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Review of the mite genus *Ololaelaps* (Acari, Laelapidae) and redescription of *O. formidabilis* Berlese

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Abstract

A species of laelapid mite, *Ololaelaps formidabilis*, is redescribed based on male and female adults from soil in Sumatra, Indonesia. This species is distinguished from other *Ololaelaps* species by its metapodal platelet narrowly fused with the parapodal plate and by its hologastric shield having two inverted-V-like ridges. The genus is redescribed based on a review of the literature and examination of specimens of some species. Valid species of *Ololaelaps* are listed and accompanied by notes on morphological characters to assist future revision of the genus.

Keywords

Gamasida, Indonesia, laelapid mites, rubber plantation, soil fauna, Sumatra

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Introduction

Laelapidae is a large, ecologically diverse family of Mesostigmata, with several species described from Indonesia, including symbionts of bees (Krantz 1998, Delfinado-Baker and Baker 1999, Lundqvist 1999), tarantulas (Moraza et al. 2009), beetles (Berlese 1910), and ectoparasites of small mammals (Vitzthum 1926, Tenorio 1975, Hadi and Tenorio 1982). Yet, the dearth of information on soil-dwelling Laelapidae in Indonesia is striking.

The cosmopolitan genus *Ololaelaps* was initially proposed by Berlese (1904) for a cluster of species characterized by a well-sclerotized idiosoma and particularly a genitiventral shield fused with the anal shield. However, two of the five species originally included in the genus merely have a genital shield abutting a ventrianal shield, and were later transferred to genera that are now included in the family Ologamasidae (*Hydrogamasellus coleoptratus* (Berlese), *Sessiluncus holostaspoides* (Canestrini), see Table 3). *Ololaelaps* species are found in soil and litter of wet meadows, forests and near water bodies (river banks, pond margins, seacoasts), as well as in rodent and insectivore nests, or less frequently on mammals themselves and in bird nests (Ryke 1962, Bregetova and Koroleva 1964). Laboratory rearing of a few species indicate that they are predators of nematodes, collembolans and other mites, and that they also scavenge on dead invertebrates (Hurlbutt 1958, Bregetova and Koroleva 1964, Walter et al. 1988). This genus includes 26 valid species names (Table 1) and only one has been recorded from Indonesia: *Ololaelaps formidabilis* Berlese, 1913. The genus clearly needs revision as the identity and taxonomic boundaries of most species are unclear, including most of the 11 species that have been described since the reviews of Ryke (1962) and Bregetova and Koroleva (1964).

The initial goal of this paper was to redescribe *O. formidabilis*, which was collected from soil in a rubber plantation (*Hevea brasiliensis* Müll. Arg.) near a lowland rainforest on the island of Sumatra, Indonesia. We took this opportunity to review the generic concept, based on the literature and examination of specimens of some species. We also present (1) a list of valid species of *Ololaelaps*, including notes on their most salient morphological features, and (2) a list of species that were previously classified as *Ololaelaps* but that have unclear taxonomic affinity (nomina dubia) or that now belong to other genera of Mesostigmata.

Materials and methods

This study is part of a larger investigation on arthropods of Indonesia within the framework of the interdisciplinary project "Ecological and socioeconomic functions of tropical lowland rainforest transformation systems (Sumatra, Indonesia)" – EFForTS. For details on the study region and the experimental design, see Drescher et al. (2016).

Soil and litter samples were taken, using a spade, from rubber plantation plots at the rainforests of Bukit Duabelas (National Park) and Harapan (National Forest), Jambi Province, Sumatra (see “Material examined” section for details on localities). Samples represented 16 × 16 cm of litter and soil taken down to a 5-cm depth. Mites were extracted from samples using a modified high-gradient canister method (Kempson et al. 1963). Mites were stored in 70% ethanol until clearing in 55% lactic acid and slide-mounting in Hoyer’s medium. Specimens were dissected prior to slide-mounting to separate the gnathosoma from the idiosoma.

Photographs and measurements were made using a compound microscope (Nikon Eclipse Ci or Leica DM5500B) equipped with phase contrast or differential interference contrast and connected to a computer-controlled digital camera (Sight Ds-L3 or Leica DMC4500). Most images were captured in stacks (with focal depth manually or electronically controlled). Selected images were combined using Zerene Stacker version 1.04 or Helicon Focus 6.7.1 Pro (Helicon Soft Ltd., 2000). Digital drawings were prepared using Adobe Illustrator, version CC 2015 (19.0.0), based on mite photographs that were first imported into the software.

All measurements are given in micrometers (μm) and presented as ranges (minimum–maximum). Lengths of shields were measured along their midlines, and widths at the widest point except for the sternal shield, measured at level of setae st2. Legs were measured from proximal margin of the coxa to the tip of tarsus, excluding ambulacrum (stalk, claws, pulvillus), and corniculi from their apex to the midpoint of their internal base. Spermatodactyl was measured from its point of departure from the movable digit to its apex. Notations of structures and idiosomal chaetotaxy generally follow Lindquist and Evans (1965), as slightly modified by Lindquist (1994); leg chaetotaxy follows Evans (1963) and Evans and Till (1965). Notations of idiosomal pore-like structures, as gland openings and poroids (proprioceptors, often called ‘lyrifissures’), follow mostly that of Athias-Henriot (1971, 1975) and secondarily Johnston and Moraza (1991), as applied by Kazemi et al. (2014) to Laelapidae.

Specimens of *O. formidabilis* are deposited in LIPI (Indonesian Institute of Science), Cibinong, Indonesia; the SMNG (Senckenberg Museum), Görlitz, Germany; and the CNC (Canadian National Collection of Insects, Arachnids and Nematodes), Ottawa, Canada.

Additional photos of the species are digitally deposited in the online database available at ecotaxonomy.org.

The diagnosis and description of the genus were prepared after consultation of previous diagnoses of the genus (Womersley 1956, Ryke 1962, Bregetova and Koroleva 1964, Evans and Till 1966, Bregetova 1977a, Keum et al. 2017, Joharchi et al. 2018) and species descriptions, as well as examination of specimens at hand of three described species (*O. formidabilis*, *O. placidus*, *O. placentula*), two tentatively identified species from Colombia (*O.* nr *dililoensis*) and Iraq (*O.* nr *mooiensis*) and at least three undescribed species from North America and Costa Rica. The species list in Moreira (2014) was consulted to aid in tracking species descriptions. Species authorships are presented in Table 1.

Table 1. List of valid *Ololaelaps* species (in bold) and synonyms (in regular font), type localities [and additional records], habitats and depository.

Species	Original genus	**Type locality** [other distribution records]	**Type habitat** [other records]	Type repository[1]	Notes and additional references (incl. for selected distribution records)
bregetovae Shereef & Soliman, 1980: 81	*Ololaelaps*	EGYPT: Giza	debris	FAC	
burdwanensis Bhattacharyya, 1978: 86	*Ololaelaps*	INDIA: Burdwan (West Bengal)	soil under grass beside pond	ZSI (presumably)	
caucasicus Bregetova & Koroleva, 1964: 73	*Ololaelaps*	RUSSIA: near Kizlyar (Dagestan); ARMENIA: Yerevan[2]	litter of *Elaeagnus* (Russia), litter under ash tree (Armenia)	ZIN	Bregetova 1977a
confinis Berlese, 1904: 261 **[?syn. of *placentula*]**	*Ololaelaps*	NORWAY	?	ISZA[3]	Not illustr. by Berlese (1904); synonymy by Ryke (1962), accepted by Evans and Till (1966); it's unclear (1) if types have been re-examined and therefore (2) if this syn. is valid (Bregetova and Koroleva 1964)
dililoensis Marais & Loots, 1972: 31	*Ololaelaps*	REPUBLIC OF THE CONGO: Eala	soil	KMMA	
expansus Ma, 2015: 95	*Pristolaelaps*	TAIWAN: Tainan	soil	AMMS	
flavus Ewing, 1909: 66 **[syn. of *placidus*]**	*Laelaps*	USA: Arcola (Illinois)	under log	USNM (lectotype)	Lectotype designated by Hennessey and Farrier (1988)
formidabilis Berlese, 1913: 82	*Ololaelaps*	INDONESIA: Semarang (Java); [Sumatra (this paper)]	? [forest litter]	ISZA[3]	
gamagarensis Jordaan & Loots, 1987: 49 **[syn. of *mooiensis*]**	*Ololaelaps*	SOUTH AFRICA: Gamagara River, Sishen	soil under grasses and reeds, on river bank	NWU	Synonymy by Nemati et al. (2018), based on types comparison and intraspecific variation of specimens from Iran
haemisphaericus Koch, 1839b: 16 **[?syn. of *sellnicki*]**	*Iphis*	GERMANY	marshy meadows	?	Recognized as *Ololaelaps* by Sellnick (1940: 69) and as *Stylochirus* (Ologamasidae) by others (see Table 3 and main text for details)
halaskovae Bregetova & Koroleva, 1964: 81 **[syn. of *venetus*]**	*Ololaelaps*	RUSSIA (widespread locations); UKRAINE (Zakarpattia Oblast); MOLDAVIA: Egorovka[2]	litter in meadows and forests; on small rodents or in their nests	ZIN	Synonymy by Evans and Till (1966)
hemisphaera Berlese, 1916b: 303	*Ololaelaps*	USA: Columbia (Missouri[4])	litter	ISZA[3]	Farrier and Hennessey 1993
holaspis Oudemans, 1902b: 53	*Hypoaspis*	ITALY: Sanremo	litter	RMNH	
interruptus Karg, 1994: 186	*Pseudoparasitus*	ECUADOR (Galápagos Islands): Cerro Banderas, 4 km NE of Santa Rosa, Santa Cruz island	litter of *Miconia* sp., in a cave	ZMB	
leptochelae Karg, 1994: 187	*Pseudoparasitus*	ECUADOR (Galápagos Islands): near El Puntudo, Santa Cruz island	moist litter in fern-sedge zone	ZMB	
magnichela Ewing, 1909: 65 **[syn. of *placidus*]**	*Laelaps*	USA: Muncie (Illinois)	moss	USNM (lectotype)	Lectotype designated by Hennessey and Farrier (1988)
mooiensis Ryke, 1962: 126	*Ololaelaps*	SOUTH AFRICA: Mooi River, Potchefstroom; [ANGOLA, IRAN]	damp soil on river bank; [soil, litter]	NWU	Marais and Loots 1972, Halliday 2005, Nemati et al. 2018
nasri Hassan, 1989: 593	*Ololaelaps*	EGYPT: Kafr Shokr	debris under citrus trees	?	

