîşcăuți and in OC. *Mesaphorura italica*, *M. macrochaeta*, *M. sylvatica* and *M. yosii* were especially observed in open habitats of calcareous canyons covered with low shrubs, and are not present in Vîşcăuți. The species *Mesaphorura jarmilae* and *Karlstejnia rusekiana*, only cited previously from the soils of natural deciduous forest, are here recorded in Vîşcăuți. The genus *Jevania* includes only two rare silvicolous species in Europe. Both of them inhabit the soils in Moldova, with *Jevania weinerae* only cited from calcareous soil of Lalova canyon (Buşmachiu and Weiner 2010) and *Jevania fageticola* cited from Vîşcăuţi (first record for Moldova). *Karlstejnia rusekiana* is a silvicolous euedaphic species described from a cave of southern Poland in beech and oak-hornbeam forest area (Weiner 1983) and cited from Ukrainian forest (Kaprus' et al. 2006).

Family Isotomidae was represented in the canyons by 17 species from 10 genera. The most speciose genera were *Folsomia* and *Folsomides*. The most interesting, and new for Moldova, was the genus *Appendisotoma*. *Folsomides angularis* and *F. marchicus* were present in some of the studied canyons, mostly in open habitat or under lower shrubs, but not found in Vîşcăuţi; they have a similar ecology in Europe (Potapov 2001). Species from genus *Folsomia* may inhabit several types of ecosystems, including disturbed ones. Four species of the genus were found in Moldavian calcareous canyons, of which one, *Folsomia volgensis*, is cited for the first time in the country. This species inhabits forest – steppe region in central part of the Palaearctic region, being common in dry forest biotopes (Potapov 2001) and is very rare in the Ukrainian fauna (Kaprus' et al. 2006). Two species of *Appendisotoma*, *A. abiskoensis* (Fig. 3A) and *A. absoloni* (Fig. 3B), were identified. Both are first records for Moldova, and so far restricted to Vîşcăuţi canyon where they were collected in January, in litter. The first species is considered rare, recorded in litter and moss near the streams (Potapov 2001) and also cited from the Ukrainian steppe (Kaprus' et al. 2006). *A. absoloni* is rather common in Czech deciduous forest, mostly abundant in autumn (Rusek 1968). Remarkably, these two species were collected in a same sample, both in large number.

The total number of Entomobryidae represented in the studied canyons was 21 species from 6 genera. Among species living preferentially in moss on limestone in Moldova are several *Orchesella* and *Entomobrya* species. One of them, *Orchesella maculosa* was found in most studied canyons and not in other ecological conditions. This species was first cited from calcareous places near caves in south-western Romania (Ionesco 1915), and then from meadows near the Dniester canyon of the Ukrainian part of the river (Chernobai et al. 2003).

The microhabitats of the studied locality are rich in rare species from families Isotomidae (*Appendisotoma abiskoensis*, *Appendisotoma absoloni*, *Folsomia volgensis*), Tullbergiidae (*Karlstejnia rusekiana*, *Jevania fageticola*) and Onychiuridae (*Dimorphaphorura irinae*), but poor in Symphypleona species. Symphypleona species are rare not only in microhabitats of calcareous canyons, but also in the riparian habitats exposed to periodical flooding on the bank of Dniester River (Buşmachiu and Weiner 2013). The species of this group, especially from the families Dicyrtomidae, Katiannidae and Sminthuridae, are abundant in the herbaceous plants of open habitats (Buşmachiu 2011b). Their rarity (3 species, versus 7 for OC) in our samples may result from a lack of favourable open habitats in Vîşcăuţi, but also by unadapted sampling techniques, as suggested by the abundance of Neelipleona and soil-dependent species of Symphypleona (*Sphaeridia pumilis*, *Sminthurinus aureus*, *Pygmarrhopalites* sp.).

The Dniester flows through Ukraine and Moldova. It is therefore not surprising that more than 90 collembolan species revealed in our study are shared with Ukraine.



Figures 3. A *Appendisotoma abiskoensis* **B** *Appendisotoma absoloni*.

The analysis of collembolan species from studied calcareous canyons brings new information on the peculiarities of species distribution and on their ecological preferences. Of special interest is the fact that, for several families, a large proportion of the species are not shared by Vîşcăuţi and other canyons. This may be due to differences more important than estimated at first sight that may exist in sampled habitats.

The three classical morpho-functional groups of epiedaphic, hemiedaphic and euedaphic were represented by a quite similar number of species, i.e. 35 epiedaphic, 31 hemiedaphic, and 32 euedaphic (Table 2). These groups differ in dispersal ability and other life traits such as reproduction, mobility, metabolic activity and feeding behaviour (Hopkin 1997). In our dataset, they usually match the vertical gradient from surface to deep soil. So the petrophyte ecosystems covered by natural forest, with moss and decayed wood, provide diversified micro-microhabitats to a large diversity in each of these three functional groups.

The most part of identified species in the calcareous canyons have a wide occurrence (Fig. 4). Between them 43.3% have European, 20.7% – cosmopolitan, 15.3% – Palaearctic and 13.4% – Holarctic distribution. Only three species have Mediterranean distribution and two species were described from the Republic of Moldova; for the description of two other species, supplementary material is needed.

Conclusions

With a total of 98 species of Collembola in 49 genera and 15 families, the fauna of the calcareous canyons of Moldova can be qualified of rich, though comparative data are lacking in other areas. Enlarging the spectrum of sampled habitats and collecting techniques (pitfall, berlesing, beating vegetation) will probably increase significantly this number, especially for Symphypleona. A second important result is the large differences in the composition of fauna between canyons. It is suggested that the relative importance of open versus forest habitats may explain most of these differences. At least, the presence

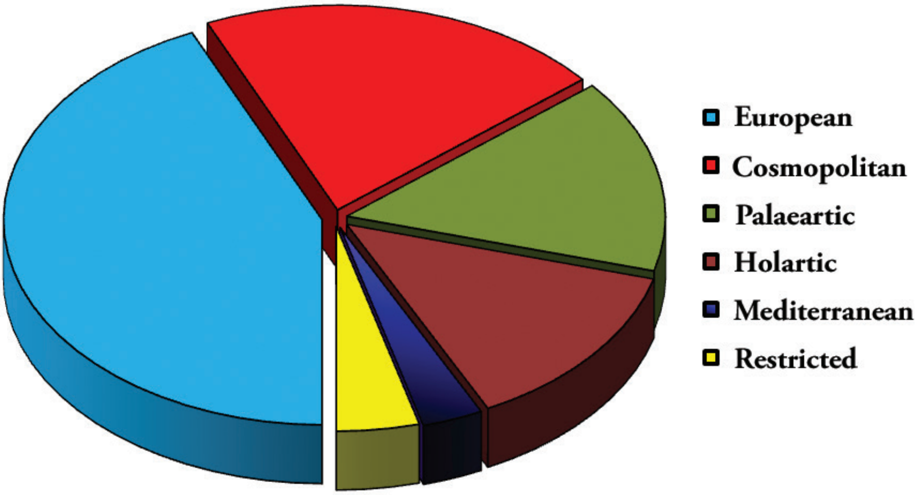


Figure 4. Percentage of identified collembolan species per biogeographical categories in the studied calcareous canyons.

of rare and even of a few endemic species may be noticed, giving a further interest to this Collembolan fauna of calcareous habitats. Additional sampling is currently carried out to check whether the originality of Vîşcăuți is real or an effect of sampling bias.

Acknowledgements

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RESEARCH ARTICLE

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Revision of the Oriental genus *Horniella* Raffray (Coleoptera, Staphylinidae, Pselaphinae) – Supplementum 1

Zi-Wei Yin[1], Li-Zhen Li[1]

[1] *Department of Biology, College of Life and Environmental Sciences, Shanghai Normal University, 100 Guilin Road, Shanghai, 200234, P. R. China*

Corresponding author: *Li-Zhen Li* (lizhenli@shnu.edu.cn)

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Abstract

Two new species of the genus *Horniella* Raffray are described from China: *H. aculeata* **sp. n.** (Yunnan Province) and *H. jinggangshana* **sp. n.** (Jiangxi Province). *Horniella nakhi* Yin & Li is recorded from a new locality. Three potentially new species from Myanmar and China, each represented by female specimen(s) only, are left unnamed. Their collecting data are given, and the genital complex figured for future comparison.

Keywords

Pselaphinae, *Horniella*, new species, new record, China, Myanmar

Introduction

Since the publication of our revision of the genus *Horniella* Raffray (Yin and Li 2014), we have had the opportunity to examine additional material collected in China and Myanmar. A study of this material revealed two new species, a new locality for *Horniella nakhi* Yin & Li, and the first record of the genus from Myanmar. The material also includes three possibly different species represented only by females that are kept unnamed until associated males become available in the future.

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Material and methods

The methods, terminology, and abbreviations applied are the same as in Yin and Li 2014. Authors' supplementary notes are included in brackets.

Material treated in this study is housed in the following public institution and museums:

MSNG	Museo Civico di Storia Naturale "Giacomo Doria", Genova, Italy (Roberto Poggi);
NSMT	National Museum of Nature and Science, Tokyo, Japan (Shûhei Nomura);
SNUC	Insect Collection of the Shanghai Normal University, Shanghai, China (Zi-Wei Yin).

Species treatment

Horniella aculeata Yin & Li, sp. n.

http://zoobank.org/2E67E322-EC41-4D79-8166-CAD99F352B77

Figs 1A, 2, 5A

Type material (2 ♂♂, 4 ♀♀)**. Holotype: China:** ♂, labeled 'Mengla Ziranbaohuqu {勐腊自然保护区}, (Xishuangbanna) {西双版纳}, S. Yunnan, China, Sept. 13th, 1993, Coll. Y. Watanabe / HOLOTYPE {red} ♂, *Horniella aculeata* sp. n., det. Yin & Li, 2015, NSMT' (NSMT). **Paratypes: China:** 3 ♀♀, same label data as holotype (NSMT); 1 ♂, 1 ♀, labeled 'Tropical Rainforest (Tropical Botanical Garden) {热带植物园}, Menglun {孟仑}, Mengla County {勐腊县} / (Xishuangbanna), S. Yunnan, China, Oct. 29th, 1992, Coll. Y. Watanabe.' (SNUC). Each paratype bears a type label as: 'PARATYPE {yellow} ♀ {or ♂}, *Horniella aculeata* sp. n., det. Yin & Li, 2015, NSMT {or SNUC}'.

Description. Male (Fig. 1A). Length 2.95–3.0 mm. Head slightly wider than long, HL 0.54–0.58 mm, HW 0.61–0.62 mm; anterolateral genal projections (Fig. 2C) distinct, anterior margins evenly concave; median sulcus between antennal tubercles short and deep; scapes (Fig. 2B) acutely expanded at basolateral margins; clubs (Fig. 2A) loosely formed by apical three moderately enlarged antennomeres; head venter with pair of short, strongly curved lateral spines (Fig. 2D). Maxillary palpomeres II stout, broadened at middle. Each eye composed of about 30 facets. Pronotum slightly longer than wide, PL 0.63–0.64 mm, PW 0. 59–0. 61 mm. Elytra wider than long, EL 0.82–0.85 mm, EW 1.23–1.25 mm; discal striae reaching apical 2/3 of elytral length. Protrochanters and profemora (Fig. 2E) each with one distinct ventral spine, protibiae (Fig. 2F) with mesal margins strongly arcuate at apical half, with large sharp spine at mesal margin near middle; mesotrochanters (Fig. 2G) each with one short, blunt ventral protuberance, mesofemora simple, mesotibiae (Fig. 2H) simple; tarsomeres II normal, not extending to beneath tarsomeres III. Abdomen large, AL 0.94–0.95 mm, AW 1.19–1.26 mm; tergite IV (first visible tergite) with median carina extending to half

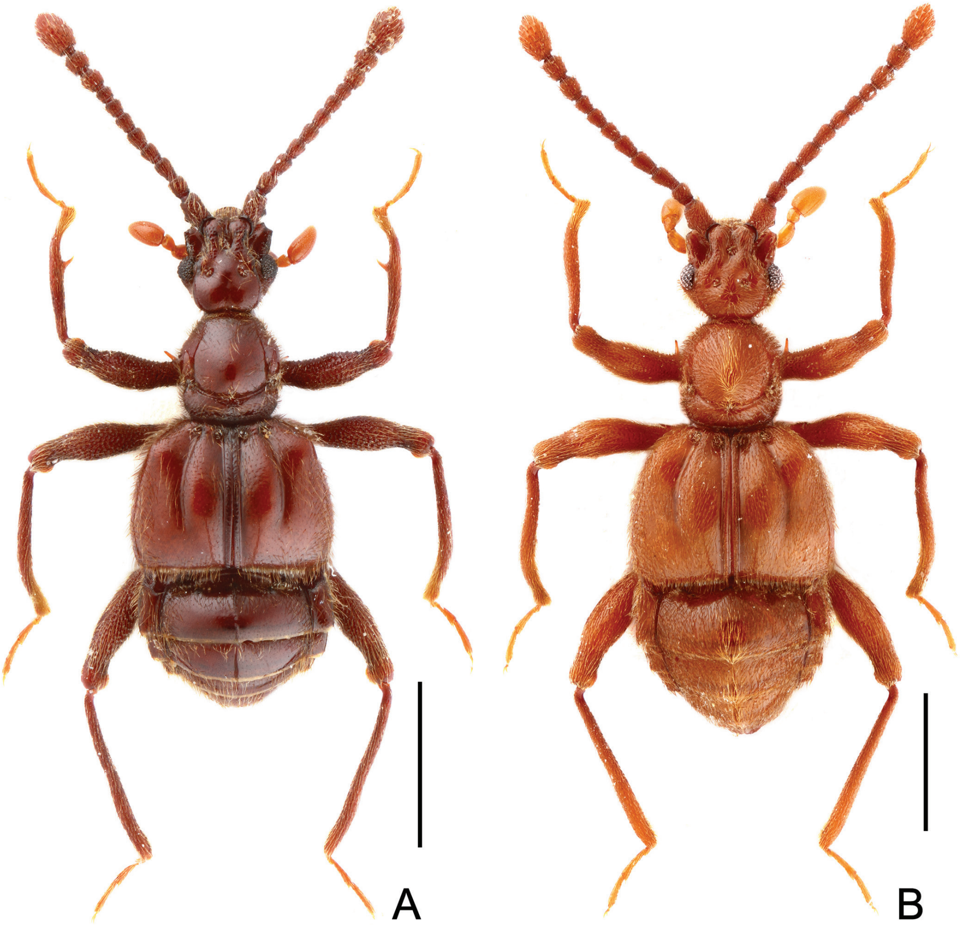

Figure 1. Male habitus of *Horniella* species. **A** *H. aculeata* **B** *H. jinggangshana*. Scales: 1.0 mm.

tergal length or slightly more, lateral discal carinae short; tergite V lacking median carina. Sternite IX (Fig. 2I) nearly oval, with well-sclerotized apical half and membranous basal half. AeL 0.62 mm; aedeagus (Fig. 2J–L) with slightly asymmetric median lobe slightly curved rightwards in dorso-ventral view; endophallus composed of one conspicuously long, partly membranous, and twisted sclerite with pointed, curved apex.