Species	**Original genus**	**Type locality** [other distribution records]	**Type habitat** [other records]	**Type repository**[1]	**Notes and additional references (incl. for selected distribution records)**
obovatus Womersley, 1960: 33	*Pristolaelaps*	AUSTRALIA: Koroit (Victoria)	?	SAM	
paratasmanicus Ryke, 1962: 127	*Ololaelaps*	NEW ZEALAND: Dunedin; [CHINA: Kunming]	bracken	NHMUK	Ma 2015
placentula Berlese, 1887: 3	*Laelaps*	ITALY: Vallombrosa; [widespread in Europe; CHINA, RUSSIA, USA, CANADA]	moss; [litter in forests and meadows, nest of small mammals]	ISZA[3]	Bregetova and Koroleva 1964, Lapina 1976, Farrier and Hennessey 1993, Luxton 1998, Gwiazdowicz and Klemt 2004, Salmane and Kontschán 2005, Bai and Ma 2014
placidus Banks, 1895: 128	*Laelaps*	USA: near Roslyn (New York); [CANADA]	wet moss; [litter]	MCZ	Lectotype designated by Hennessey and Farrier (1988); Farrier and Hennessey 1993
platensis Berlese, 1916a: 166	*Ololaelaps*	ARGENTINA: La Plata	?	ISZA[3]	
rectagoni Karg, 1993b: 269	*Pseudoparasitus* (*Ololaelaps*)	ECUADOR (Galápagos Islands): south of Wreck Bay, San Cristóbal island	moist and salty litter	ZMB	
sellnicki Bregetova & Koroleva, 1964: 77	*Ololaelaps*	RUSSIA, UKRAINE, LITHUANIA[2]; [widespread in western parts of Eurasia]	wet meadows, stream banks, coastal habitats, alpine meadows, rodent nests	ZIN	Bregetova and Koroleva (1964) proposed the name *O. sellnicki* to represent *O. haemisphaericus* (Koch 1839b) (see main text); Evans and Till 1966, Solomon 1968, Beron 1974, Lapina 1976, Kavianpour et al. 2017
sinensis Berlese, 1923: 252	*Ololaelaps*	CHINA: near Beijing	?	ISZA[3]	Originally described as *O. venetus* var. *sinensis*; Ryke (1962) Bai et al. (1996) and Karg (1978) use *sinensis* at species level; types may never have been re-examined
sitalaensis Bhattacharyya, 1978: 84	*Ololaelaps*	INDIA: Sonarpur (West Bengal)	litter under *Pistia stratiotes* at pond margin	ZSI (presumably)	
tasmanicus Womersely, 1956: 571	*Pristolaelaps*	AUSTRALIA: Tasmania; [USA: Hawaii; NEW ZEALAND]	strawberry plants; [moss, soil, on a rat]	SAM	Womersley 1960, Tenorio 1982
translineatus Barilo, 1991: 15	*Pseudoparasitus* (*Ololaelaps*)	UZBEKISTAN: Baysun	turf of [urban] park	SIZK	
ussuriensis Bregetova & Koroleva, 1964: 75	*Ololaelaps*	RUSSIA (Primorsky Territory)[2]; [CHINA]	on small rodents, in their nests, or soil	ZIN	Bregetova 1977a, Ren and Guo 2008
venetus Berlese, 1903: 14 [?jun. syn. of *placidus*]	*Laelaps* (*Hypoaspis*)	ITALY: Veneto[3]; [widespread in Europe and parts of Asia]	moss; [see records for *O. halaskovae*]	ISZA[3]	*Laelaps* (*H.*) *venetus* was proposed by Berlese (1903) for specimens misidentified as *Laelaps tumidulus* (Koch) in Berlese (1889: 5); as syn. of *O. placidus* in Hennessey and Farrier (1988); Luxton 1998, Gwiazdowicz and Klemt 2004, Ren and Guo 2008
wangi Bai, Gu & Wang, 1996: 74	*Ololaelaps*	CHINA: Southern Yinchuan; [SOUTH KOREA]	decaying *Zea mays*; [grassland soil]	EDC	Keum et al. 2017

? indicates unknown or uncertain data. [1]Type repository: AMMS – Academy of Military Medical Sciences, Institute of Microbiology and Epidemiology, Beijing, China; EDC – Institute of Endemic Disease Control, Ningxia Hui Autonomous Region, China; FAC – Faculty of Agriculture, Cairo University, Giza, Egypt; ISZA – Istituto Sperimentale per la Zoologia Agraria, Firenze, Italy; KMMA – Koninklijk Museum voor Midden-Afrika, Tervuren, Belgium; MCZ – Museum of Comparative Zoology, Harvard University, Cambridge, USA; NHMUK – The Natural History Museum, London, United Kingdom; NWU – North-West University, Potchefstroom, South Africa; RMNH – Naturalis Biodiversity Center, Leiden, The Netherlands; SAM – South Australian Museum, South Australia, Australia; SIZK – Schmalhausen Institute of Zoology of National Academy of Sciences of Ukraine, Kiev, Ukraine; USNM – United States National Museum, Beltsville, USA; ZIN – Zoological Institute of the Russian Academy of Sciences, St. Petersburg, Russia; ZMB – Museum für Naturkunde, Berlin, Germany; ZSI – Zoological Survey of India, Kolkata, India. [2]Localities based on type series. [3]Also based on Castagnoli and Pegazzano (1985), which provide information on specimens kept at the ISZA (= "Berlese Acaroteca"). [4]The type locality "Columbia (N.A.)" indicated in Berlese (1916b) is probably Columbia, Missouri (USA) because at least three species described in Berlese (1916) are from "Columbia (N.A.)" and later taxonomic revisions published by various authors indicate that the type locality for those species is Columbia, Missouri.

Taxononomic accounts

Genus *Ololaelaps* Berlese, 1904: 260

Pristolaelaps Womersley, 1956: 571. Synonymy by Ryke (1962).

Type species. *Laelaps* (*Hypoaspis*) *venetus* Berlese, 1903

Diagnosis (adult male and female, unless stated).Well-sclerotized hypoaspidine laelapid with a hologastric (genitiventrianal) shield in female, bearing 3–5 pairs of preanal setae (plus st5), as well as the following character states: dorsal shield covering entirely idiosoma dorsally, narrowly to broadly extending onto venter; bearing 39 or slightly fewer pairs of slender setae, including px2–3 and often one Jx. A pair of well-sclerotized presternal platelets. Female with seta st4 on sternal shield or on soft cuticle (or putatively on endopodal plate). Peritrematal shield free posteriorly or variously (narrowly) fused with hologastric and/or parapodal shields, via metapodal platelet; metapodal platelet free or variously fused to above-mentioned shields; parapodal plate well-developed, subtriangular. Soft opisthogastric cuticle with 5–10 pairs of setae. Male holoventral shield broad, fused to parapodal-exopodal plates, sometimes also to peritrematal shield. Gnathotectum convex, with few to numerous fine denticles; deutosternal groove with six rows of 1–10 denticles; female cheliceral movable digit with two teeth (rarely more), fixed digit with 3–5 (exceptionally 8); palp-apotele three-tined, third tine reduced. Leg chaetotaxy normal for Laelapidae; setae generally slender.

Description. ***Dorsal idiosoma*.** Dorsal shield relatively large (435–800 in female), broadly oval to narrowly suboval (length/width ratio 1.2–1.8), completely covering idiosoma dorsally, barely to moderately extending ventrally (this can be determined most accurately before slide-mounting); shield smooth (except for fine granulation or punctuation) to strongly reticulate; shield's ventral extension ('epipleura' of Bregetova and Koroleva (1964)) smooth to reticulate (sometimes in contrast to smooth dorsal region of shield); shield with a delineated marginal strip along its edge. Dorsal shield bearing 39 pairs of simple, slender, almost hair-like setae, short to moderately long, including px2–3, and often one unpaired median seta (Jx) inserted at a level between J2 and J3 (Table 2); sometimes fewer than 39 pairs of setae, with z1 (absent in *O. sellnicki*), z3 (see Evans and Till 1966), or setae in r or S series apparently absent; shield never hypertrichous; setae slender and smooth, occasionally with a few light barbs on Z5 and J5 (Jordaan and Loots 1987). Shield with 16 pairs of poroids and four or five pairs of gland openings (based on Bregetova and Koroleva (1964) and specimens examined, representing a few species only): gd1, gd2 (sometimes absent), gd4 (usually conspicuous, on or near shield margin), gd6, gd9.