Female. Similar to male in general appearance; scapes not expanded at basolateral margins; each eye composed of about 25 facets; profemora each with two subequal ventral spines near base, protibiae lacking spine, not strongly arcuate at apical half; mesotrochanters lacking ventral spine. BL 2.81–2.94 mm, HL 0.65–0.69 mm, HW 0.57–0.58 mm, PL 0.62–0.63 mm, PW 0.59–0.61 mm, EL 0.70–0.74 mm, EW 1.12–1.16, AL 0.84–0.88 mm, AW 1.22–1.23 mm. Genital complex (Fig. 5A) 0.36 mm wide, with slightly sclerotized, transverse apical portion, and with membranous, elongate basal portion.

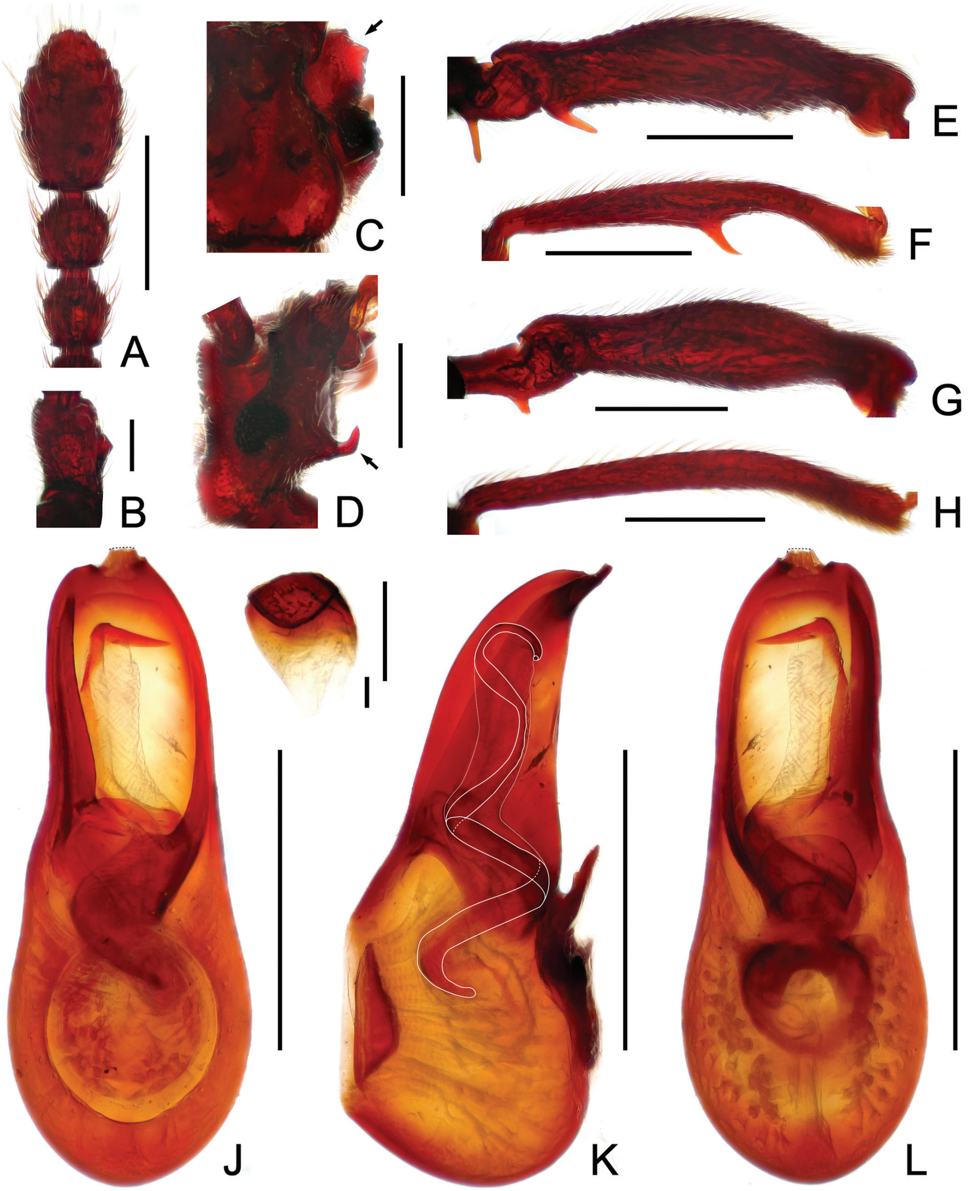

Figure 2. Male diagnostic features of *Horniella aculeata* **A** antennal club **B** scape **C** right half of the head, in dorsal view **D** head, in lateral view **E** protrochanter and profemur **F** protibia **G** mesotrochanter and mesofemur **H** mesotibia **I** sternite IX **J** aedeagus, in dorsal view **K** same, in lateral view **L** same, in ventral view. Scales: all = 0.3 mm, except **B, I** = 0.1 mm.

Differential diagnosis. The new species is placed as a member of the *H. burckhardti* group (for diagnoses of species-groups refer to Yin and Li 2014). Males of *Horniella aculeata* have the aedeagal endophallus composed of one elongate sclerite, similar to that of *H. hongkongensis* Yin & Li. The two species can be readily separated by 1) the more distinct and acute protuberance on the mesal margins of the scapes, 2) the oblique ventral spine at base of the profemora, and 3) the presence of a large, sharp spine on the mesal margins of the protibiae in *H. aculeata*. In *Horniella*, the presence of a spine on the mesal margin of the protibiae only occurs in *H. simplaria* Yin & Li which belongs to the *H. hirtella* group, otherwise the two species are easily separable from each other.

Distribution. Southwestern China: Yunnan.

Etymology. The specific epithet refers to the acute spine on the protibia.

Horniella jinggangshana Yin & Li, sp. n.

http://zoobank.org/F79959DA-392F-42A1-86BA-BF8F0C1172BC
Figs 1B, 3, 5B–C

Type material (1 ♂, 2 ♀♀). **Holotype: China:** ♂, labeled 'China: W. Jiangxi, Ji'an City, Jinggang Shan N. R. {井冈山自然保护区}, Shuikou {水口}, 26°32'42"N, 114°06'03"E, mixed leaf litter, sifted, 790–900 m, 30.vii.2014, J.Y. Hu / HOLOTYPE {red} ♂, *Horniella jinggangshana* sp. n., det. Yin & Li, 2015, SNUC' (SNUC). **Paratypes: China:** 2 ♀♀, same label data as holotype (SNUC). Each paratype bears a following label: 'PARATYPE {yellow} ♀, *Horniella jinggangshana* sp. n., det. Yin & Li, 2015, SNUC'.

Description. Male (Fig. 1B). Length 3.67 mm. Head as long wide, HL 0.75 mm, HW 0.75 mm; anterolateral genal projections (Fig. 3C) distinct, anterior margins slightly concave; median sulcus between antennal tubercles short and moderately deep; scapes (Fig. 3B) angularly expanded at basolateral margins; clubs (Fig. 3A) loosely formed by apical three moderately enlarged antennomeres; venter with pair of markedly long, curved lateral spines (Fig. 3D). Maxillary palpomeres II stout, broadened at middle. Each eye composed of about 35 facets. Pronotum slightly longer than wide, PL 0.76 mm, PW 0.72 mm. Elytra wider than long, EL 0.94 mm, EW 1.46 mm; discal striae reaching more than apical 2/3 of elytral length. Protrochanters and profemora (Fig. 3E) each with one distinct ventral spine, protibiae (Fig. 3F) each with short apical protuberance; mesotrochanters (Fig. 3G) each with one big ventral spine, mesofemora simple, mesotibiae (Fig. 3H) with small preapical denticles and short apical projection; tarsomeres II normal, not extending to beneath tarsomeres III. Abdomen large, AL 1.22 mm, AW 1.41 mm; tergite IV (first visible tergite) with short median carina, lacking lateral discal carinae; tergite V lacking median carina. Sternite IX (Fig. 3I) nearly oval, with well-sclerotized apical half and membranous basal half. AeL 0.82 mm; aedeagus (Fig 3J–L) with left half of median lobe greatly protruding in dorso-ventral view; endophallus composed of three long, curved sclerites.

Female. Similar to male in general appearance; scapes not expanded at basolateral margins; each eye composed of about 35 facets; profemora each with two subequal ventral spines near base, protibiae lacking preapical protuberance; mesotrochanters

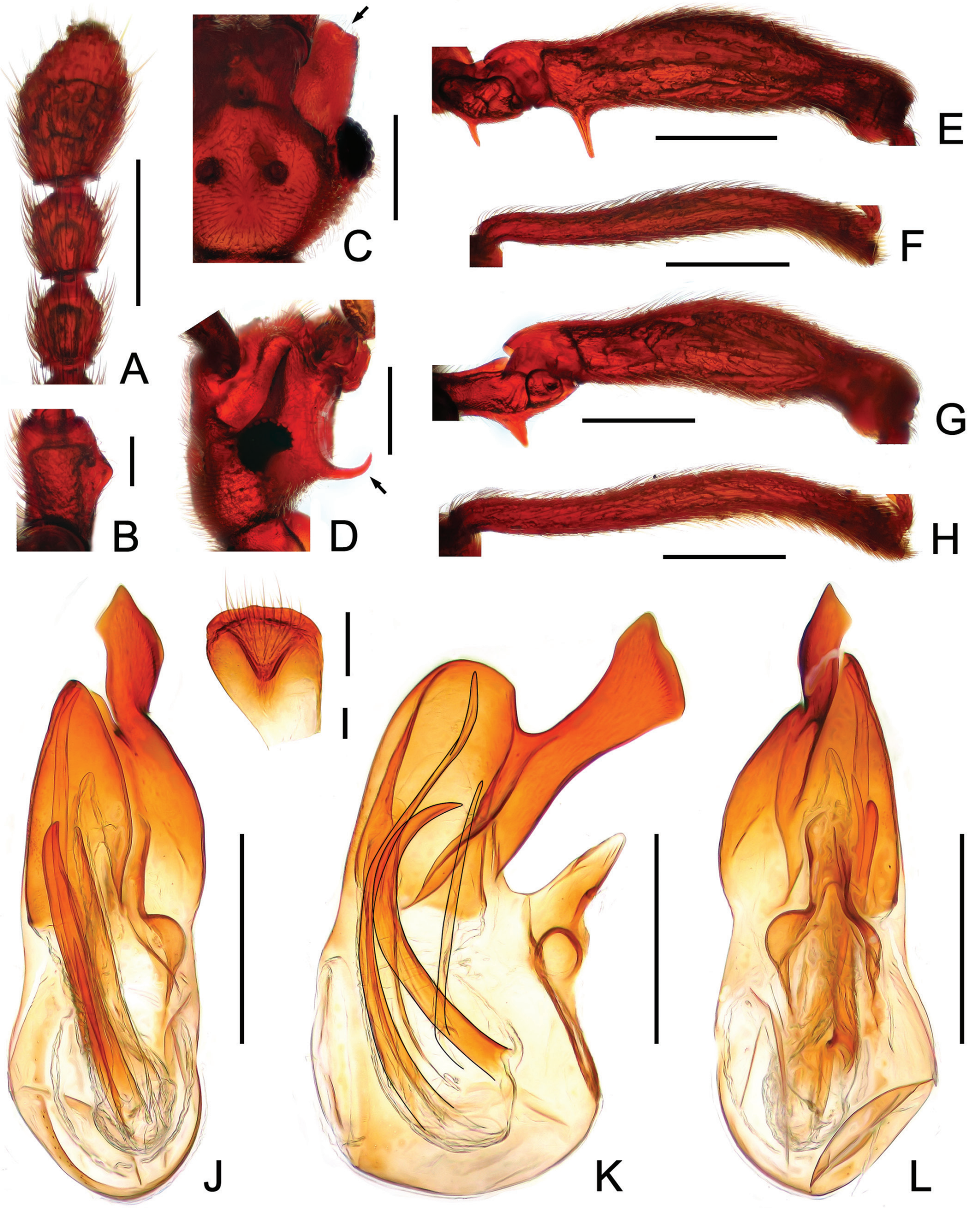

Figure 3. Male diagnostic features of *Horniella jinggangshana* **A** antennal club **B** scape **C** right half of the head, in dorsal view **D** head, in lateral view **E** protrochanter and profemur **F** protibia **G** mesotrochanter and mesofemur **H** mesotibia **I** sternite IX **J** aedeagus, in dorsal view **K** same, in lateral view **L** same, in ventral view. Scales: all = 0.3 mm, except **B**, **I** = 0.1 mm.

lacking ventral spine, mesotibiae lacking apical projection; tergite VII with posterior margin protruding at middle. BL 3.53–3.58 mm, HL 0.65–0.69 mm, HW 0.66–0.72 mm, PL 0.66–0.70 mm, PW 0.65–0.66 mm, EL 0.92–0.93 mm, EW 1.30–1.37, AL

1.26–1.30 mm, AW 1.33–1.34 mm. Genital complex (Fig. 5B–C) 0.43 mm wide, with broad apical portion, and coil-shaped basal portion.