***Ventral idiosoma*.** Tritosternum normal, with two pilose laciniae. Presternal region with a pair of sclerotized platelets, wedge-shaped to subrectangular, lineate (typically with 2–4 transversal lineae); typically an additional, poorly sclerotized area, lineate and granulate, anteriorly or anteromesally adjoining each platelet. Female sternal shield as long as or longer than wide, sometimes wider than long; shield length/

width ratio 0.6–1.8; Shield posterior margin straight, slightly to moderately concave, or sometimes convex; shield reticulate, smooth in its posterior fourth or fifth, bearing 3–4 pairs of simple setae and 2–3 pairs of poroids, therefore sometimes including seta st4 and poroid iv3; seta st4 on sternal shield (near or on its posterolateral edge), on soft cuticle, or apparently on endopodal plate (Table 2; see Discussion). Female hologastric shield broad, laterally extending to or beyond margin of parapodal (or adcoxal, Bregetova (1977a)) plate, overlapping sternal and endopodal shields, bearing usually five pairs of preanal setae (JV1–3, ZV1–2) in addition to seta st5, occasionally only three or four pairs of preanals (JV3 and/or ZV2 off shield) or exceptionally six (ZV3 apparently on shield in *O. rectagoni*); shield setae usually moderately long, sometimes short; hologastric shield ornamented with reticulation, cells polygonal, scale-like or elongate transversally (note that shield reticulation is not drawn for some species in Ryke (1962), but probably present; compare *O. mooiensis* in Ryke (1962) vs Marais and Loots (1972)); circumanal setae shorter than preanals, and postanal usually shorter than paranal setae; cribrum typically with 2–3 rows of spicules. Endopodal plate besides coxae III–IV well-developed (appears reduced in *O. dililoensis*, but the portion of endopodal plate that is overlapped by hologastric shield may have been overlooked); plate free, more or less contiguous with sternal shield (or apparently fused to it, e.g., *O. expansus* (Ma 2015)) or slightly overlapped by it. Peritrematal shield well-developed, fused to dorsal shield anteriorly, usually free posteriorly, reaching approximately posterior margin of coxa IV, occasionally only mid-coxa IV, or moderately surpassing coxa; sometimes narrowly connected to hologastric shield and/or parapodal element; peritrematal shield posteriorly bifid in some species (*O. interruptus*, *O. leptochelae*, and an undescribed species from North America). Peritreme narrow, usually reaching anteriorly level of coxa I, sometimes slightly less. Parapodal plate well-developed, subtriangular, with outer margin convex (especially when peritrematal shield free and not extending beyond coxa IV) or straight (typically when peritrematal shield extended posteriorly or fused to hologastric shield); parapodal exceptionally not produced in *O. rectagoni* (Table 2) and an undescribed species from Costa Rica; parapodal posteriorly free, more or less abutting hologastric shield, or narrowly fused to hologastric and/or peritrematal shields, via metapodal element as connecting 'bridge'. Metapodal platelet entirely free, suboval to strip-like, or variously fused to hologastric shield, parapodal and/or peritrematal plates. Exopodal strip well-developed, fused to parapodal element posteriorly, and anteriorly to sternal shield between coxae I–II. Soft opisthogastric cuticle surrounding shield with 5–10 pairs of simple setae, often including 1–2 pairs of r-R setae isolated at level near parapodal plate; never hypertrichous. Male holoventral shield fused to parapodal-exopodal elements, sometimes also to peritrematal shield, bearing 3–5 preanals (JV1–3, ZV1–2; JV3 and ZV2 sometimes off shield, e.g., *O. ussuriensis*); metapodal element merged with holoventral shield.

Gnathosoma. Gnathotectum with subtriangular to rounded margin, usually finely denticulate, may appear smooth when denticles sparse or (possibly) absent. Deutosternal groove of moderate, regular width, or slightly tapering posteriorly, with six (occasionally seven, and rarely five) rows of denticles, each row bearing 1–10 denticles, most of the rows with 3–7 denticles; denticulate rows usually preceded by a smooth ridge anteriorly, and sometimes also posteriorly. Corniculi horn-like, of moderate length. Internal malae with two pairs of long projections, median pair fimbriate on its basal portion, lateral pair smooth or branched or fimbriate in its apical portion; lateral projection absent in males (and apparently in the female of *O. sitalaensis*). Palptarsal claw three-tined, third tine reduced. Chelicerae of moderate length, chelate-dentate; female movable digit with two moderately-sized teeth, rarely more (two additional small teeth between the two typical large teeth in *O. interruptus*; Table 2); fixed digit with 3–5 teeth, variously sized, rarely more (eight in *O. leptochelae*), including a subapical, laterally offset tooth (gabelzhan); male digits each with a single tooth; pilus dentilis setiform; arthrodial process a simple corona. Male spermatodactyl 0.7–2.0 × as long as movable digit, from its departure from edge of digit; more or less straight or variously bent; junction between spermatodactyl and movable digit straight to strongly angled (*O. translineatus*); duct inside spermatodactyl straight or sinuous. Chaetotaxy of subcapitulum and palps normal for Laelapidae (sensu Evans and Till 1965).

Legs. Chaetotaxy normal for Laelapidae (sensu Evans and Till 1965); most setae slender; ventral and/or subapical setae of tarsi II–IV usually moderately thickened, sometimes lateral setae too (e.g., al2, pl2–3 of tarsus IV); setae on other leg segments occasionally thickened (e.g., pd2, ad3 on femur I, pd on femur III in *O. placentula*; also dorsally on femur IV in *O. mooiensis* (Jordaan and Loots 1987)). Males of some species with a spine-like seta on femur II (*O. translineatus*); pv thickened on genu or tibia III (in undescribed species); a ventral spine on tarsus II, apparently representing pv2 (position shifted proximad) (e.g., *O. venetus*, *O. placentula*, *O. ussuriensis*); or with cuticular tubercles on various leg segments (femur and genu of *O. placentula*, *O. ussuriensis*). Ambulacra I–IV with well-developed paired claws and pulvillus.

Spermatheca. Spermathecal ducts well-sclerotized and discernable in some species.

Remarks on the genus

We herein recognize 26 valid species names in the genus *Ololaelaps*, and at least four synonyms (Table 1). The majority of species need redescription, including four species that are nearly entirely unknown morphologically (*O. hemisphaera*, *holaspis*, *platensis*, *sinensis*). While some species are relatively well understood (e.g., *O. formidabilis*, *placentula*, *sellnicki*, *ussuriensis*, *wangi*), they nevertheless require additional study to elucidate intraspecific variability, in turn to better distinguish them from close relatives (Table 2). Table 2 presents some of the available diagnostic features of species, which are few. Indeed, identification of most species is problematic; our attempt to prepare a useful key to species was unsuccessful, due to the limited set of reliable diagnostic characters for most species. Other characters not presented in Table 2 may become useful (see Discussion), but intraspecific variability and their diagnostic potential remain to be determined. The case of *O. mooiensis*, a senior synonym of *O. gamagarensis* as established by Nemati et al. (2018), is a good example of intraspecific variation of

Table 2. Some diagnostic features of valid *Ololaelaps* species based on the literature, except for a few species for which type (**) or voucher (*) specimens were examined. Species are sorted in groups based on shared features, mainly the various fusion of shields ventrally (groups may or may not reflect relatedness).

Species	Shared features (mostly fusion of shields^1)	Dorsal shield ornamentation^1	Epipleura^2 ornament.	Dorsal seta *Jx*	Insertion of *st4*^{3}	Other features^1	Notes and references (redescriptions)
venetus	(1) all shields (HOLOG + METAP + PERIT + PARAP) narrowly fused together; (2) spermatod. with sinuous duct; (3) spermathecae well-sclerotized, distinctive	smooth with sculptured areas anteriorly (Evans and Till's text)	smooth	1	stern.	*JV3*, *ZV2* setae sometimes off HOLOG	Ryke 1962, Bregetova and Koroleva 1964, Evans and Till 1966, Bregetova 1977a
placidus*		smooth except light reticul. near ant. margin	smooth	0–1	stern.	as above	Hennessey and Farrier 1988, F.B. pers. obs.
sellnicki		as *venetus*; reticul. visible only when freshly moulted (Bregetova and Koroleva 1964)	smooth?^{4}	1	stern.	*JV3*, *ZV2* off HOLOG; *z1*, *z3* absent	Evans and Till 1966, Solomon 1968, Bregetova 1977a, Kavianpour et al. 2017; also Sellnick (1940), as *O. haemisphaericus*
hemisphaera	HOLOG + METAP + PERIT fused [PARAP apparently free]	?	lineate-reticulate?	?	soft cut.?	broad idiosoma	not illustr. in Berlese (1916b); partly illustr. in Ryke (1962), possibly based on Berlese's types or drawings (see Ryke's introduction)
interruptus	(1) HOLOG + METAP + PERIT narrowly fused [PARAP clearly free]; (2) PERIT notched post.	?	?	1	soft cut.	MD with 2 small teeth in-between the 2 standard teeth; broad idiosoma	
leptochelae		?	?	?	?	FD with a total of 8 teeth	
burdwanensis	HOLOG + METAP + PARA narrowly fused [PERIT free]	?	lineate-reticulate	1	soft cut.?		
translineatus		smooth?	lineate-reticulate	1	soft cut.?	sternal shield with transverse ridge; spermatod. at 90° angle from MD; spermath. distinctive	similar to *O. burdwanensis*
wangi		smooth except lineate anteriorly	lineate-reticulate	0	soft cut.?	only 2–4 deutosternal denticles / row	similar to *O. burdwanensis*; Keum et al. 2017
formidabilis*,**	only METAP + PARAP fused	light reticul.; lighter and sparser anteriorly	reticulate	0–1	soft cuticle	HOLOG with inverse V-shaped ridges; spermatod. elongate; spermath. not discerned	*O. formidabilis* sensu Ryke (1962) differs: METAP partly fused to HOLOG, not to PARAP
caucasicus	only HOLOG + METAP (partly to completely) fused	similar to *placentula* or *ussuriensis*?	lineate-reticulate	0–1	stern. or soft cut.	broad idiosoma; spermatheca not discerned	similar to *O. ussuriensis*; Bregetova 1977a
dililoensis		dense scale-like reticul. post., smooth or scattered reticul. ant.	reticulate	0	soft cut.	broad idiosoma	

Species	Shared features (mostly fusion of shields[1])	Dorsal shield ornamentation[1]	Epipleura[2] ornament.	Dorsal seta *Jx*	Insertion of *st4*[3]	Other features[1]	Notes and references (redescriptions)
holaspis	only HOLOG + METAP (partly to completely) fused	reticulate? (Oudemans' text says "all shields with large scales")	?	?	soft cut.?	elongate idiosoma	Oudemans (1903: 11) provided a more complete description than Oudemans (1902b); partly illustr. by Ryke (1962)
mooiensis		reticulate; reticul. sparser anteriorly	?	0–1	soft cut. or endop.?	elongate idiosoma; METAP rarely free (based on syn. *O gamagarensis*)	Marais and Loots 1972, Jordan and Loots 1987, Nemati et al. 2018 (notes on characters)
placentula*		essentially smooth (finely granulate) or faintly reticulate	lineate-reticulate	0	stern.	broad idiosoma; sternal shield wider than long, with concave margin; PERIT reaching past coxa IV; spermatheca not discerned	Sellnick 1940: 69, Ryke 1962, Bregetova and Koroleva 1964, Evans and Till 1966, Bai and Ma 2014
platensis		?	?	?	soft cut.?	peritreme short, reaching between coxae I–II; *ZV1* absent?	Ryke 1962 (partial illustration)
rectagoni		?	?	0	soft cut.?	*j1* seta elongate; broad idiosoma and HOLOG; PARAP truncate; *ZV3* apparently on HOLOG	Karg 1994 (male chelicera and spermatodactyl)
sinensis		?	?	?	soft cut.?		Ryke 1962 (partial illustration)
ussuriensis		polygonal reticul. scarcely evident (text)	lineate-reticulate	0?	stern.	spermatheca not discerned; only 2–3 deutosternal denticles / row	Bregetova 1977a
bregetovae	all shields (HOLOG, METAP, PERIT, PARAP) free	with (scale-like?) reticulation post.	?	0?	?	elongate idiosoma	similar to *O. tasmanicus* and *O. sitalensis*?
expansus		?	?	0?	soft cut.		
nasri		finely granulate?	lineate-reticulate?	0	soft cut.?	broad dorsal and sternal shields	similar to *O. obovatus*
obovatus		smooth?	?	?	soft cut.	broad idiosoma; *ZV1* absent?	
paratasmanicus		reticulate	?	0	soft cut.	elongate idiosoma; HOLOG rounded laterally	similar to *O. tasmanicus*; Ma 2015
sitalaensis		?	reticulate	1	soft cut.?	elongate idiosoma	
tasmanicus		lightly reticulate (Womersley's text)	?	0	soft cut.	Tenorio (1982) indicates broader idiosomal shields than those in Womersley (1956)	Tenorio 1982 (photograph)

? indicates unknown or uncertain data. [1]"Shields" include: HOLOG – hologastric, METAP – metapodal, PARAP – parapodal, PERIT – peritrematal; other acronyms or abbreviations: FD – fixed digit; MD – movable digit; ant. – anteriorly; post. – posteriorly; reticul. – reticulate or reticulation; spermatod. – spermatodactyl; spermath. – spermatheca. [2]Epipleura: portions of the dorsal shield that extend ventrolaterally (see Bregetova and Koroleva 1964); "lineate-reticulate" emphasizes that cells of the reticulation are stretched out so that they appear mostly as (parallel) lines (also parallel to the shield margin) instead of the typical scale-like (e.g., Fig. 1) or polygonal reticulation (Fig. 2, sternal shield) ("reticulate"). [3]Seta *st4* inserted on sternal shield ("stern."), soft cuticle ("soft cut.") or endopodal plate ("endop."). [4]Bregetova and Koroleva's (1964) text (for female) and illustrations (figs 17, 19: female and male, respectively) indicate that *O. sellnicki*'s epipleura are smooth, but Evans and Till's (1966) illustration of the male shows epipleura with reticulation posteriorly.

characters, including the degree of fusion of the metapodal platelet – free to completely fused – with the hologastric shield, and the length of sternal setae. These two characters were apparent differences between *O. mooiensis* and *O. gamararensis* (Jordaan and Loots 1987) but now appear as mere variation along a range within a single species (A Nemati pers. comm.). Other names in Table 2 may represent synonyms.

The identity of *Iphis haemisphaericus* (Koch 1839b) is complicated. The species is placed by some authors in *Ololaelaps* (Laelapidae) and in *Stylochirus* (Ologamasidae) by others (Table 3). Berlese (1914) redescribed the species as *Gamasiphis* (*Periphis*) *haemisphaericus* (Koch) based on non-type specimens that he collected from Italy. Following Berlese's concept, Sellnick (1958) and Vitzthum (1943) mention *Periphis haemisphaericus* (Koch), and Lee (1970) redescribed the species as *Stylochirus* (= *Periphis*) *haemisphaericus* using female specimens from Italy that Berlese (1914) himself had studied for his description. *Stylochirus haemisphaericus* (Koch) is listed in the catalogue of Ologamasidae by Castilho et al. (2016).

Meanwhile, Sellnick (1940) redescribed the species as *Ololaelaps haemisphaericus* (Koch). His interpretation of *haemisphaericus* as an *Ololaelaps* species has been followed by some authors (Haarlov 1943, Franz and Beir 1948, Willmann 1949, 1950, 1952, Piryanik 1962, Reitblat 1963) until Bregetova and Koroleva (1964) proposed *O. sellnicki* as a nom. nov. for *O. haemisphaericus* (Koch 1839b). Bregetova and Koroleva (1964) argued that using a new name was better than using the confusing name *haemisphaericus*, which was also applied to other species in at least one other family. Before Sellnick (1940), Oudemans (1906, 1929, 1936) mentioned *Iphis haemisphaericus* as conspecific either with *O. placentula* or with *O. venetus*. Oudemans (1936: 217) stated that Berlese erroneously identified a different species as "*Periphis haemisphaericus*" (certainly referring to Berlese 1914).

There is no indication that anyone examined Koch's types of *haemisphaericus*, and the types of most species described by Koch are presumably lost. Therefore, it may be impossible to confirm with certainty whether Koch's species is *Stylochirus* or *Ololaelaps*. Resolving this dual identity of *Iphis haemisphaericus* (Koch 1839b) will require submitting a case to the International Commission of Zoological Nomenclature. Because the name *Ololaelaps sellnicki* Bregetova and Koroleva is frequently used, and the name *haemisphaericus* Koch has been more recently applied in the sense of an ologamasid and not as an *Ololaelaps* species, the best approach may be to designate (1) a neotype for *Stylochirus haemisphaericus* (Koch 1839b) and (2) a lectotype for *Ololaelaps sellnicki* Bregetova and Koroleva (1964) in order to maintain the prevailing concepts of these names. Note that Bregetova and Koroleva (1964) had not designated a type for *O. sellnicki* since they treated *sellnicki* as a replacement name for *haemisphaericus*, but the specimens they studied can be considered as syntypes.

Hennessey and Farrier (1988) synonymized *O. venetus* (Berlese 1903), a Palearctic species (and the type species of the genus), with *O. placidus* (Banks 1895), a species otherwise previously restricted to the Nearctic region. However, despite Hennessey and Farrier's (1988) analysis, we refrain from accepting this synonymy because we consider that these two species (or populations) from North America and Eurasia are not known in sufficient details yet (see further explanations in the Discussion).

Table 3. List of species that have been previously considered in *Ololaelaps* (as genus or subgenus), but herein excluded or considered dubious species (nomina dubia).

Species	Original genus	Current genus	Key sources for current placement	Sources placing it in *Ololaelaps*	Additional notes	Type locality
coleoptratus Berlese, 1888: 198	*Hypoaspis*	*Hydrogamasellus* (Ologamasidae)	Castilho et al. 2016	Berlese 1904: 261	Lee (1970: 113) redescribed the species based on types	ARGENTINA: Buenos Aires
festivus Koch, 1839b: 8	*Zercon*	nomen dubium	–	Oudemans (1936: 216); he considered *Z. festivus* may be the deutonymph of *Iphis haemisphaericus* Koch, which he considered in turn as a syn. of *O. placentula*; Turk (1953: 12) accepted this syn., with *Hyletastes festivus* (Koch) (Laelaptidae) as the valid name	See also Koch (1842: 91), Sellnick (1940: 68); the concept of the genus *Hyletastes* is not clear (see notes for *Iphis globulus* below)	GERMANY: Neumarkt
germanicus Karg, 1965: 277	*Ololaelaps* (*Cypholaelaps*)	*Pseudoparasitus* (Laelapidae)	Karg 1971, 1993a; Bregetova 1977a	Karg 1965		GERMANY: Zörbig
globulus Koch, 1839b: 17	*Iphis*	nomen dubium	–	Oudemans (1902a: 289) considered *I. globulus* (as *Hypoaspis*) as syn. of *O. placentula*	Vitzthum (1943: 766) placed *Iphis globulus* as the type species for *Hyletastes* (see also Oudemans 1936: 216, 218, 221)	GERMANY: Regensburg
haemisphaericus Koch, 1839b: 16	*Iphis*	nomen dubium: either *Stylochirus* (Ologamasidae) or *Ololaelaps* (as syn. of *O. sellnicki;* see Table 1 and main text)	Castilho et al. 2016 (as *Stylochirus*)	Sellnick (1940) and subsequent authors (e.g., Willmann 1949, 1952, Halašková and Kunst 1961)	Lee (1970: 194) redescribed the species based on specimens identified by Berlese (1914: 142); Koch's types seem to never have been re-examined	GERMANY
haemisphaericus Berlese, 1916a: 166	*Ololaelaps* (*Cypholaelaps*)	nomen dubium; note that *Cypholaelaps semiglobulus* Vitzthum (1935) was considered similar to *Cypho. haemisphaericus* (Berlese)	–	Berlese (1916a), Vitzthum (1943: 763), as *O.* (*Cypholaelaps*); Karg (1965: 271), using a concept of *O.* (*Cypholaelaps*) for species now in *Pseudoparasitus*; Karg (1971) and Karg (1993a) mention it (wrongly) as syn. of *Pseudoparasitus* (*O.*) *sellnicki*	Berlese's (1916a) species description incl. an "anal shield obtriangular", in accord with description of subgenus *O.* (*Cypholaelaps*) (Berlese 1916a), which incl. an anal shield separate from (though contiguous to) a genitiventral shield	ARGENTINA: La Plata
holostaspoides Canestrini, 1884: 700	*Laelaps*	*Sessiluncus* (Ologamasidae)	Bregetova 1977b; Castilho et al. 2016; see also Bregetova and Koroleva (1964)	Berlese 1904: 260; Oudemans (1902b, 1903) compares *holostaspoides* Can. with *holaspis* Oud. (as *Hypoaspis* spp.)	Unclear if types have been examined, but Canestrini (1884) indicates there are 3 shields ventrally, incl. an intermediate, semicircular shield (probably epigynal), which excludes it from *Ololaelaps*	ITALY: Messina
inornatus Johnston, 1849: 305	*Eumaeus*	nomen dubium	–	considered a sen. syn. of *Ololaelaps confinis* in Turk (1953: 12), within genus *Hyletastes*	See notes for *Z. festivus* above, and Oudemans (1936: 222)	UK (Scotland): Berwickshire
pergibbus Berlese (in Castagnoli and Pegazzano 1985: 316)	*Ololaelaps*?	species name not available	–	Castagnoli and Pegazzano 1985	The species name was not published (see Castagnoli and Pegazzano 1985), therefore it is not available (ICZN article 11.1)	CHINA

Nonetheless, we accept for now the synonymy of *O. venetus* and *O. halaskovae* (the latter is also Palearctic), which was originally proposed by Evans and Till (1966) and also accepted by Bregetova (1977a). However, Evans and Till (1966) did not specify what specimens they used for their redescriptions of *O. venetus* and *O. placentula* and whether they examined Berlese's types.