Differential diagnosis. The new species is placed as a member of the *H. centralis* group. Its closest congener is probably *H. falcis* Yin & Li, which is known from a single female. The females of these two species share a similar habitus, the protruding posterior margin of tergite VII, and a similar form of the genital complex. They can be tentatively separated by the less protruding posterior margin of tergite VII, the broader genital complex in dorsal-ventral view in *Horniella jinggangshana*, and their distributions (straight line distance of separation measures ca. 710 km). The males of *Horniella jinggangshana* can be readily separated from all other congeners by the unique form of the aedeagus and structure of the endophallus.

Distribution. Eastern China: Jiangxi.

Etymology. The new species is named after its type locality, the Jinggang Shan Nature Reserve.

Horniella nakhi Yin & Li

Fig. 5D–E

Horniella nakhi Yin & Li, 2014: 25.

Material examined. 1 ♂, 1 ♀, labeled 'Mt. Jizu Shan {鸡足山, ca. 25°58'N, 100°23'E } (2130 m), Binchuan {宾川县}, NW Yunnan, China, 25.X.1995, Coll. Y. Watanabe & Xiao N. / *Horniella nakhi* Yin & Li, 2014, det. Z.W. Yin, 2015' (NSMT).

Distribution. This species was known from one male and two females collected in Naxi Autonomous County. The present record extends its distribution to the Jizu Mountain, ca. 90 km south from the type locality.

Comments. The population from Jizu Mountain exhibits a stouter aedeagal form and different structure of the endophallus (Fig. 5D–E). These are attributed to intraspecific variation because all other male diagnostic features, e.g. the strongly projecting apical portion of the protibiae, seem quite stable.

Horniella sp. 1

Figs 4A, 5F, G

Material examined. 3 ♀♀, labeled 'Carin, Asciuii Chebà, 1200–1300 m, L. Fea. III-IV. {18}88. / Museo, Civico, di Genova; 1 ♀, same data, except for 'I - 88' (MSNG). Each specimen bears a following label: 'cf. *Horniella* sup. 1., *Horniella* sp. 1, det. Z.W. Yin, 2015'.

Measurements. Female (Fig. 4A). BL 3.70–3.78 mm, HL 0.80–0.81 mm, HW 0.72–0.73 mm, PL 0.76–0.78 mm, PW 0.74–0.75 mm, EL 1.0–1.02 mm, EW 1.48–1.52 mm, AL 1.11–1.20 mm, AW 1.59–1.60 mm. Each eye composed of about 38 facets. Width of genital complex 0.37 mm.

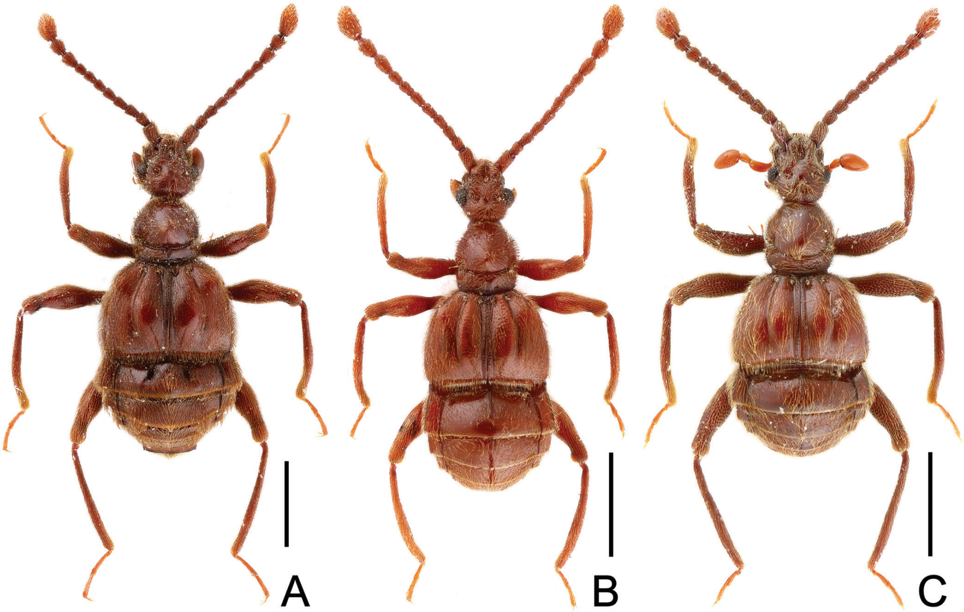

Figure 4. Male habitus of *Horniella* species. **A** *Horniella* sp. 1 **B** *Horniella* sp. 2 **C** *Horniella* sp. 3. Scales: 1.0 mm.

Distribution. Eastern Myanmar: Kayah State.

Comments. The large body size combined with the unique setation on tergite V (Fig. 5F) clearly indicates a new species. The female genital complex (Fig. 5G) is here illustrated for reference to future study.

Horniella sp. 2

Figs 4B, 5H

Material examined. 2 ♀♀, labeled 'Carin, Asciuii Chebà, 900–1100 m, L. Fea. V XII-{18}88. / Museo, Civico, di Genova / cf. *Horniella* sup. 1., *Horniella* sp. 2, det. Z.W. Yin, 2015' (MSNG).

Measurements. Female (Fig. 4B). BL 3.09 mm, HL 0.61–0.64 mm, HW 0.57–0.58 mm, PL 0.66–0.67 mm, PW 0.57–0.58 mm, EL 0.79–0.80 mm, EW 1.19–1.20 mm, AL 1.00–1.01 mm, AW 1.23–1.25 mm. Each eye composed of about 40 facets. Width of genital complex 0.33 mm.

Distribution. Eastern Myanmar: Kayah State.

Comments. This material represents the first record of the *Horniella hirtella* group in Myanmar. The form of the genital complex (Fig. 5H) is highly similar to that of *Horniella philippina* Yin & Li (Yin and Li 2014: fig. 49F), but the Myanmar population probably represents a different species insomuch as its distribution is considered, as well as the presence of a much longer median carina on tergite IV.

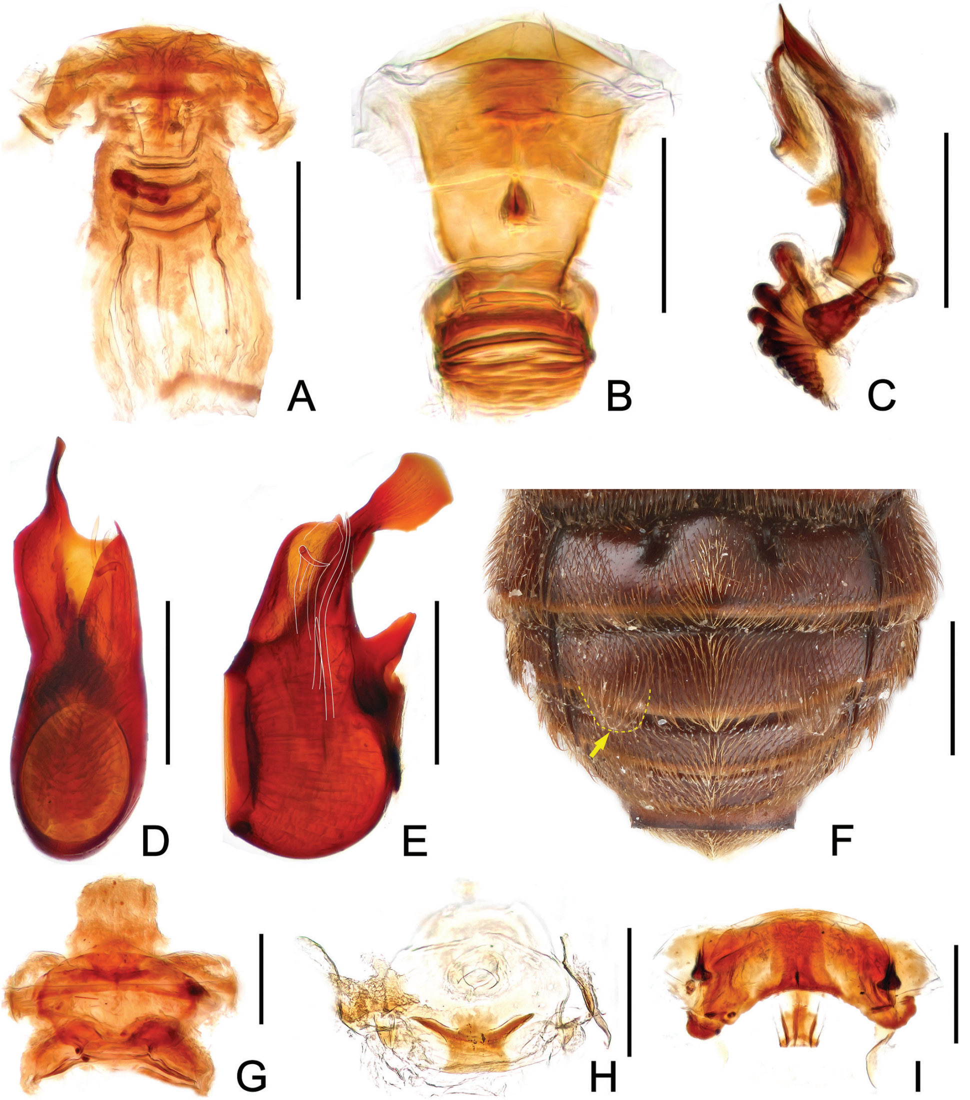

Figure 5. Details of *Horniella* species (**A** *Horniella aculeata* **B–C** *Horniella jinggangshana* **D–E** *Horniella nakhi* **F–G** *Horniella* sp. 1 **H** *Horniella* sp. 2 **I** *Horniella* sp. 3). **A, B, G, H, I** female genital complex, in dorsal view **C** same, in lateral view **D** aedeagus, in dorsal view **E** same, in lateral view **F** abdomen, in dorsal view. Scales: all = 0.2 mm, except **F** = 0.5 mm.

Horniella sp. 3

Figs 4C, 5I

Material examined. 1 ♀, labeled 'Guibeishan (450 m), (Tull.), Yaoshan Xiang, Libo Xian / [Guizhou, CHINA], 中国贵州省荔波县瑶山乡, 11.ix.1997, T. Kishimoto / cf. *Horniella* sup. 1., *Horniella* sp. 3, det. Z.W. Yin, 2015' (NSMT).

Measurements. Female (Fig. 4C). BL 3.15 mm, HL 0.74 mm, HW 0.60 mm, PL 0.66 mm, PW 0.64 mm, EL 0.81 mm, EW 1.31 mm, AL 0.94 mm, AW 1.32 mm. Each eye composed of about 22 facets. Width of genital complex 0.46 mm.

Distribution. Southwestern China: Guizhou.

Comments. The unique form of the genital complex and distribution of this female indicate a different species. Illustration of its genital complex (Fig. 5I) is provided for future comparison.

Acknowledgments

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RESEARCH ARTICLE

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The real identity of *Leptodira nycthemera* Werner, 1901 from Ecuador: a junior synonym of *Oxyrhopus petolarius* (Linnaeus, 1758) (Serpentes, Dipsadidae)

João Carlos Lopes Costa[1], Christoph Kucharzewski[2], Ana Lúcia da Costa Prudente[1,3]

1 *Museu Paraense Emílio Goeldi, Coordenação de Zoologia, Programa de Pós-Graduação em Zoologia, Av. Perimetral, 1901, Bairro Terra Firme, 66077-530, Belém, PA, Brazil* **2** *Museum für Naturkunde - Leibniz-Institut für Evolutions- und Biodiversitätsforschung, Invalidenstraße 43, 10115 Berlin, Germany* **3** *Museu Paraense Emílio Goeldi, Coordenação de Zoologia, Av. Perimetral, 1901, Bairro Terra Firme, 66077-530, Belém, PA, Brazil*

Corresponding author: *João Carlos Lopes Costa* (joaoclcosta@gmail.com)

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Abstract

Leptodira nycthemera Werner, 1901, was described from a specimen collected in Ecuador. No information on the holotype was published after its description. In the most recent review of *Leptodeira*, *L. nycthemera* was considered to be a synonym of *L. a. annulata*, although the author emphasized that the holotype was lost and did not include the pholidotic data from the original description in his account of *L. a. annulata*. Since this review, a number of authors have accepted this synonymy. Recently, analyzing specimens of *Leptodeira* in the Museum für Naturkunde, Berlin, Germany, we discovered the holotype of *Leptodira nycthemera*. This holotype is re-described here, and its correct identity is determined. Based on the analysis of meristic characters and the color of the holotype, we recognize *Leptodira nycthemera* as a junior synonym of *Oxyrhopus petolarius*.

Keywords

Leptodeira annulata annulata, new synonym, *Oxyrhopus petolarius*

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Introduction

Leptodira nycthemera was described by Werner (1901), based on a specimen collected in Ecuador by the German entomologist Richard Haensch. However, this original description lacks sufficient information for the definition of the species. The exact type locality also remains unknown, given that Haensch and his companion Edmund Schmidt travelled through large parts of cis- and trans-Andean central Ecuador (Haensch 1903, Racheli and Racheli 2001, 2003).

Subsequently, Werner (1913) described *Leptodira dunckeri* without defining a precise locality, which might be Mexico or Venezuela, and presented a key to the species of the genus that included *L. nycthemera*. Müller (1923) described *Leptodira weiseri* from Argentina, which differed from *L. nycthemera* by having a subocular scale, reduced number of ventral and subcaudal scales, in addition to a very distinctive color pattern. *L. weiseri* was subsequently considered to be a synonym of *Oxyrhopus rhombifer bachmanni* (Weyenberg, 1876) by Bailey (1970). Werner (1924) presented the second part of a survey of the snakes of the family Colubridae, including identification keys. As a valid species, *Leptodira nycthemera* is distinguished from all other Neotropical *Leptodira* taxa by the presence of an undivided anal scute.