Some species names once considered as *Ololaelaps* are herein excluded from the genus, based on the interpretation of the original description or more recent publications (Table 3): the two ologamasids *Hydrogamasus coleoptratus* and *Sessiluncus holostaspoides*, the laelapid *Pseudoparasitus germanicus*, and the nomen dubium *Ololaelaps* (*Cypholaelaps*) *haemisphaericus* Berlese (not Koch). The type of the latter should be re-examined. From our current understanding, other species with doubtful identity cannot be excluded from *Ololaelaps* with certainty: *Zercon festivus*, *Iphis globulus* and *Eumaeus inornatus* (Table 3). Unfortunately, the types of those species may be lost. Note that *Ololaelaps* is distinct from '*Oolaelaps*' which usually refers to species now placed in *Holostaspis* (Laelapidae) (Keum et al. 2017).

Although Evans and Till (1966) treated the genus *Ololaelaps* as feminine (indicated by *O. venetus*), Berlese (1904) originally treated it as masculine, indicated by two species that he originally included in the genus which had names in adjectival forms with clear masculine ending: *O. venetus* and *O. coleoptratus*. We herein follow Berlese and treat *Ololaelaps* as masculine for the following reason. As per Article 30.1.1 of the ICZN, "a genus-group name that is or ends in a Latin word takes the gender given for that word in standard Latin dictionaries". The name *Ololaelaps*, as created by Berlese, probably stands for '*holo*', ancient Greek for 'complete', putatively referring to the nearly completely sclerotized idiosoma, or opisthogaster, of the mites he included in the genus at the time; and '*laelaps*', borrowed from the generic name *Laelaps*, first used by Koch (1836). Like Berlese (e.g., *Laelaps spiniferus* Berl., *L. myrmecophilus* Berl.), Koch appears to have treated *Laelaps* as masculine (as in *L. festinus* Koch 1839a). In Latin dictionaries (e.g., Lewis and Short 1879), *Laelaps* is masculine and refers to the Greek mythological dog of that name. Koch's choice itself was almost certainly for that mythological hound which was known to never fail to catch its prey. 'Laelaps' was originally borrowed from Greek and means 'hurricane'. Treating *Ololaelaps* as masculine results in the change of a single species name from its original ending: *O. obovata* to *O. obovatus*. Note that some species names are feminine, such as *placentula* (= little cake) and *hemisphaera* (= hemisphere), but these are nouns in apposition and have therefore invariable spellings, irrespective of the gender of the genus.

Ololaelaps formidabilis **Berlese, 1913**

Figs 1–8

Diagnosis. Dorsal shield broad, length/width ratio ~1.3–1.4, lightly reticulate, bearing 39 pairs of simple setae, including *px2–3*, plus one unpaired seta *Jx* (sometimes absent); all setae short (21–27; j1, z1, J5 shorter); shield with gland opening gd4 conspicuous,

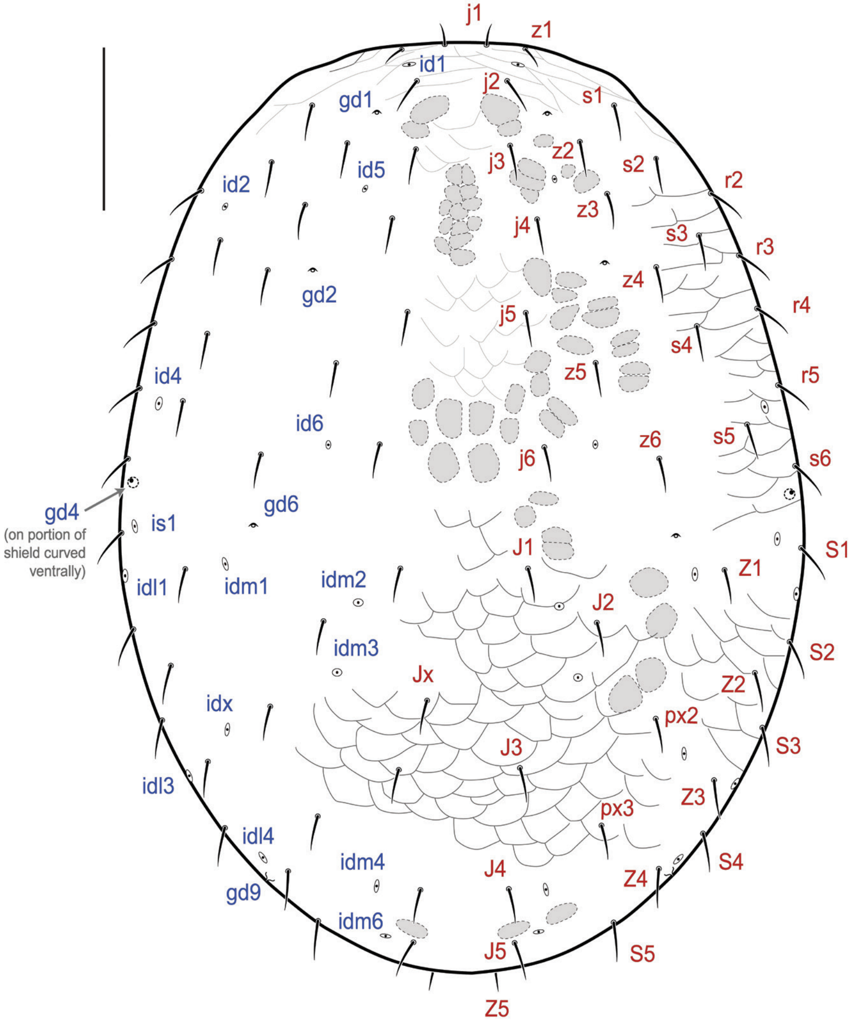

Figure 1. *Ololaelaps formidabilis*, adult female. Dorsal idiosoma. Note that setae *Z5* and poroid *idm5* are inserted on the ventral portion of the dorsal shield (see Fig. 2). Grey zones represent sigillae. Scale bar: 100 µm.

on shield margin; epipleura narrow, strongly reticulate. Female sternal shield as long as wide (length/width ratio 0.96–1.02), bearing setae st1–st3; seta st4 and poroid iv3 on soft cuticle. Hologastric shield with two inverted V-like ridges, and strongly reticulate; cells scale-like in region anterior to anus, bearing seta st5 and five pairs of preanal setae. Soft opisthogastric cuticle laterad of shield with nine pairs of setae. Peritrematal shield free posteriorly, reaching level of coxa IV posterior margin. Metapodal shield suboval, narrowly fused to parapodal shield (and contiguous with hologastric shield) in female. Deutosternal groove with 3–5 denticles per row. Spermatodactyl prominent, 1.8× as long as movable digit.

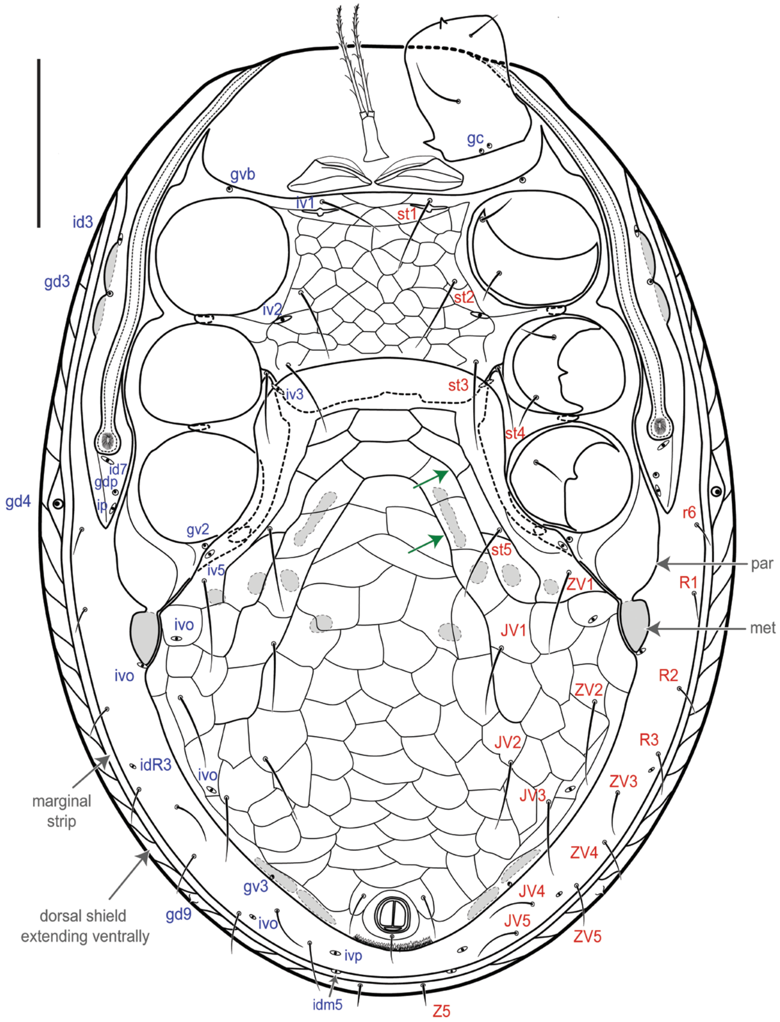

Figure 2. *Ololaelaps formidabilis*, adult female. Ventral idiosoma. Green arrows show the two inverted V-shaped ridges; other arrows indicate parapodal ("par") and metapodal ("met") plates. Scale bar: 100 µm.