Amaral (1930a) redefined *Leptodira dunckeri*, *L. nycthemera*, and *L. weiseri* as synonyms of *Leptodeira annulata*. However, while recognizing *Leptodira dunckeri* and *L. weiseri* as junior synonyms of *Leptodeira annulata annulata* (Linnaeus, 1758), Amaral (1930b) did not refer specifically to *L. nycthemera*.

In a review of the *Leptodeira* species of North America, Dunn (1936) presented a list of synonyms of *L. a. annulata*, in which *L. nycthemera* was not mentioned, referring only to *L. dunckeri* as a junior synonym of *Leptodeira septentrionalis maculata* (Hallowell, 1861). Taylor (1938), revising *Leptodeira* from Mexico, did not mention *L. nycthemera*, but recognized *L. dunckeri* as a valid species.

The name *L. nycthemera* reappeared in the most recent review of *Leptodeira*, presented by Duellman (1958). In this case, *L. nycthemera* was considered to be a junior synonym of *L. a. annulata*, although the author emphasized the fact that the holotype had been lost, and the pholidotic data from the original description were not included in the account of *L. a. annulata*. Subsequently, a number of authors (Peters 1960, Peters and Orejas-Miranda 1970, Kornacker 1999, Wallach et al. 2014) accepted the synonymy of *L. nycthemera*, even though no further information on the locality of the specimen or the morphological characteristics of the taxon have been provided, until now.

Recently, we discovered the *Leptodira nycthemera* holotype during the analysis of the *Leptodeira* specimens at the Museum für Naturkunde in Berlin, Germany. This specimen is redescribed here, and its taxonomic status is determined.

Material and methods

Measurements of the specimens are presented in millimeters, and were taken with a digital caliper and flexible ruler. The measurements of the head and cephalic scales have a precision of 0.1 mm, and those of the SVL and tail, a precision of 1 mm. The head length was defined as the distance between the rostral and the angle of the jaws. Head width is the widest point of the head at the level of the temporal scales.

The cephalic scales were counted on both sides (right/left) of the head and body (Peters 1964). Scales were measured based on the largest dimensions of the visible portion. Ventral scales were counted according to Dowling (1951a) and the formula for the reduction of the dorsal scale row was based on Dowling (1951b). We determined the sex of the specimen by the presence or absence of a hemipenis, inspected visually through a ventral incision at the base of the tail.

Results

The type specimen of *Leptodira nycthemera* Werner, 1901, is currently housed in the Museum für Naturkunde in Berlin, Germany, under catalog number ZMB 16596.

Redescription: The holotype is a juvenile female (Figure 1) as indicated by the presence of a distinctly recognizable umbilicar scar on ventral scales 174–175. The specimen is in a good state of preservation, with the following characters: **Folidosis**: loreal approximately twice as long as high; internasals approximately half the length of the prefrontals; frontal longer than wide; parietals longer than wide; preoculars 1 / 1, in contact with frontal; postoculars 2 / 2; supralabials 8 / 8, the fourth and fifth in contact with the orbit, sixth and seventh of approximately the same size; temporals 2 + 3 / 2 + 3; infralabials 10 / 10 [a lesion on left side of infralabial region did not affect the count of this character], first to fifth in contact with the anterior genials, fifth and sixth in contact with the posterior genials; two pairs of genials of nearly the same size; dorsal scales smooth, apical pits absent, 19 / 19 / 17 dorsal rows, reduction by fusion of dorsal scale rows 3 + 4, according to the formula:

$$19\,\frac{3+4\,(140)}{3+4\,(140)}\,17\,(205);$$

vertebral row not enlarged; 2 preventrals + 205 ventrals; anal scute undivided; 101 / 101 subcaudals + terminal spine. **Morphometric data**: Snout-vent length (SVL) = 200 mm; tail length = 64 mm; head length = 10.7 mm; head width = 6.6 mm; head height = 3.7 mm; horizontal eye diameter = 1.75 mm; distance from anterior margin of eye to nostril = 2.5 mm; frontal length = 3.4 mm; frontal width = 3.1 mm; parietal length = 4.2 mm; parietal width = 3.2 mm; anterior genials= 2.6 mm; posterior genials= 2.3 mm. **Proportions**: Ratio of tail length to total length = 32.5 %; ratio of head length to SVL= 5.35 %. **Color pattern in preservative:** The head is somewhat discolored but it is still possible to observe a dark area, as mentioned in the original description, which forms a hood covering the rostral, internasal, pre-frontal, frontal, and parietal scales; symphyseal and infralabials gray; occipital area white, starting at the supralabials, through the margins of the posterior parietal, and all occipitals; well preserved coloration of the body and tail, with clearly visible pigmentation, body with dark (black) bands, which extend to the edge of the ventral scales and are separated

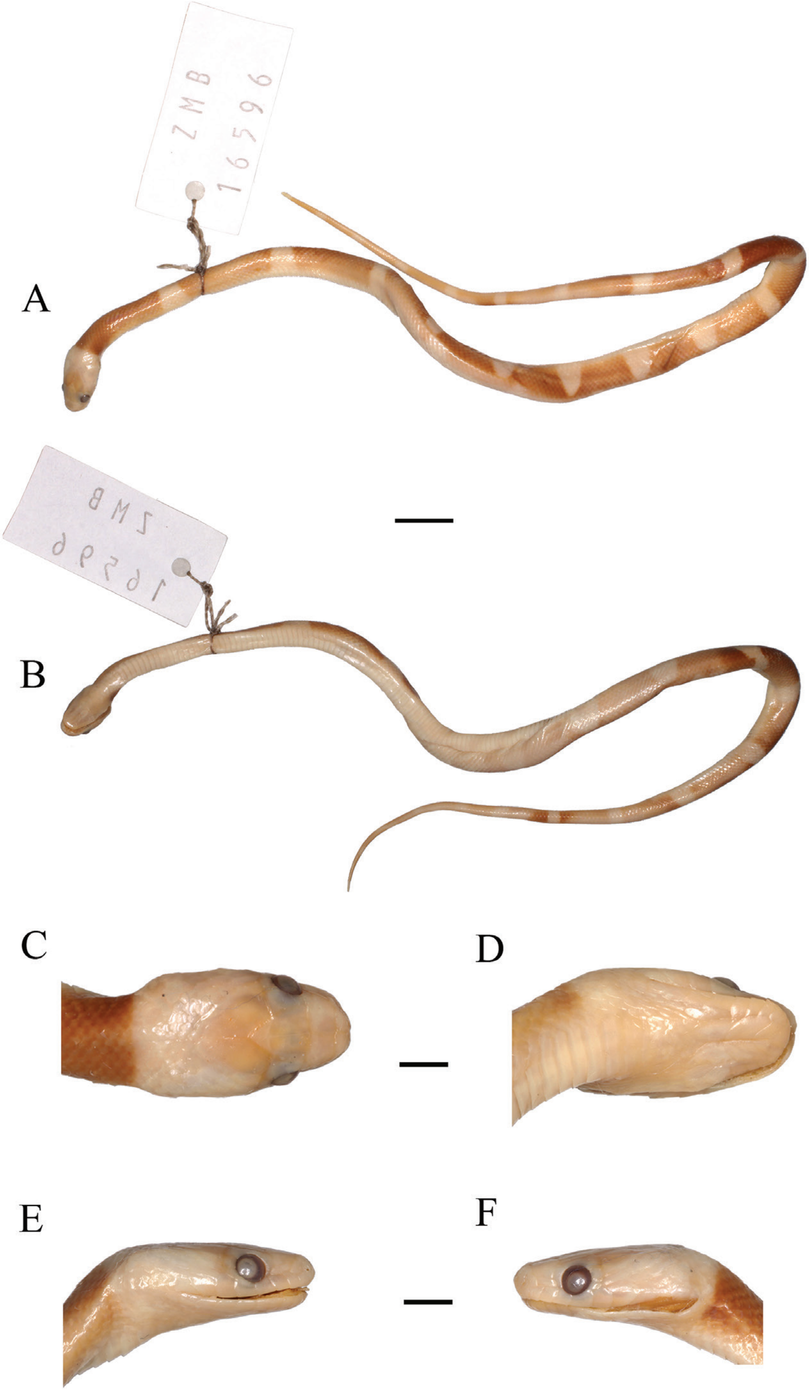

Figure 1. Holotype of *Leptodira nycthemera* Werner, 1901 (ZMB 16596). **A** dorsal view of the body **B** ventral view of the body **C** dorsal view of the head **D** ventral view of the head **E** right lateral view of the head, and **F** left lateral view of the head. Scale bar: 10 mm (**A, B**), 2.5 mm (**C–F**).

by light (white) bands; a pattern comprised of 12 + ½ black bands on the body and 6 + ½ on the tail, the bands merge starting at the fourth dorsal blotch forming a zigzag pattern, the dark bands are longer on the anterior portion of the body, and the three first are 19, 17, and 16 scales long on the vertebral line, respectively; ventrals and subcaudals scales are lightly colored (cream in preservative).

Discussion

The holotype presents the typical characters of species of the genus *Oxyrhopus* (Bailey 1970, Duellman 1958, 1978, Peters 1960, Savage 2002, Lynch 2009), including: (i) the absence of apical pits (*vs.* two in *Leptodeira*), (ii) 2 + 3 temporal scales (*vs.* 1 + 2 in *Leptodeira*), (iii) undivided anal scute (*vs.* divided in *Leptodeira*), (iv) lateral reduction of the dorsal scale rows (*vs.* vertebral or paravertebral reduction in *Leptodeira*), (v) black banding pattern that reaches the ventral scales (*vs* small saddle-shaped or ovoid blotches, reaching only the sixth or seventh dorsal row in the *Leptodeira* specimens from Ecuador). This diagnosis allowed us to exclude *L. nycthemera* from the genus *Leptodeira*.

The only species of *Oxyrhopus* from Ecuador that has the same color pattern and pholidosis as *L. nycthemera* is *Oxyrhopus petolarius* (Linnaeus, 1758). A number of characters of the holotype are consistent with or within the range of the data presented for female *O. petolarius* by Duellman (1978) and Lynch (2009). These are (i) the high number of ventrals (191–225) and subcaudals (77–112), (ii) the number of bands on the body (11 ½–13 ½), (iii) preocular contacting the frontal, and (iv) juvenile individuals of *O. petolarius* (< 300 mm body length) have a black head, white occipital region, black bands on the body wider than the light ones, and dislocated black bands in the dorsal midline, adjacent to the middle of the body, forming a zigzag pattern.

Based on the analysis of meristic characters and the color pattern of the redescribed holotype, we recognize *Leptodira nycthemera* as a junior synonym of *Oxyrhopus petolarius*. *Oxyrhopus petolarius* has the most ample geographic distribution of the species of the genus, occurring from Veracruz, on the Atlantic slope of Mexico, and the Pacific slope of Costa Rica, through Central America, to western Equator, and throughout northern South America, including Bolivia, Brazil, Ecuador, and Peru (Savage 2002). Due to this wide distribution and the morphological variation found in *O. petolarius*, three subspecies are recognized – *O. p. digitalis*, *O. p. petolarius*, and *O. p. sebae*. These forms are differentiated by the number of dorsal blotches on the body, length of light bands on the posterior region of the body, and by the contact between postocular and frontal scales (Bailey 1970). However, Lynch (2009) identified inconsistencies in these characters, recognizing the need for more systematic studies of this geographical variation in order to elucidate the status of these taxa. For this reason, we have chosen to allocate *L. nycthemera* only to the species level.

The taxonomy of *O. petolarius* is also subject to some controversy (see Savage 2011). Because of this, we have opted to follow Savage (2011) in using *Oxyrhopus petolarius* as the valid species name, rather than *O. petola*.

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RESEARCH ARTICLE

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Notes on *Metaphire multitheca* (Chen, 1938) (Oligochaeta, Megascolecidae) recorded from Vietnam, with descriptions of two new species

Anh D. Nguyen[1], Tung T. Nguyen[2]

1 *Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology, No.18, Hoangquocviet Rd., Hanoi, Vietnam* **2** *Department of Biology, School of Education, Cantho University, Cantho City, Vietnam*

Corresponding author: *Anh D. Nguyen* (ducanh@ierb.ac.vn, ducanh410@yahoo.com)

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Abstract

The paper deals with *Pheretima multitheca multitheca* Chen, 1938 recorded from Vietnam (non *Pheretima multitheca* Chen, 1938 now in *Metaphire* from Hainan Island). As a result, a new species, *Amynthas erroneous* **sp. n.**, is revealed from materials which were previously misidentified as *Pheretima multitheca multitheca*. The new species is obviously distinguished from other *Amynthas* species by multiple spermathecal pores lateroventral in intersegments 5/6/7/8/9, and presence of two pairs of crescentic genital markings in xviii. In addition, another new species, *Amynthas nhonmontis* **sp. n.**, is described and easily recognized by multiple spermathecal pores ventral in intersegments 5/6/7/8 and three pairs of genital markings in xvii, xix and xx.

Keywords

Annelida, *Pheretima*, *Amynthas*, earthworm, new species, taxonomy

Introduction

The species, *Metaphire multitheca* (Chen, 1938) was originally described from Hainan Island (China) in genus *Pheretima* by Chen (1938). The species is recognized by multiple spermathecal pores (more than two spermathecal pores per segment) in vi, vii and viii, two pairs of genital markings in 17/18 and 18/19, and presence of copulatory

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pouches. The species, was subsequently recorded from various parts of Vietnam by Nguyen (1994), Pham (1995, 2010), Huynh (2005a, 2005b), and Nguyen and Tran (2008). However, all of these authors commented that the population from Vietnam has differences from the original description, such as absence of copulatory pouches, and multiple spermathecal pores in intersegments 5/6/7/8/9.

While examining new materials, we realized that all previous records have been misidentified as *Pheretima multitheca* Chen, 1938 requiring its naming as a new species. In addition, another new species having multiple spermathecae per segment is also described from Vietnam.

Material and methods

Examined specimens were previously collected from various parts of Vietnam and deposited in:

SORC	Soil Organism Research Center;
HNUE	Hanoi National University of Education;
CTU	Laboratory of Zoology, Cantho University, Cantho City, Vietnam.

Material for DNA barcoding was taken from holotype.

The primer sets, LCO1490 and HCO2198, used in a wide range of invertebrate taxa were used to amplify a fragment of the cytochrome c oxydase subunit I gene (Folmer et al. 1994).

Holotype and paratypes are deposited in the Laboratory of Zoology, Cantho University (= CTU), Cantho City, Vietnam.

Abbreviations: C = Clitellate specimen/specimens, e.g. 5C.

Taxonomic account

Family Megascolecidae Rosa, 1891

Genus *Amynthas* Kinberg, 1867

Amynthas Kinberg, 1867: 97 et *Amyntas* (laps. praeocc.) pg. 101.
Amyntas (part) – Beddard 1900a: 612.
Nitocris Kinberg, 1867: 102 (praeocc.).
Pheretima – Michaelsen 1900: 234.
Perichaeta (part praeocc.) – Beddard 1895: 388.
Promegascolex Cognetti, 1922 (part see Blakemore et al. 2007)
Pheretima (*Pheretima*) (part) – Michaelsen 1928: 8; Michaelsen 1934: 15.
Amynthas – Sims and Easton 1972: 211; Blakemore 2002: 149, 2007, 2008.

Type species. *Amynthas aeruginosus* Kinberg, 1867, by monotypy.

Distribution. Widely distributed in the Oriental region, and also found in Australasian and Oceanian regions (Sims and Easton 1972) and distributed worldwide (Blakemore 2002, 2007).

Remarks. Members of the genus can be easily recognized by the presence of intestinal caeca near xxvii, the absence of copulatory pouches, and often by absence of micronephridia on spermathecal ducts. It is noted that about 500+ nominal species have been recorded, but a considerable number are likely synonyms (Blakemore 2002, 2007).

Amynthas erroneous sp. n.

http://zoobank.org/27A9F82B-A620-4EEC-83A7-28B849954C1A
Fig. 1, Table 1

Pheretima multitheca multitheca – Nguyen 1994: 53; Pham 1995: 68; Huynh 2005a: 89; Huynh 2005b: 20; Nguyen and Tran 2008: 185; Pham 2010: 63.
Non *Pheretima multitheca* Chen, 1938: 383, fig. 2.

Material examined. *Holotype.* 1C (CTU–EW 071.02–h01) taro garden, Duc Pho commune (108°57'9"E, 14°48'18"N), elevation of 5 m a.s.l., Pho Minh district, Quang Ngai province, Vietnam, 15 April 1995, coll. Huynh Thi Kim Hoi. *Paratypes.* 13C (CTU–EW 071.02–p02) same data as for holotype. *Further material.* 8C (SORC–V.153.01) garden, Duc Pho town, Pho Minh, Quang Ngai, 15 April 1995, coll. Huynh Thi Kim Hoi. Fixed in formalin.

Diagnosis. Medium-size worm. First dorsal pore in 11/12 or 12/13. Prostomium 1/3 epilobous. Multiple spermathecal pores lateroventral in intersegments 5/6/7/8/9. Male pores located in xviii, without copulatory pouches. Two pairs of crescentic genital markings in xviii. Holandric. Testis sacs not separated. Intestinal caeca simple, within xxvii-xxv. Septa 8/9/10 absent.

Etymology. To emphasize the misidentification of the species as *Pheretima multitheca*.

Description. *External characters*: Body cylindrical, medium size. Length 112–150 mm, diameter 3.81–5.0 mm, segments 119–150, weight 1.61–2.94 g. Body coloration uniformly brown. Setae perichaetine, more concentrated ventrally; preclitellar setae sparser than postclitellar setae, 42–46 in v, 37–65 in viii, 61–71 in xxv, 42–72 in xxx, 10–16 between male porophores in xviii; setal distance aa=2ab, zz=1.5zy. First dorsal pore in 12/13, rarely in 11/12. Prostomium ⅓ epilobous. Clitellum annular, xiv-¾xvi, darkish brown, smooth and without setae and dorsal pores. Female pore single, mid-ventral in xiv.

Spermathecal pores round and small, multiple, lateroventral in intersegments 5/6/7/8/9, sometimes invisible. No genital markings in spermathecal region.

Male pores located in porophores in xviii, without copulatory pouches; ventral distance between male porophores about 0.28× body circumference. Two pairs of large, crescentic genital markings in xviii, located in front of and behind male porophores.

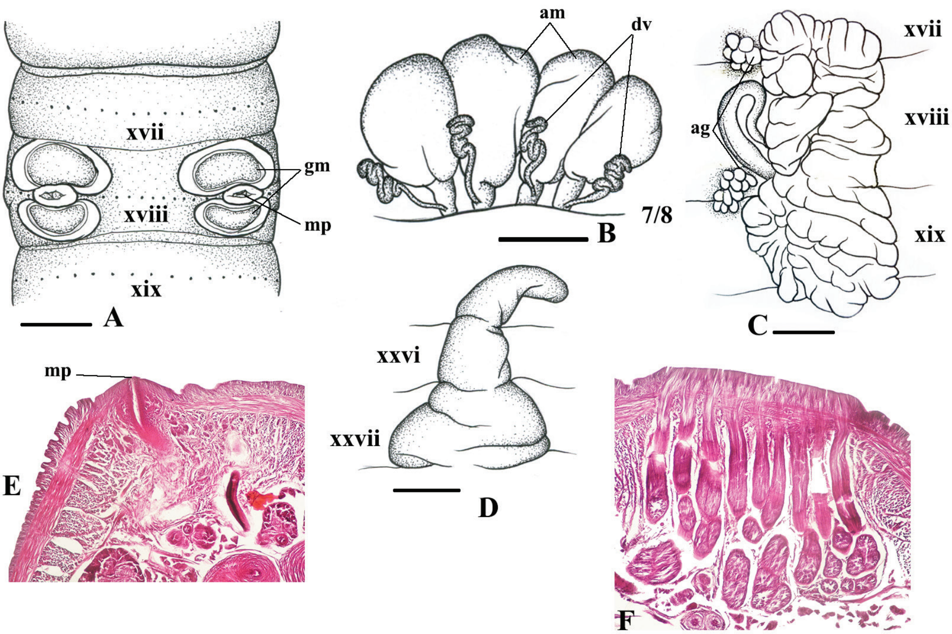

Figure 1. *Amynthas erroneous* sp. n., holotype. **A** Male pore region (mp = male pore; gm = genital markings) **B** Spermathecae, right side on intersegment 7/8 (am = ampulla; dv = diverticulum) **C** Prostate gland (ag = accessory gland) **D** Intestinal caecum **E–F** Transverse body section of segment xviii, male pore (**E**), accessory glands (**F**). Scale bars = 1 mm.

Internal characters: Septa 6/7/8 thickened, 8/9/10 absent, and 10/11/12/13 relatively thickened. Oesophageal gizzard after 7/8, pear-shaped. Intestinal origin at xv; caeca simple, within xxvii–xxv. Last hearts in xiii. Pharyngeal micronephridia developed in 4/5/6. Lymph glands present from xvii, rarely xvi, and lobulated. Typhlosole simple, lamelliform.

Spemathecae variable, 21–27 altogether in 5/6/7/8/9: 2–4 in 5/6, 4–6 in 6/7, 5–7 in 7/8 and 6–8 in 8/9. Spermathecal ampulla large, oval; duct about ⅓, rarely as much as ½ the length of the ampulla. Diverticula irregularly sinusoidal, folded onto itself several times, enlarged distally, about half length of ampulla; stalk attached to base of duct of ampulla. No accessory glands.

Holandric. Testis sacs not separated, developed in x and xi. Seminal vesicles well developed within xi–xii, yellowish white. Oviduct poorly developed on septum 12/13 posteriorly; a pair of ovaries in xiii. Prostate glands racemose, paired in xvii–xix; prostatic ducts C-shaped. Two accessory glands present.

DNA. COI barcode data not yet available.

Habitat and ecology. The species was found in soils in which old growth trees had been grown. No other ecological data had been recorded.

Distribution. Previous misidentifications of *Pheretima multitheca multitheca* were from Quang Tri (Quang Tri town); Thua Thien Hue (Huong Tra; Hue; Nam Dong;

Table 1. Marker characters of three species, *Amynthas erroneous* sp. n., *Metaphire dipapillata* (Thai & Tran, 1986), stat. n., and *M. multitheca* (Chen, 1938).

No	Characters	*A. erroneous*	*M. dipapillata*	*M. multitheca*
1	Length (mm)	112–150 mm	115–180 mm	155 mm
2	Diameter (mm)	3.81–5.0 mm	5–7 mm	7 mm
3	Weight	1.61–2.94 g	4.2–7.0 g	?
4	Segments	119–150	103–124	95
5	Setae between male porophores	10–16	10–11	4
6	Coloration	uniformly brown	Dorsa whitish grey, ventra paler	Dorsa darkish grey, ventra paler
	Clitellum	xiv–¾xvi	xiv–xvi	xiv–xvi
7	Prostomium	⅓ epilobous	epilobous	⅓ epilobous
8	First dorsal pore	12/13, rarely 11/12	11/12	12/13
9	Spermathecal pores	Multiple in 5/6/7/8/9	Multiple in 5/6/7/8/9	Multiple in vi, vii, viii
10	GM near spermathecae	Absent	Absent	Absent
11	GM in male region	Two pairs in xviii	A pair in 17/18	Two pairs in xviii
12	Copulatory pouches	Absent	Present	Present
13	Spermathecae	21–27	30–40	30–32
14	Male sexual system	Holandric	Holandric	Holandric
15	Pharyngeal micronephridia	4/5/6	5/6/7/8	5/6/7
16	Septa 8/9/10	Absent	Absent	Absent

Phu Loc); Danang; Quang Nam (Que Son); Quang Ngai (Quang Ngai city; Duc Pho); Binh Dinh; Dak Nong (Ta Dung Mts.) (Nguyen 1994, Pham 1995, 2010, Huynh 2005a, 2005b, Nguyen and Tran 2008).

Remarks. This new species was previously misidentified as *Pheretima multitheca multitheca* Chen, 1938 (= *Metaphire multitheca*), which was originally known only from Hainan Island. Both species share multiple spermathecal pores per segment and presence of intestinal caeca. However, *Amynthas erroneous* sp. n. has multiple spermathecal pores in intersegments 5/6/7/8/9, and lacks copulatory pouches while *Metaphire multitheca* (Chen, 1938) has multiple spermathecal pores located behind setal rings of segments vi, vii, viii, and presence of copulatory pouches. The new species is also fairly similar to *Metaphire multitheca dipapillata* (Thai & Tran, 1986), now *M. dipapillata* stat. n.; both species have multiple spermathecal pores in intersegments 5/6/7/8/9, and genital markings associated with the male pores. However, *Amynthas erroneous* sp. n. lacks copulatory pouches and has two pairs of crescentic genital markings in xviii, whereas *Metaphire dipapillata* has copulatory pouches and only a pair of genital markings in 17/18, located in front of male porophores. Marker characters of three species, *A. erroneous*, *M. dipapillata* and *M. multitheca* are presented in Table 1.

The new species is also distinguished from other 5/6/7/8/9 polythecate species such as *Polypheretima bifaria* (Michaelsen, 1924) from New Guinea, *Po. polytheca*

(Beddard, 1900b) from Malay penisula, *Po. koyana* Michaelsen, 1934 from Sarawak, and *Metapheretima elrondi* Easton, 1979 from New Guinea by having intestinal caeca. Althought it shares with *Amynthas bleckwenni* (Ude, 1925) from Borneo the multiple spermathecae at 5/6/7/8/9, and having intestinal caeca, the new species differs from *A. bleckwenni* in having two pairs of crescentic genital markings in front of and behind male pores on xviii.

We herein raised the subspecies *M. multitheca dipapillata* to full rank as *M. dipapillata* stat. n., and also restore *M. multitheca multitheca* as *M. multitheca*.

The new species is widely distributed in central parts and highlands of Vietnam. Surprisingly, it has never yet been found in northern and southern Vietnam.

***Amynthas nhonmontis* sp. n.**

http://zoobank.org/6231C5E9-8812-419D-BDB9-34007C10B1F4
Fig. 2

Material examined. *Holotype.* 1C (CTU.EW 023–h01) natural forest, Nhon mountain, (104°56'09.2"E, 10°35'39.6"N), elevation of 56 m a.s.l., Tinh Bien district, An Giang province, Vietnam, 7 November 2010, coll. Nguyen Thanh Tung. *Paratypes.* 6C (CTU. EW023–p02) same data as for holotype.

Diagnosis. Medium-size worm. First dorsal pore in 10/11. Prostomium prolobous. Multiple spermathecal pores ventral in intersegments 5/6/7/8. Male pores in xviii, without copulatory pouches. Three pairs of genital markings present in xvii, xix and xx, rarely more or less than three pairs. Holandric. Intestinal caeca simple, from xxvii. Septa 8/9/10 absent, 10/11 thickened.

Etymology. "*nhonmontis*", after locality.

Description. *External characters*: Body cylindrical, medium size. Length 103–106 mm, diameter 3.28–4.05 mm, segments 138–168, weight 0.91–1.65 g. Living specimens whitish pink while preserved specimens uniformly whitish brown; clitellum darkish brown.