Female (Figs 1–5) (n = 3). **Description.** ***Idiosomal dorsum*** (Figs 1, 2, 3B). **Dorsal shield** 567–607 long, 410–440 wide (near level of seta S1), covering all dorsal idiosoma, oval-shaped, dome-like, strongly sclerotized and slightly covering ventrolateral margins (epipleura), with a light reticulation on most areas of shield, more conspicuous in opisthonotal region (as shown in region of J3 vs region between j5 and z6) and epipleura strongly reticulate; region anterior to setae j2–s1 with conspicuous, transverse lineae; shield with a delineated marginal strip along its edge (Figs 2, 3A). Shield with 39 pairs of simple setae: j1–j6, z1–z6, s1–s6, r2–r5 on podonotal region, J1–J5, Z1–Z5, S1–S5, px2–3 on opisthonotal region, and usually one unpaired seta Jx

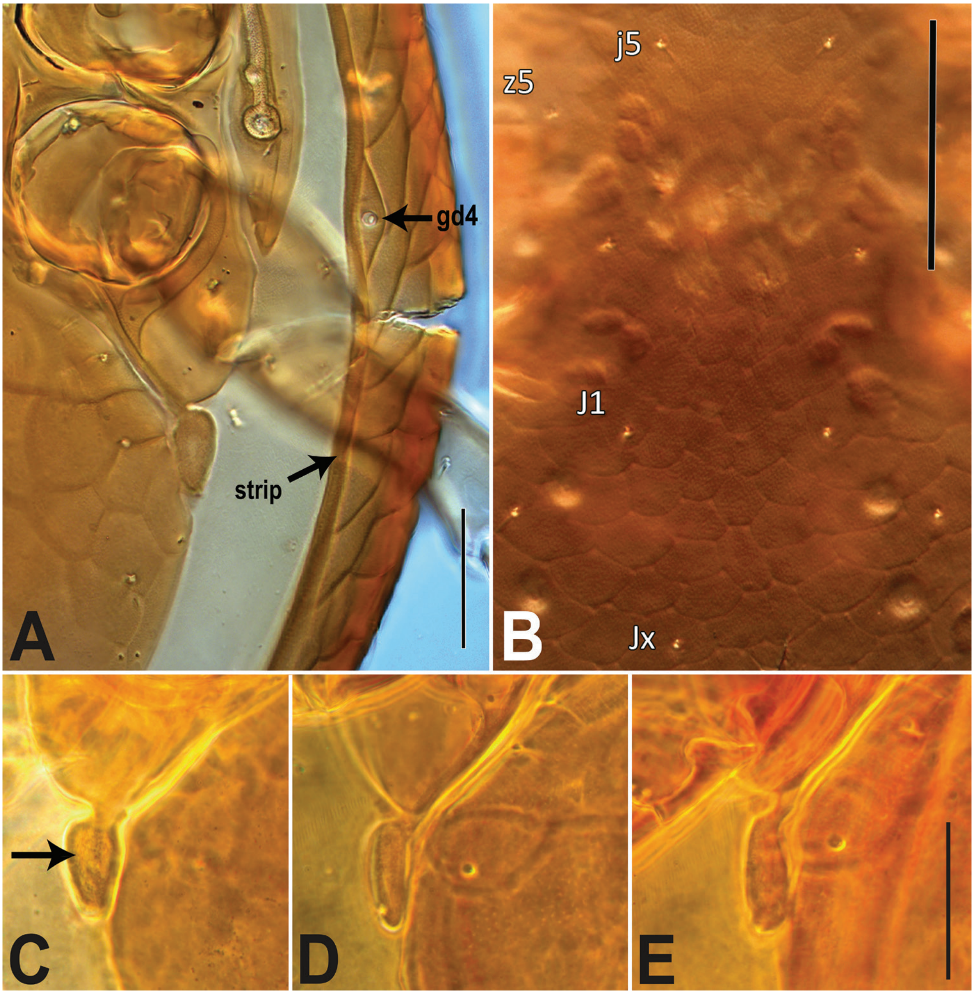

Figure 3. *Ololaelaps formidabilis*, adult female. **A** ventrolateral region of idiosoma, showing the well-reticulated epipleuron (ventrolateral portion of dorsal shield), gland opening gd4, and the dorsal shield's marginal strip ("strip"); note that the epipleuron appears broader than in live specimen, because the specimen was squashed on the slide, as indicated by the broken dorsal shield **B** central region of the dorsal shield, showing the light reticulation of the opisthonotal area (near J1, Jx) and even lighter reticulation of the podonotal area (see between setae j5) **C–E** metapodal platelet (arrow), variously fused to the parapodal plate and contiguous with the hologastric shield. Scale bars: 50 µm (**A**); 100 µm (**B**); 50 µm (**C–E**).

(absent in one of three females) inserted on right side (one female) or left side (another female) of shield's median axis. All dorsal setae slender, relatively short (21–27), with j1, z1 and Z5 shorter (11–15); distance between J5 setae 62–66, distance between Z5 setae 40–46. Dorsal shield with 21 pairs of pore-like structures, including five pairs of gland openings (gd1, gd2, gd4, gd6, gd9) and 16 pairs of poroids; gd4 large, on lateral shield margin (discernible ventrally), posterolaterad of s6 (and level with mid-coxa IV), surrounded by a curved linea (Figs 2, 3A).

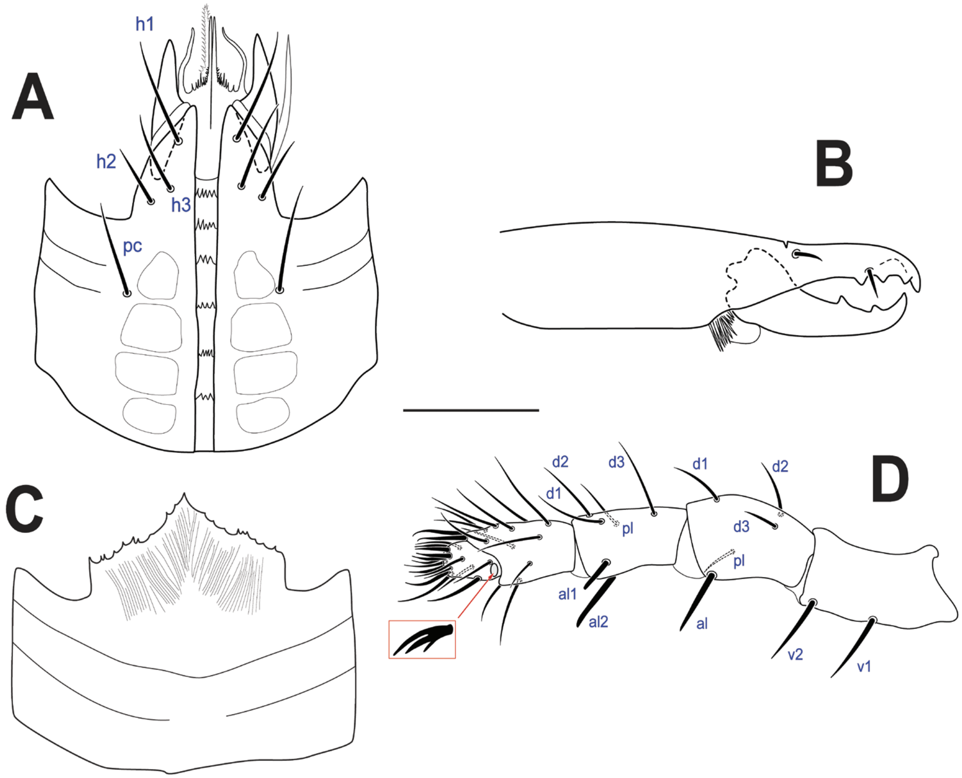

Figure 4. *Ololaelaps formidabilis*, adult female **A** subcapitulum **B** chelicera (antiaxial view) **C** gnathotectum **D** palp, with inset showing palp apotele. Scale bar: 50 µm.

Idiosomal venter (Figs 2; 3A, C–E). **Tritosternum** with columnar base and a pair of pilose laciniae. **Presternal area** with a pair of well-sclerotized presternal platelets, wedge-shaped, with transverse lineae; region anteromesal to platelets poorly sclerotized, lineate and granulate. **Sternal shield** 118–125 long, 122–125 wide (at level of setae *st2*), strongly reticulate, smooth in posterior fifth where overlapped by hologastric shield, with inconspicuous punctae; anterior shield margin straight and posterior shield margin slightly concave, bearing three pairs of simple, slender setae, st1–3 (44–65), and slit-like poroids iv1–2; st1–st1 distance 65–70, and st1–st3 distance 93–98; st4 (45–48) and iv3 on soft cuticle (which may overlap endopodal plate), near posterolateral margin of sternal shield, mesal to coxa III. **Endopodal shield** besides coxa III–IV large, free, narrowly abutting sternal shield, slightly overlapped by hologastric and exopodal shields. **Exopodal shield** surrounding acetabula II–IV narrowly fused with sternal shield (via endopodal element) anteriorly between coxae I–II, posteriorly fused with well-developed parapodal element. **Peritrematal shield** fused anteriorly to dorsal shield at level between coxae I–II, posteriorly free, not extending beyond posterior margin of coxa IV, bearing three pairs of poroids (id3, id7, ip) and two pairs of gland pores (gd3, gdp); peritreme extending anteriorly beyond coxa I, near level of seta z1. **Hologastric shield** strongly reticulate, 359–366 long, 289–301 wide; one or two discernible inverted-V ridges in anterior half of shield (the anterior ridge may be less evident in some individuals); cells more compressed, scale-like (and narrow, transversally elongate) in region directly anterior to anal opening; shield with inconspicuous punctae; bearing six pairs of slender setae, st5, JV1–3, ZV1–2 of subequal length (37–53), three pairs of poroids, including paragenital poroids iv5; st5–st5 distance 130–138; insertion of paranal setae (24–30) aligned with anterior margin of anal opening, postanal seta shorter (12–19); gland opening gv3 on posterolateral shield margins, at level slightly anterior to paranals; cribrum with 2–3 rows of spicules. Soft opisthogastric cuticle with nine pairs of setae, r6, R1–2 (15–22), R3, ZV3–5, JV4–5 (19–35), four poroids, including one (ivo) at posterior edge of metapodal platelet, and another (idR3; = Rp) near seta R3. **Metapodal** element oval-shaped, narrowly fused to parapodal-exopodal shield (Fig. 3A, C–E) and contiguous with hologastric shield (may also appear narrowly, inconspicuously fused to hologastric shield in some individuals).