Prostomium prolobous. First dorsal pore in 10/11. Setae perichaetine; preclitellar setae stouter and thicker than postclitellar setae, 42–51 in viii, 31–36 in xxx, 5–8 between male porophores in xviii; setal distance aa=ab, zz=zy. Clitellum annular, xiv–xvi, without setae and dorsal pores. Female pore single, mid-ventral in xiv. Body wall thinned, especially segments after male region having very thin wall. Preclitellar segments obviously shorter than postclitellar ones.

Multiple spermathecal pores ventral in intersegments 5/6/7/8. No genital markings in spermathecal region. Male porophores flattened; male pores located in setal ring in xviii, without copulatory pouches. Ventral distance between male porophores about 0.3x body circumference. Genital markings usually three pairs in setal rings in xvii, xix and xx, rarely more or less than three pairs; genital markings arranged in longitudinal line with male pores.

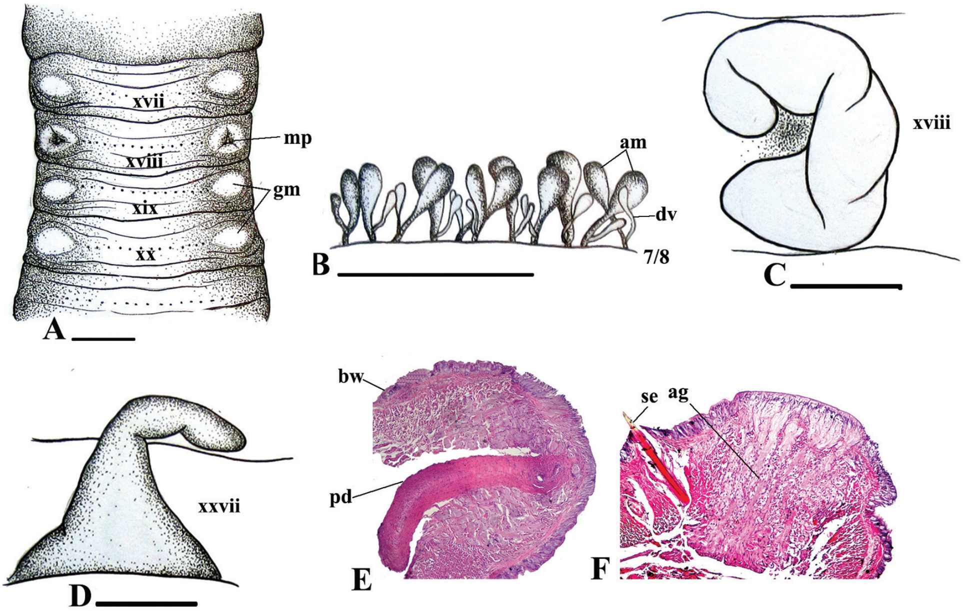

Figure 2. *Amynthas nhonmontis* sp. n., holotype. **A** Male region (mp = male pore; gm = genital markings) **B** Spermathecae, right side on intersegment 7/8 (dv = diverticulum, am = ampulla) **C** Prostate **D** Intestinal caecum **E** Transverse body section of male porophore in xviii (bw = body wall, pd = prostatic duct) **F** Transverse body section of genital markings in xvii (ag = accessory gland). Scale bars = 1 mm.

Internal characters: Septa 5/6/7/8 and 10/11 thickened, 8/9/10 absent, 11/12/13 very thin. Oesophageal gizzard within viii–x. Intestinal origin at xv; caeca small, simple within xxvii–xxvi or xxvii–½xxv. Last hearts in xiii. Pharyngeal micronephridia well-developed on septa 4/5/6. Lymph glands lobulated from xxvii. Typhlosole simple, lamelliform.

Spermathecae small, about 43–48 altogether in intersegments 5/6/7/8: 11–13 in 5/6, 15–17 in 6/7, and 17–18 in 7/8. Spermathecal ampulla very small, clavate, yellowish brown; duct extremely short. Diverticulum shorter and attached directly to duct of ampulla. No accessory glands.

Holandric. Testis sacs separated. Seminal vesicles poorly developed in xi–xii. Oviduct on septum 12/13 ventrally. Ovaries minute (not clearly found). Prostate glands poorly developed, largely lobulated, only within xviii; prostatic ducts undetected, covered body wall. Accessory glands concealed within body walls.

DNA. COI barcode data (partial) is for holotype uploaded to GenBank with accession number KR676559.

Habitats and ecology. This species has been found only in Nhon mountain (Tinh Bien district) in An Giang province. Adult specimens were only collected during the rainy season (from October to March) in southern Vietnam and found in heavy clays at the foothill of Nhon mountain.

Remarks. *Amynthas nhonmontis* sp. n. differs from other *Amynthas* species in having multiple spermathecal pores ventral in intersegments 5/6/7/8 and three pairs of genital markings in xvii, xix and xx. The new species is superficially similar to *Polypheretima elongata* (Perrier, 1872) due to external morphology: body cylindrical, multiple spermathecae per segment, presence and arrangement of genital markings near male pores. However, it is clearly distinguished from *Po. elongata* by presence of intestinal caeca, three spermathecal segments, absence of copulatory pouches.

Its DNA barcode is definitive for the new species (nearest BLAST result is *Amynthas morrisi* at 87%).

Conclusion

Two new species of the genus *Amynthas* Kinberg, 1867 are described. Both of them are characterised by multiple spermathecal pores per segment, lack of copulatory pouches, and presence of intestinal caeca from xxvii. To date, only eight species having multiple (more than two) spermathecae per segment have been found in Vietnam. They are arranged in three genera: *Polypheretima* Michaelsen, 1934, *Amynthas* Kinberg, 1867 and *Metaphire* Sims & Easton, 1972, namely:

Polypheretima spiridonovi (Thai, 1996), from Khanh Hoa province, southern Vietnam (stat. n. from Blakemore 2007, 2008).
Po. mekongmontis Nguyen, Tran & Nguyen, 2014, from Kien Giang province, southern Vietnam.
Po. cattienensis Nguyen, Tran & Nguyen, 2015, from Dong Nai province, southern Vietnam.
Po. militium Nguyen, Tran & Nguyen, 2015, from Dong Nai province, southern Vietnam.
Po. cordata Nguyen, Tran & Nguyen, 2015, from Dong Nai province, southern Vietnam.
Amynthas erroneous Nguyen, Tran & Nguyen, sp. n., from central and highlands.
A. nhonmontis Nguyen, Tran & Nguyen, sp. n., from An Giang province, southern Vietnam.
Metaphire dipapillata (Thai & Tran, 1986), stat. n. from Nghe An province, central Vietnam.

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RESEARCH ARTICLE

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A distinctive new subspecies of *Scytalopus griseicollis* (Aves, Passeriformes, Rhinocryptidae) from the northern Eastern Cordillera of Colombia and Venezuela

Jorge Enrique Avendaño[1], Thomas M. Donegan[2]

1 *Programa de Biología y Museo de Historia Natural, Universidad de los Llanos, Sede Barcelona, km 12 vía Puerto López, Villavicencio, COLOMBIA* **2** *ProAves Foundation, Southmead, The Vale, London N14 6HN, UK*

Corresponding author: *Jorge Enrique Avendaño* (jorgeavec@gmail.com)

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Abstract

We describe a new subspecies of Pale-bellied Tapaculo *Scytalopus griseicollis* from the northern Eastern Cordillera of Colombia and Venezuela. This form differs diagnosably in plumage from described subspecies *S. g. griseicollis* and *S. g. gilesi* and from the latter in tail length. It is also differentiated non-diagnosably in voice from both these populations. Ecological niche modelling analysis suggests that the new subspecies is restricted to the Andean montane forest and páramo north of both the arid Chicamocha valley and the Sierra Nevada del Cocuy.

Keywords

Andes, endemism, geographic variation, inter-Andean valley, páramo, Tamá

Introduction

Scytalopus Tapaculos are a genus of small and dull suboscine passerines which inhabit the undergrowth of humid forests and tree-line habitats of Neotropical mountains from Costa Rica to Argentina (Krabbe and Schulenberg 2003). *Scytalopus* taxonomy has been challenging due to the lack of plumage differences among species, scarcity of specimens and historically poor knowledge of their distributions and vocalisations

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(Krabbe and Schulenberg 1997, 2003, Cuervo et al. 2005). Recent studies have resulted in new taxon descriptions and reclassifications for at least 30 species (principally in Fjeldså and Krabbe 1990, Krabbe and Schulenberg 2003 and in many other publications, see Remsen et al. 2015). Six of these new *Scytalopus* taxa have been described with a distribution partially or exclusively in Colombia since the late 1990s (Krabbe and Schulenberg 1997, Cuervo et al. 2005, Krabbe et al. 2005, Donegan and Avendaño 2008, Donegan et al. 2013, Avendaño et al. 2015) and some diagnosable populations in the Colombian Andes remain undescribed (e.g. Donegan and Avendaño 2008, López-O et al. 2013, McMullan and Donegan 2014).

The Pale-bellied Tapaculo *Scytalopus griseicollis* inhabits subpáramo and páramo habitats of the Eastern Cordillera (Eastern Andes) of Colombia and Venezuela (Hilty and Brown 1986, Donegan and Avendaño 2008). We recently reviewed the taxonomy of the group and related taxa (Donegan and Avendaño 2008), clarified the status and affinities of the type specimens of various names from the region, addressed the previously controversial status of *S. infasciatus* as a synonym of nominate *S. griseicollis* and described *S. griseicollis gilesi* from the Serranía de los Yariguíes of the Eastern Cordillera of Colombia. Two named subspecies and, in some cases, an additional undescribed subspecies have been recognised by subsequent authors who have considered the group's taxonomy (Salaman et al. 2008, 2009, 2010, McMullan and Donegan 2014, Dickinson and Christidis 2014). We identified a further population as "*S. griseicollis subsp*." which we considered to possess a "notably browner back in adult plumage than any of the other populations" (at Fig. 9, p. 39). This population was mapped as present in the northern section of the Eastern Cordillera from Santander and Norte de Santander departments in Colombia to Apure and Táchira states in Venezuela. Vocal, plumage and biometric data relating to this population were presented but it was not described.

Methods

A total of 88 specimens of *S. griseicollis* from eight museum collections, reviewed in Donegan and Avendaño (2008), plus another 23 recently collected and 12 from the Smithsonian National Museum of Natural History (USNM) were inspected directly or using photographs in order to investigate geographical variation in plumage and biometrics of *S. griseicollis* (Suppl. material 1). Specimens of the northern population were collected by JEA at seven localities in Santander department as part of various different projects (see Acknowledgments). In all localities, specimens were collected using mist nets and air shotgun cal. 4.5. We made color descriptions in the description of the holotype and variation in the type series using Smithe's (1975, 1981) colour nomenclature. Biometric and vocal data for several characters and each of the three same populations are based in Donegan and Avendaño (2008) and followed various statistical tests of diagnosability as set out in that reference.

With the aim of obtaining a more detailed assessment of the potential distribution of the new subspecies, we conducted an ecological niche modelling analysis in the program Maxent version 3.3 (Phillips et al. 2006), using 19 climate variables available in the WORLDCLIM ver. 1.4 database (Hijmans et al. 2005) and 13 remote-sensing variables related to vegetation and three related to topography (Buermann et al. 2008). The analysis was conducted for *S. griseicollis* as a whole, including 59 locality points, which were gathered from museum specimens, sound recordings, and reliable field observations that counted with geographic coordinates (to seconds) and elevation data. Geographic coordinates of all known localities are summarized in Suppl. material 2.

Results

Previous biometric and vocal analyses (Donegan and Avendaño 2008), combined with recent specimens and new analyses of plumage and ecological niche modelling, reinforce the conclusion that the population of *S. griseicollis* in the northern Eastern Cordillera represents a previously undescribed subspecies, which we propose be named:

Scytalopus griseicollis morenoi Avendaño & Donegan, ssp. n.

http://zoobank.org/70DE583A-AC75-466D-B3FB-84B1046BBBBB

Holotype. An adult male study skin specimen (Figs 1 and 3), no. 37538 of the ornithological collection of the Instituto de Ciencias Naturales (ICN), Universidad Nacional de Colombia, Bogotá. Tissue samples (pectoral muscle) are deposited at the Banco de Tejidos of Universidad de los Andes (ANDES-BT 1567), Bogotá. The specimen and tissue samples relate to the same individual organism which was collected and prepared on 2 August 2009 by J. E. Avendaño (original field no. JEA 811) in secondary growth / forest ecotone at La Pica, finca La Rinconada, vereda Potrero de Rodríguez, municipality of Molagavita, Santander department, Colombia (06°43'N; 72°47'W; 2880 m).

Diagnosis. *Scytalopus griseicollis morenoi* exhibits all the characteristics of the genus *Scytalopus* (Ridgway 1911, Krabbe and Schulenberg 1997, Cuervo et al. 2005). It appears to be most closely related to *S. griseicollis* on account of its rather grey plumage, orange-rufous vent (Fig. 1) and similar vocalisations (Figs 4–5). *S. g. morenoi* is distinguishable from *S. perijanus* from the Serranía de Perijá by its entirely brown nape and back (Fig. 1) and distinct vocalisations (Avendaño et al. 2015). It is diagnosable from *S. g. griseicollis* of the Altiplano Cundiboyacense and *S. g. gilesi* of the Serranía de los Yariguíes by its brown (not grey) mantle, tail, wing coverts and nape (Fig. 1). Juveniles of the new subspecies differ mainly from the nominate and *S. g. gilesi* in having darker base plumage ventrally (which is scalloped white) whereas they are dorsally darker than the nominate, like in *S. g. gilesi* (Fig. 2). These characters also distinguish juveniles of the new subspecies from those of *S. perijanus*, which are more yellowish ventrally. It also has a shorter tail than *S. g. gilesi* (see Appendices 2 and 4 in Donegan and Avendaño (2008)). It has an on average higher pitched scold than *S. g. griseicollis* but this is not diagnostic. Compared to *S. g. gilesi*, the new subspecies has a faster and

Figure 1. Dorsal and ventral views of three subspecies of *S. griseicollis* found in the Eastern Cordillera of Colombia and Venezuela and *S. perijanus* from the Serranía de Perijá. From left to right. *S. g. griseicollis* (ICN 31235); *S. g. gilesi* (ICN 36901); *S. g. morenoi* (holotype); and *S. perijanus* (ICN 36745). Note the distinctive browner back and nape of the new subspecies.

Figure 2. Ventral and lateral views of fledglings of three subspecies of *S. griseicollis* and *S. perijanus* found in Colombia and Venezuela. **A** *S. g. morenoi* (MLS 3993) **B** *S. g. morenoi* (IAvH-A 14948); **C** *S. g. griseicollis* (IAvH-A 13935) **D** *S. g. griseicollis* (ICN 35441) **E** *S. g. gilesi* (ICN 36916) **F** *S. perijanus* (ICN 36734). Note the darker plumage and ventral white scalloping in *S. g. morenoi*.

higher frequency song and higher frequency scold (in the latter case, with no overlap) (Figs 4–5; and Appendices 3–4 in Donegan and Avendaño (2008)).

Description of the holotype. Lores, forehead, crown, auriculars and neck sides Dark Neutral Gray 83; nape, scapulars, mantle, rump, tail and upper-tail coverts between Verona Brown 223B and Amber 36, the latter barred with Sepia 219. Underparts Medium Neutral Gray 84, becoming slightly lighter (Light Neutral Gray 85) on the center of belly; flanks, lower belly, thighs and under-tail coverts between Buff 24 and Tawny 38, the latter barred with Sepia 29. Wing coverts Dark Neutral Gray 83 fading to Dark Brownish Olive 129 and tipped with Verona Brown 223B; remiges and

Figure 3. Selected specimens of the type series of *S. griseicollis morenoi*. From left to right: holotype (ICN 37538), male paratype (ICN 37514), male paratype (ICN 37570), male paratype (ICN 37548), and female paratype (ICN 37516). Note the slight individual variation in the color of the underparts and upperparts.

tertials Dark Grayish Brown 20 with external margin Cinnamon-Rufous 40, and the latter tipped Tawny 38, with dark (Sepia 119) subterminal bar. Light molt in mantle, throat, breast and abdomen. 10 rectrices. Measurements (in mm): wing flat 56.0, tail 41.1, tarsus 20.5, total culmen 13.2, exposed culmen 9.9. Mass 17.0 g. During preparation and dissection, the following features were noted, none of which is evident from the holotype itself: some subcutaneous fat in furcula and neck; testes rather enlarged (left testis: 5.3 × 2.5 mm; right testis 4.8 × 3.0 mm); stomach contained insect remains. Soft parts in life (not coded for colours in the field): bill dark ('horn'), lighter on the base of the lower mandible; iris dark brown; tarsus and feet light brown, claws whitish, hallux blackish, soles pale yellow.

Paratypes. The type series includes the following specimens in museums which we have been able to compare directly with fresh specimens collected as part of this study. The specimens showed in Figures 2–3 are denoted with an asterisk. (1) Adult male (ICN 37548*) collected at the type locality on 4 August 2009; (2) adult male (ICN 37514*) collected at 2700 m elevation above finca La Paterna, vereda San Isidro, corregimiento of Pangote, municipality of San Andrés, Santander department, on 28 July 2009; (3) adult male (ICN 37570*) collected at 2800 m elevation at finca El Tablón, vereda Santa Cruz, municipality of San Andrés, Santander department, on 14 September 2009; (4) adult male (ICN 36121) collected at 2950 m elevation at El Gritadero, vereda El Monsalve, municipality of Suratá, Santander department, on 19 August 2006; (5) adult male (ICN 36416) collected at 3100 m elevation at finca Ramírez, vereda Parra Juan Rodríguez, municipality of Piedecuesta, Santander department, on 11 July 2007; (6) adult female (ICN 37516*) collected at 2725 m elevation at La Corcova, vereda San Isidro, municipality of San Andrés, Santander department, on 28 July 2009; (7) adult female (ICN 37522) collected at 2950 m elevation below Pozo El Indio, La Pica, finca La Rinconada, Vereda Potrero de Rodríguez, municipality of Molagavita, Santander department, on 30 July 2009; (8) fledgling male (IAvH-A 14948*) collected at 2800 m elevation by S. Sierra at Alto El Pesebre, Sector Orocué, Tamá NP, municipality of Herrán, Norte de Santander department, on 18 September 2008; (9) unsexed fledgling (MLS 3993*) collected by Hno. Nicéforo María at Fontibón, municipality of Pamplona, Norte de Santander, on 30 April 1941. Specimens 1 to 7 were collected and prepared by J. E. Avendaño under original field numbers JEA-821, 787, 916, 323, 499, 789 and 795, respectively. See further Suppl. material 1.

Etymology. The new subspecies name honours the late Nelson Moreno Rodríguez, co-founder and curator of the Museo de Historia Natural of the Universidad Industrial de Santander. He was a mentor and friend of the first author and an enthusiastic naturalist. This name also recognizes his contributions to ornithology, natural history and education in the department of Santander. The name is formed from a fictional masculine Latin noun "morenous", in the genitive singular. The name is non-variable.

Remarks. Variation in the type series. Plumage variation in the type series is slight and mainly concentrated in the colour tone of the nape, back and underparts (Fig. 3). Males ICN 37548 and 37570 have paler underparts (Pale Neutral Gray 86),

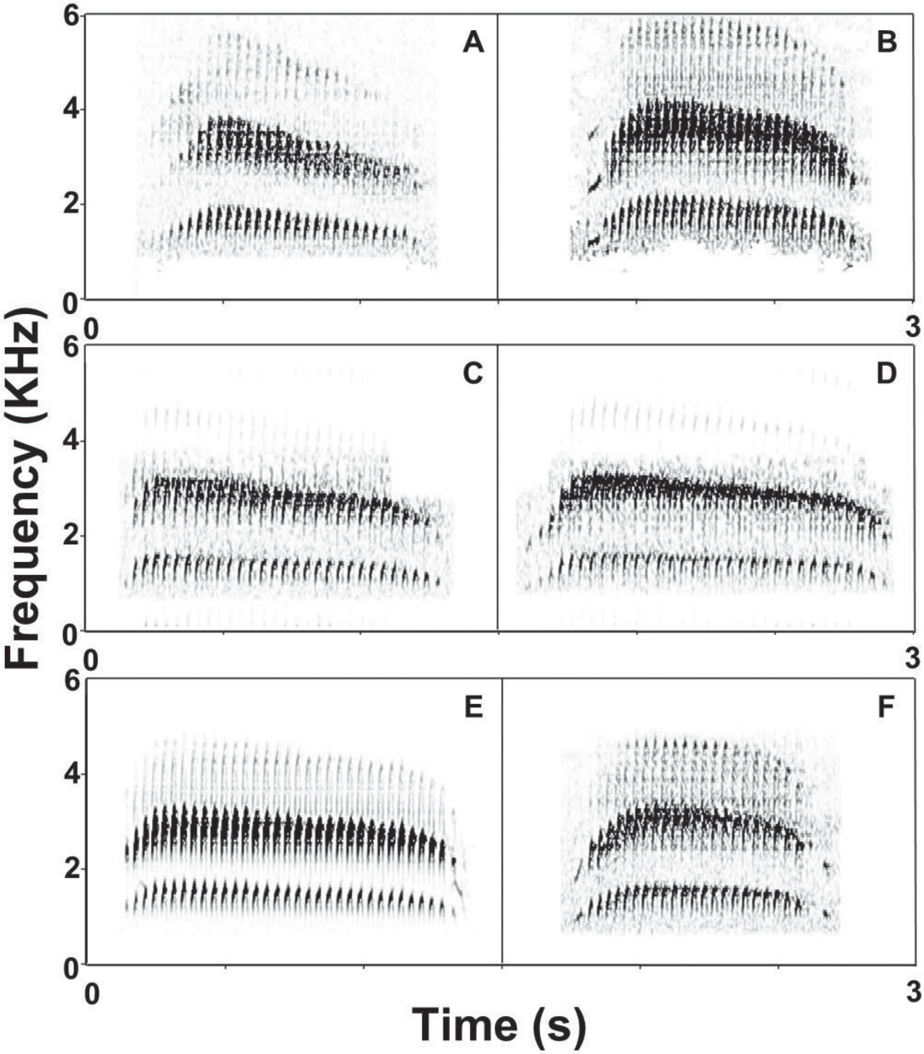

Figure 4. Spectograms of scolds of *S. griseicollis* subspecies found in Colombia and Venezuela. *S. g. morenoi*: **A** Oirá River, border with Colombia, Apure state, Venezuela (XC6079, C. Parrish) **B** Páramo de Santurbán, Vetas, Santander department, Colombia (XC117002, O. Cortés). *S. g. gilesi* **C** vereda Alto Cantagallos, San Vicente de Chucurí, Santander department, Colombia (XC18457, T. M. Donegan) **D** Lepipuerto, El Carmen de Chucurí/Simacota, Santander department, Colombia (XC18477, T. M. Donegan). *S. g. griseicollis* **E** Chingaza NP, Cundinamarca department, Colombia (XC79989, A. Spencer) **F** Iguaque, Boyacá department, Colombia (XC119700, D. Edwards). Spectrograms were made in Syrinx v2.6h (Burt 2006) applying the same parameters except for adjusting brightness to improve note resolution.

the former with a whitish tinge in the center of the belly; both specimens have flanks, lower belly, thighs and under-tail coverts more tawny than the holotype. Male ICN 37514 is slightly paler on the belly. Some males (e.g. ICN 37514, 37548 and 37570)

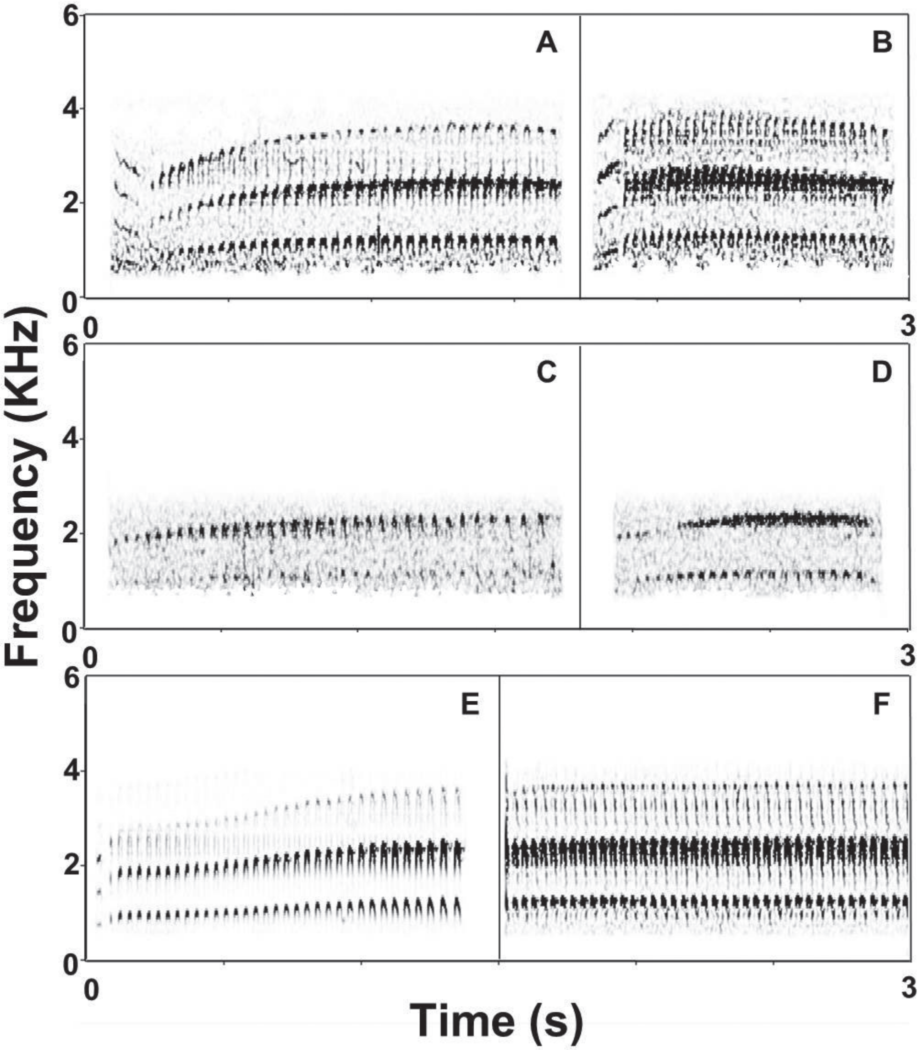

Figure 5. Spectograms of reeling songs of *S. griseicollis* subspecies found in Colombia and Venezuela. *S. g. morenoi*: **A** Las Picotas, vereda Angosturas, Vetas, Santander department, Colombia (XC86713, J. E. Avendaño) **B** Oirá River, border with Colombia, Apure state, Venezuela (XC16658, C. Parrish). *S. g. gilesi* **C** Filo Pamplona, vereda La Aurora, Galán, Santander department, Colombia (XC18454, T. M. Donegan) **D** Lepipuerto, El Carmen de Chucurí/Simacota, dpto. Santander, Colombia (XC18472, T. M. Donegan). *S. g. griseicollis* **E** Chingaza NP, dpto. Cundinamarca, Colombia (XC102520, F. Schmitt) **F** (first part of song) Reserva de Aves para *Amazilia castaneiventris* y *Macroagelaius subalaris*, Soatá, dpto. Boyacá, Colombia (XC94523, O. Cortés).

are duller (less Amber 36) than the holotype and show some grey (Dark Neutral Gray 83) feathers in the nape and mantle. Both females at ICN are ventrally similar to the holotype, but ICN 37516 has a tinge of Pale Pinkish Buff 121D in the belly. Nape and back coloration differs from the holotype as in males ICN 37514, 37548 and 37570. Juvenile specimens, such as MLS 3993 and IAVH-A 14948, have very dark brown base coloration with narrow, scallopped whitish markings on the trailing edges of all head, underparts, dorsal and wing covert feathers (Fig. 2). Details on vocal and biometric variation are presented in the appendices to Donegan and Avendaño (2008).