Gnathosoma (Fig. 4). **Subcapitulum** (Fig. 4A): corniculi horn-like (45–51); internal malae with two pairs of long projections, slightly longer than corniculi, median pair fringed at its base; labrum acuminate, slightly longer than internal malae; hypostomal and capitular setae smooth, h1, h3, pc (27–44), h2 shorter (20–24); deutosternal groove with five (1 female) or six rows (2 females) of denticles, progressively broader from posterior to anterior, each with 3–5 denticles. **Cheliceral** (Fig. 4B) fixed digit (63–68) with a subapical, offset tooth, followed by two moderately large teeth and setiform pilus dentilis, movable digit with two similarly sized teeth; simple dorsal seta. **Gnathotectum** (Fig. 4C) with anterior margin subtriangular, irregularly and lightly serrate. **Palp** (Fig. 4D) with normal chaetotaxy for Laelapidae (sensu Evans and Till 1965), with 2-5-6-14-15 setae on trochanter-femur-genu-tibia-tarsus; palptrochanter setae v1 and v2 thickened; palpfemur al thickened, blunt apically, palpgenu al1, al2 thickened, spatulate (flat and rounded) apically; palp-tarsal claw with three tines, third (proximal) one smaller.

Legs (Fig. 5). Chaetotaxy normal for Laelapidae (sensu Evans and Till 1966). Leg II slightly thicker than other legs. Lengths of legs: I 471–485, II 360–381, III 342–360, IV 470–485. All legs with ambulacral stalk, claws and pulvillus; entire ambulacrum I (26–28), including claw I (8–10), slightly shorter than ambulacra II–IV (31–39) and claws II–IV (12–15), respectively. Most setae slender and of moderate length, except a few shorter and/or thickened setae: femur II with al2 short; femur III–IV with pd and pl 2–3 times shorter than v1 and al; tarsi II–IV with av1–2, pv1–2, mv, md thickened, and md, al1–2, pl1–2 slightly thickened, pl2 thickened on tarsus IV.

Spermatheca. Not discerned.

Male (Figs 6–7) (n = 1) **Description.** ***Idiosomal dorsum***. **Dorsal shield** 493 long, 382 wide (at level of setae *S1*), as female: covering all dorsal idiosoma, oval-shaped, dome-like and slightly covering ventral surface. Poroidotaxy, adenotaxy, chaetotaxy and ornamentation essentially identical to those of female; setae slightly shorter.

Idiosomal venter (Fig. 6). Similar to female except the following: **holoventral shield** 380 long, 106 wide at level of st2, 267 wide at level of ZV1, strongly reticulate; shield bearing 10 pairs of simple, slender setae (st1–5, JV1–3, ZV1–2) in addition to circumanal setae. **Exopodal** shield fused with holoventral shield posteriorly to coxa

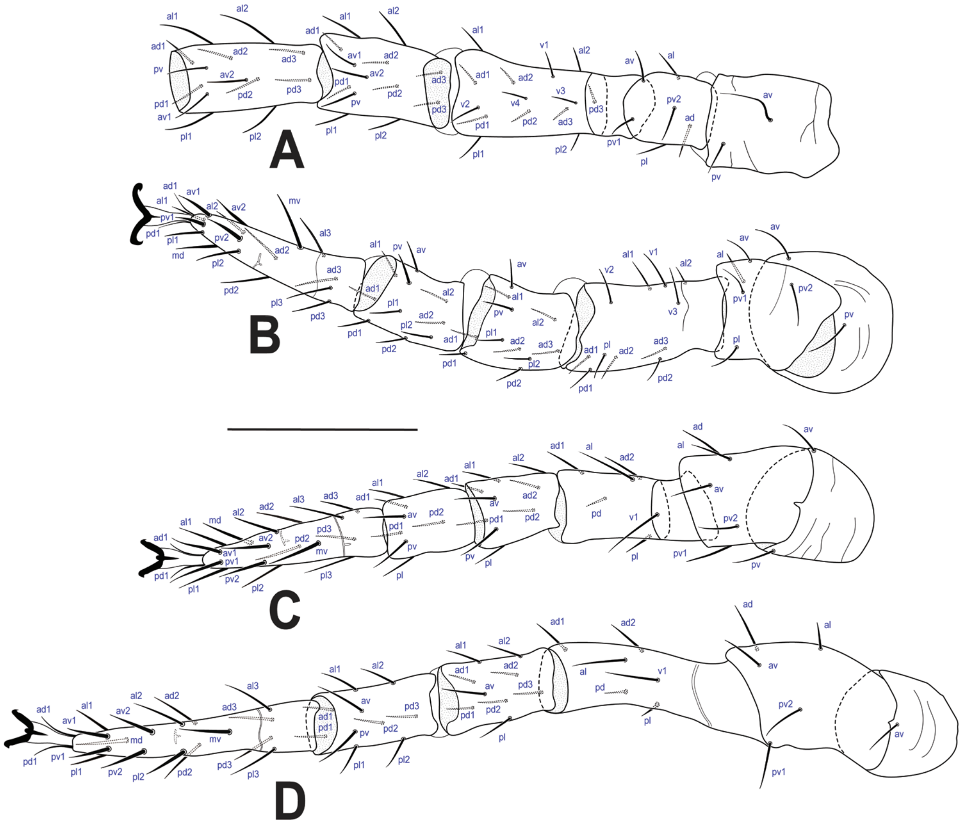

Figure 5. *Ololaelaps formidabilis*, adult female **A–D** legs I–IV, respectively. Scale bar: 100 µm.

IV, and extending anteriorly to level of mid-coxa I. **Metapodal** element (sigillum) incorporated into holoventral shield (see arrows, Figs 6, 7C).

Gnathosoma (Fig. 7). As female, except: **subcapitulum** (Fig. 7B): internal malae without the pair of lateral projections, and median projections more fimbriate than in female; deutosternal rows each with 3–5 denticles. **Cheliceral** (Fig. 7A) fixed digit with one tooth; movable digit with one tooth, subapically bearing an elongate spermatodactyl (102), broadly curved, slightly bent apically, with straight (i.e., not sinuous) duct.

Legs. Chaetotaxy and setae thickness similar to that of female. Lengths of legs: I 406–415, II 301–310, III 295–305, IV 380–395.

Material and depository. INDONESIA, Sumatra • 1♀, Harapan rainforest, litter from rubber tree plantation, research site HR4b, 01°48'18"S, 103°15'52"E, 71 m a.s.l. (LIPI; internal project ID macrolitterHR4b13_MESOS1_1) • 1♀, same data as preceding (CNC1098357; internal project ID macrolitterHR4b13_MESOS1_2) • 1♀ (with an egg), Bukit Duabelas rainforest, litter in rubber tree plantation, research site BR4b, 02°04'36"S, 102°46'22"E, 51 m a.s.l. (SMNG-ARA-13/59952; internal project ID macrolitterBR4b13_MESOS1_1) • 1♂, same data as preceding (LIPI; internal pro-

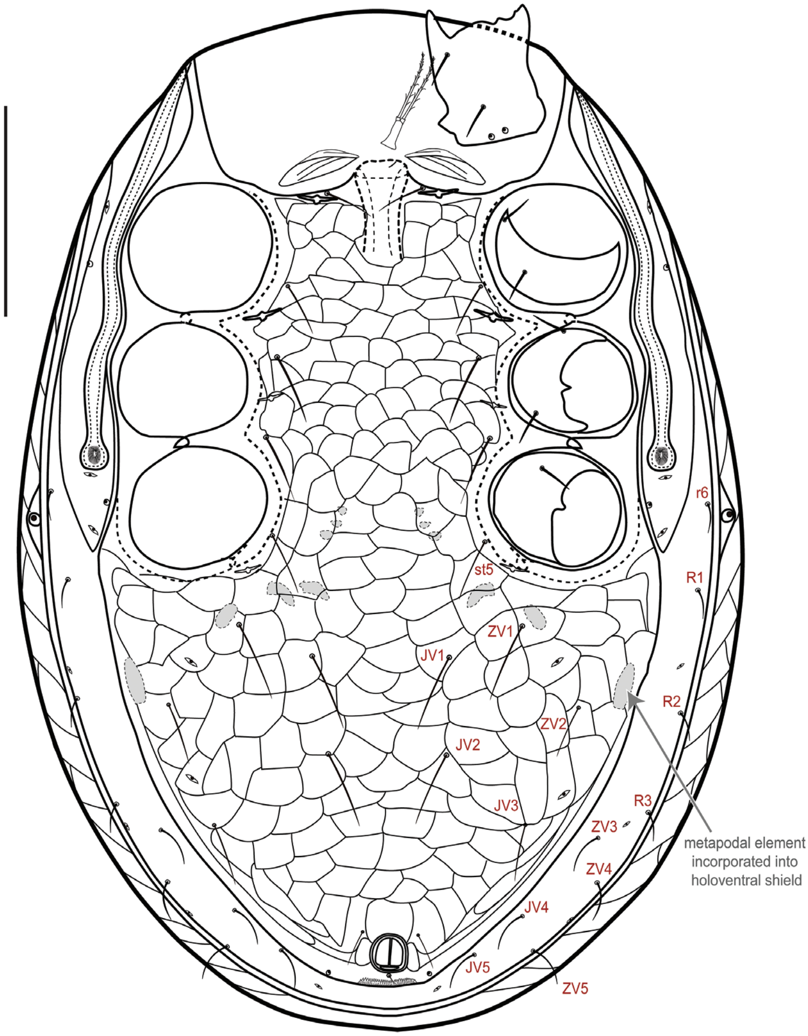

Figure 6. *Ololaelaps formidabilis*, adult male. Ventral idiosoma. Scale bar: 100 µm.

ject ID macrolitterBR4b13_MESOS1_2). All specimens collected on 15.11.2013 by B. Klarner. Additional photos of the species are digitally deposited at ecotaxonomy.org.