Additional specimens examined. We examined 42 additional specimens we identified as *S. g. morenoi* (Suppl. material 1). All these specimens exhibit variation within the range described above for the type series.

Distribution. *S. g. morenoi* is endemic to the northern Eastern Cordillera in Colombia and Venezuela, ranging from La Palmita in Norte de Santander, south to Molagavita in Santander, and covering an altitudinal range between 2000 m and 3900 m (Suppl. materials 1–2; Participantes de la Alianza Biomap 2014). Our niche model suggests that *S. g. morenoi* is present on both slopes of the northern section of the Eastern Cordillera, largely in more humid montane slopes and subpáramo to páramo habitats (Fig. 6). Range limits in *S. griseicollis*' subspecies seem to correspond to several geographic barriers and changes in environmental conditions across the northern Eastern Cordillera (Graham et al. 2010). Northern distributional limit of *S. g. morenoi* seems to concur with the Ocaña (Serranía de los Motilones) depression (*c.*1200 m). Its distribution to the north-east is restricted by the Táchira depression, despite our niche model predicting some suitable habitat in the southern Mérida Cordillera (Fig. 6). The vocally distinctive and ecologically less specialised *S. meridanus* replaces the species in the Venezuelan Andes (Donegan and Avendaño 2008, Hilty 2003). These barriers prevent contact of a high elevation specialist with poor dispersal abilities, such as this, with *S. perijanus* of the Serranía de Perijá and *S. meridanus* of the Mérida Cordillera, respectively. On the east slope of the Eastern Cordillera, the distribution of *S. g. morenoi* seems to be restricted to the Tamá-Sierra Nevada del Cocuy foothills. This region appears to constitute the northern or southern distribution limit of many montane species and subspecies on the east slope of the Eastern Cordillera (Hilty and Brown 1986, Restall et al. 2006).

To the south, *S. g. morenoi*'s potential habitat becomes reduced and discontinuous, possibly related with an environmental break at the head of the arid Chicamocha valley in the Santander-Boyacá departments boundary, which precludes any potential contact with the nominate form of the Altiplano Cundiboyacense. The headwaters of the arid Chicamocha valley represent the northern or southern distributional limit of several montante and páramo species ranging along the west slope of the Cordillera or represent internal breaks of widely distributed species (Hilty and Brown 1986, Graham et al. 2010). Likewise, the new subspecies is isolated from *S. g. gilesi* by a depression at the headwaters of the rivers Horta and Opón, which connects the Serranía de Yariguíes with the rest of the Eastern cordillera (c. 1450 m).

Ecology. A typical dweller of the understory of elfin forest, páramo and rarely montane and oak forest, although it also can be found at forest borders and bushes. Individuals, possibly young birds were occasionally observed crossing small pastures and trails between patches of more appropriate habitat. *S. g. morenoi* has been recorded

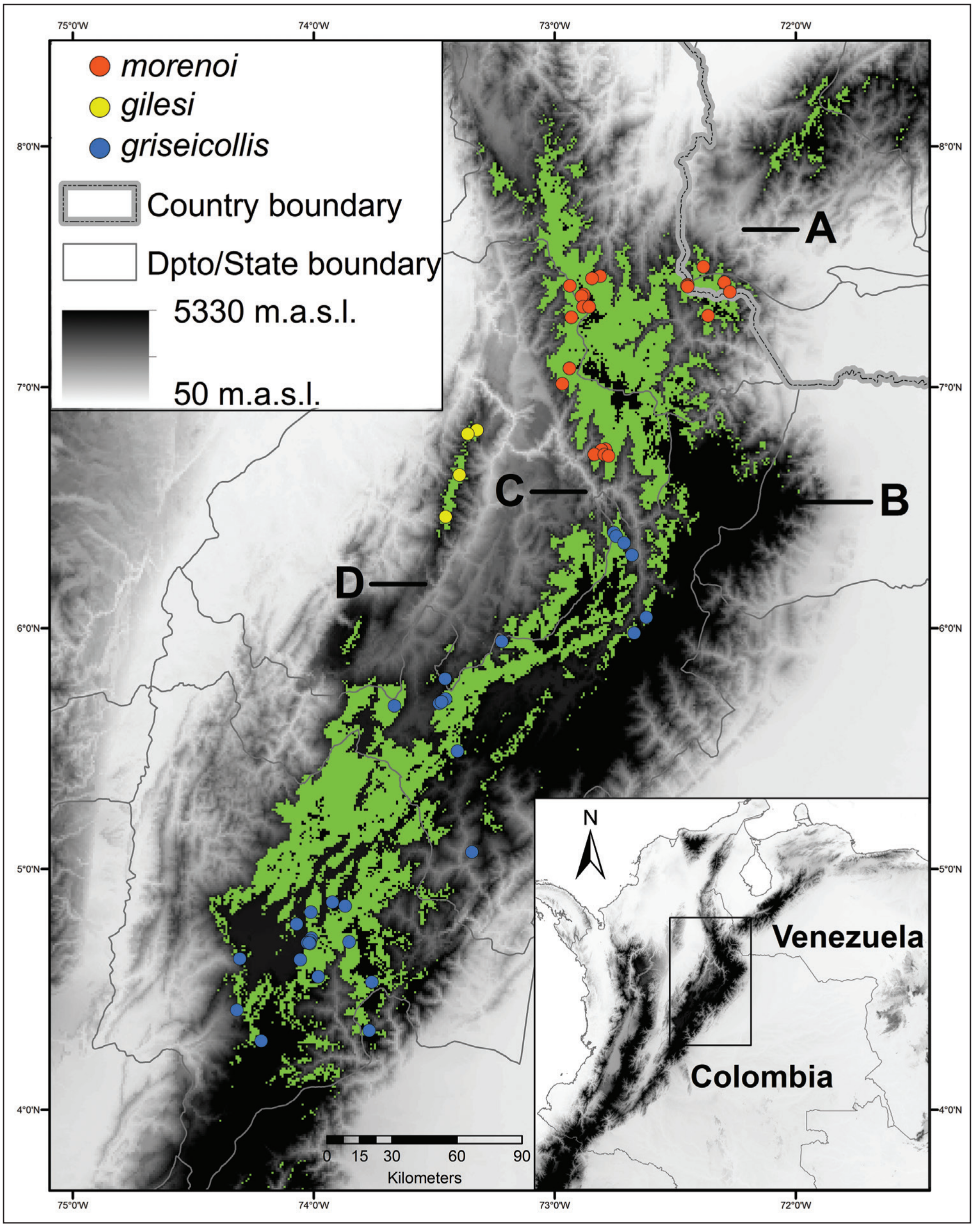

Figure 6. Potential distribution (in green, defined as ≥0.44 presence probability calculated in MAXENT) for three subspecies of *S. griseicollis* in the Eastern Cordillera of Colombia and Venezuela. Note the restricted potential range of *S. g. morenoi* to the northern section of the Eastern Cordillera. Bold letters correspond to some potential barriers or geographic locations mentioned in the text: **A** Táchira depression **B** Sierra Nevada del Cocuy **C** Chicamocha River canyon; and **D** Horta-Opón Rivers depression. Locality records by subspecies are depicted by colored circles.

as fairly common to common at several localities in Santander with 2-4 individuals recorded in 1 ha study sites (J.E.A. pers. obs.). Breeding and reproduction may take place during the second half of the year. Fledglings have been collected at Tamá National Park on 27 June 1999 (IAvH-A 10664) and 3 September 2008 (IAvH-A 14948). In the municipality of Piedecuesta, Santander, a fledgling was collected at Hacienda Las Vegas on 23 September 1949 (USNM 411791) and another was seen at at Finca Ramírez, vereda Parra Juan Rodríguez, on 13 July 2007 (J.E.A. pers. obs.). A similar periodicity for breeding has been recorded in *S. g. gilesi* (fledgling on 24 June 2008, ICN 35610) and *S. g. griseicollis* (nestlings and fledglings from June to December, ICN 35441, 36997, 38528, 38529, 373416, IAvH 10305, 12701, 13935, USNM 373416). Breeding periods in *S. griseicollis* throughout its range could be triggered by the timing of rainy seasons, which present two peaks in the Eastern Cordillera (April-May and September-November) (Morales et al. 2007).

Conservation. *S. griseicollis* is a range-restricted species mainly associated with patchy cloud forest and páramo of the northern Eastern Cordillera. A scenario of deforestation and habitat fragmentation affects the subpáramo-páramo belt of the entire Colombian Andes (Van der Hammen 2002). The west slope of the Eastern Cordillera, where most of the potentially suitable habitat for *S. g. morenoi* is found, represents the second most deforested cloud forest region in the Colombian Andes, with only small and more isolated fragments remaining (Morales-R and Armenteras-Pascual 2013). An unexpected small scale forest recovery was observed in the northern Andes (Eastern and Central Cordilleras) between 2001 and 2010, although this may have been influenced by the then prevailing security situation. Any increase in northern Andean Páramo has been slight and may have been wholly offset by expansion of potato plantations in the departments of Boyacá and Santander (Sánchez-Cuervo et al. 2012). Moreover, projected climate change is modelled to be particularly acute for higher elevations of the northern Eastern Cordillera in future (Velásquez-Tibata et al. 2012). The new subspecies occurs in few protected areas that have a broad elevational range (which might mitigate such threats). *S. griseicollis morenoi*, and the species as a whole, have doubtless suffered a significant reduction of potential area of occupancy as a result of man's influence on the habitats of the Eastern Cordillera. The largest national park established to protect East Andean montane forests, in Serranía de los Yariguíes, does not protect the new subspecies – which is replaced there by *S. g. gilesi*. Opportunities to expand other protected areas in the main East Andean range and to promote habitat connectivity in the region would be welcome (Sánchez-Cuervo et al. 2012). Several protected areas in the northern Eastern Cordillera, such as the Tamá binational National Park and the Páramo de Santurbán and Bosques Andinos Húmedos El Rasgón Regional Parks could harbour important populations of this subspecies. However, even these protected areas are threatened by a lack of on-the-ground protection measures or park staff and mining proposals.

This subspecies is locally abundant in well conserved high-Andean forests and páramos (Stiles and Rosselli 1998, Donegan and Avendaño 2008), and even in small and fragmented patches of habitat (Echeverry-Galvis and Morales-Rozo 2007, Peraza

2011), which suggests that local populations could resist extinction if some vegetation cover and connectivity is maintained. Further studies of the forests and organisms of the northern Eastern Cordillera are needed to clarify the potential ecological/geographic barriers which isolate different distinctive subspecies of the region (Avendaño et al. 2013) and to establish conservation priorities.

Discussion

Only eight of out 41 known species of *Scytalopus* exhibit geographic variation in plumage that has been recognised taxonomically at the subspecies level (Krabbe and Schulenberg 1997, 2003, Remsen et al. 2015). This suggests that plumage geographic variation within *Scytalopus* species is more the exception than the rule. However, several morphologically diagnosable populations occur in the Andes of Colombia which are either not fully diagnosable by vocal characters or which vary only in few vocal characters and respond to playback of one another (Donegan and Avendaño 2008, Donegan et al. 2013, López-O et al. 2013). This indicates that intraspecific geographical variation in the genus may have previously been overlooked and should be studied further in other species.

In Donegan and Avendaño (2008), we deferred describing *S. g. morenoi* due to the need for a more complete understanding of plumage variation and distribution of this population, particularly given the possibility of post-mortem colour changes, commonly referred to as 'foxing', which is prevalent in some *Scytalopus* (Krabbe and Schulenberg 1997). The type series of *S. g. morenoi* is sufficiently fresh to rule out foxing as the cause of the observed differences in dorsal plumage.

Geographical plumage variation in *S. griseicollis* is mainly in the hue of gray and brown in the underparts and upperparts, which are features that are considered influenced by differences in melanin concentration (Meunier et al. 2010, Galván and Møller 2013). The evolution of these plumage differences could be related to differences in humidity between populations' distributions, according to Gloger's rule (Donegan and Avendaño 2008). Certainly, the coincidence of darker populations (here, subspecies *S. g. gilesi*) in the very humid Yariguíes mountains reflects a pattern observed in several other species, including *Anisognathus lacrymosus* (Donegan and Avendaño 2010). Further work is necessary to determine if geographic variation in *S. griseicollis* and other members of the genus is correlated with selection pressures related with Gloger's rule such as thermoregulation (Walsberg 1983), background matching (Zink and Remsen 1986) or resistance to bacterial degradation (Burtt and Ichida 2004).

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Supplementary material 1

Examined specimens of *S. griseicollis*

Authors: Jorge Enrique Avendaño, Thomas M. Donegan

Data type: species data

Explanation note: Specimens of *S. griseicollis* examined at the American Museum of Natural History (AMNH), Colección Ornitológica Phelps (COP), Instituto Alexander von Humboldt (IAvH-A), Instituto de Ciencias Naturales (ICN), Museo de Historia Natural LaSalle (MLS), Museum National d'Histoire Nacional (MNHN); the National Museum of Natural History, Smithsonian Institution (USNM), and the Natural History Museum, Tring (BMNH).

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Supplementary material 2

List of localities of *S. griseicollis*

Authors: Jorge Enrique Avendaño, Thomas M. Donegan

Data type: occurence data

Explanation note: List of localities of *S. griseicollis* (geographical coordinates in decimal degrees and elevation in meters above sea level) used in ecological niche modelling analysis (Fig. 6). Acronyms for sound archives (CSA, Colección de Sonidos Animales-Instituto Alexander von Humboldt; XC, xeno-canto) and museums (IAVH-A, Colección de aves-Instituto Alexander von Humboldt; ICN, Instituto de Ciencias Naturales of Universidad Nacional de Colombia; COP, Colección Ornitológica Phelps).

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