Remarks. Our discovery of *Ololaelaps formidabilis* in Sumatra appears to be the second record of the species in Indonesia, the first corresponding to the original description by Berlese from Java specimens. It is unique among described species of *Ololaelaps* in having its metapodal platelet fused to the parapodal plate and free from the peritrematal and hologastric shields. Note, however, that the metapodal platelet is tightly contiguous with the hologastric shield and that in some specimens, at some focal depth, it may even appear narrowly fused with it (Fig. 3A). The metapodal and

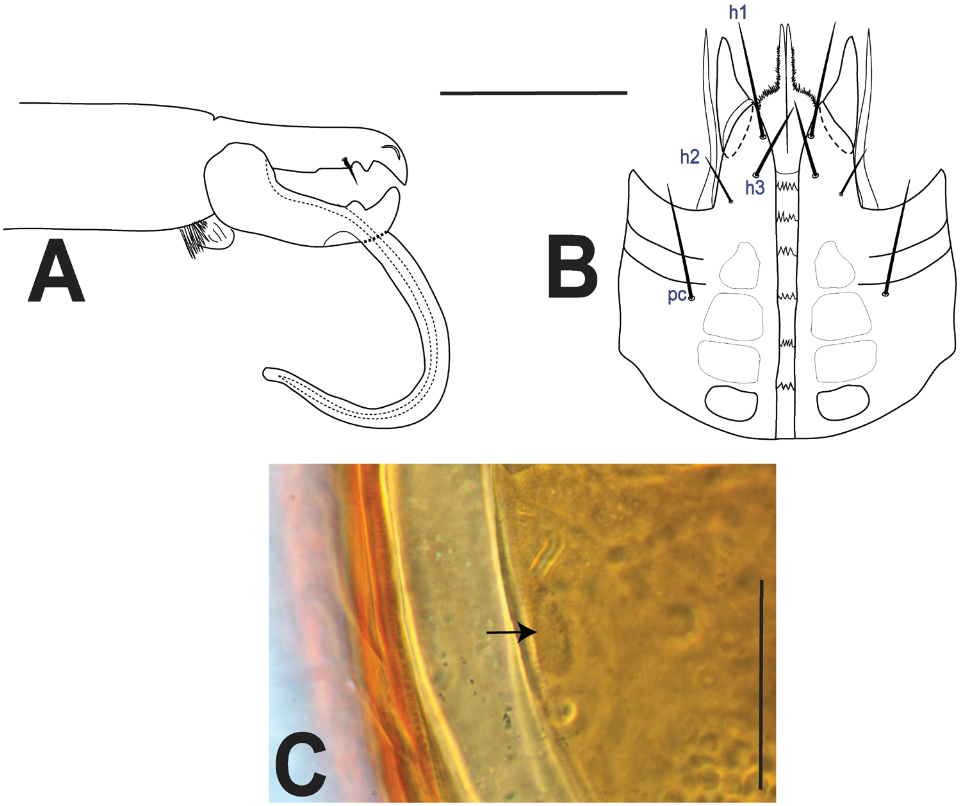

Figure 7. *Ololaelaps formidabilis*, adult male **A** chelicera **B** subcapitulum **C** posterolateral region of idiosoma, showing metapodal element (arrow) integrated in the holoventral shield. Scale bars: 50 µm.

parapodal plates are fused by a short to elongate connecting 'bridge' (Fig. 3A, C–E). Photos shared by Roberto Nannelli, who examined types at the Berlese Collection in Firenze, confirm that at least one female paratype of *O. formidabilis* has such attribute, although the connecting bridge between the metapodal and the parapodal plates seem slightly broader (Fig. 8B; although not perfectly clear) than for the three females from Sumatra (Fig. 3A, C–E). Berlese's (1913) original description (fig. 51, plate V) shows a fusion ('bridge') that is as broad as the width of the metapodal platelet. We consider that the difference between the paratype and our specimen represents intraspecific variation. In addition, *O. formidabilis* has two inverted-V-shaped ridges on the anterior half of its hologastric shield (see arrows, Fig. 1). The posteriormost ridge, shaped more narrowly, is more conspicuous than the anterior one (which is almost U-shaped). The female paratype photographed shows similar ridges (Fig. 8B). Although at least two undescribed species have similar inverted V or U ridges, the shapes of the ridges in these species are distinct from those of *O. formidabilis*.

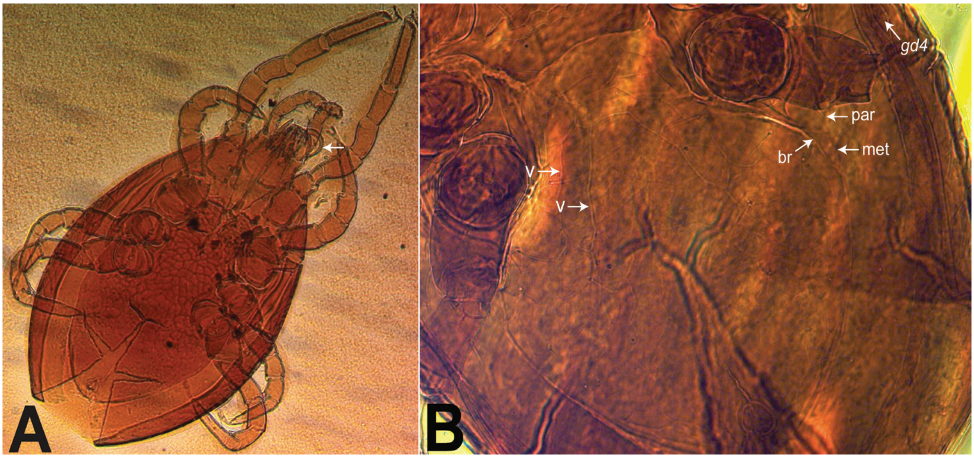

Figure 8. *Ololaelaps formidabilis* **A** male holotype (slide 145/29): ventral view, with arrow pointing at spermatodactyl **B** female paratype (slide 145/30): region of hologastric shield, showing two inverted V-shaped ridges (v), and the 'bridge' (br) connecting parapodal (par) and metapodal (met) plates. Photographs courtesy of Roberto Nannelli.

The male holotype of *O. formidabilis* (Castagnoli and Pegazzano 1985: 151) is also similar to that of the new material, including for its spermatodactyl, which has a similar thickness and length (see arrow, Fig. 8A).

Ryke (1962) redescribed *O. formidabilis*, via a species key and a single illustration, of the idiosomal venter, which clearly represents another species, distinct from *O. formidabilis* described by Berlese (1913) and examined by us. The most distinctive character in Ryke's illustration (his fig. 6) is the metapodal platelet, broadly protruding from its fusion with the hologastric shield, but free from the parapodal shield, in contrast to *O. formidabilis* sensu stricto. Such partial fusion of the metapodal-hologastric shield is similar to nine other species in the genus (*O. caucasicus*, etc., Table 2). Other information included in the key of Ryke (1962), such as idiosomal dimensions and geographic origin (Java), corresponds to those of *O. formidabilis*, but were probably simply taken from Berlese's publication (except that Ryke indicated "length 550 μ" instead of 540 μ as written in Berlese (1913)). In the introduction, Ryke (1962) thanked G.O. Evans for "putting […] the figures of the type specimens in the Berlese Collection at his disposal". From this, we could interpret that during a visit of the Berlese Collection in Firenze, Italy, Evans examined types and illustrated them, and later on, lent these illustrations to Ryke. We attempted to retrieve putative illustrations by Evans, or Ryke, but without success. It is possible that a mistake occurred at some point and that Ryke's (1962) illustration is that of a type or voucher specimen representing another species. At present, diagnostic characters included in Ryke (1962) are too limited to determine the correct name of that species (if it has one). Re-examination of *Ololaelaps* specimens in the Berlese Collection might help resolve this.

Discussion

Features of the genus

At present, *Ololaelaps* appears as a relatively well-defined genus, characterized by a unique combination of characters, many of which, individually, are shared with other genera of Laelapidae, especially hypoaspidines. The most unique feature of *Ololaelaps* is the female genital shield hyperdeveloped posteriorly and fused with the anal shield to occupy most of the opisthogaster and capture 3–5 pairs of setae in addition to st5 and circumanals. The genital shield is also expanded in several other genera (e.g., *Laelaspis*, *Laelaspisella*, *Pseudoparasitus*, *Pogonolaelaps*; Evans and Till 1966, Hunter 1966, Joharchi et al. 2016, Nemati and Gwiazdowicz 2016) but it is never fused to the anal shield like in *Ololaelaps*, except in *Oloopticus* (Karg 1978). *Oloopticus* is distinguished from *Ololaelaps* at least by the sternal shield coalesced anteriorly with presternal platelets and posteriorly with endopodal plates, and by the modification of setae st4 into sensory 'pits'. Karg and Schorlemmer (2013) suggested that *Ololaelaps* and *Oloopticus* are closely related genera, based on the hypothesis that they apomorphically share a hologastric (genitiventrianal) shield (Karg 2000). However, this character state could have evolved independently in these two genera, which otherwise appear phylogenetically distant. The fusion of epigynal + ventral + anal shields also occurs in members of Eviphidoidea, such as *Holaspulus*, some *Holaspina* (Parholaspididae; Halliday 1995, Nawar and El-Sherif 1995) and *Indutolaelaps* (a genus similar to *Holaspina*; Leptolaelapidae; Karg 1997).

The hemispherical nature of the idiosoma of several species of *Ololaelaps* is also distinctive. However, this attribute may have led to misidentifications or misclassifications in the past, as some species in other families, especially Ologamasidae, have a similarly glossy, dome-shaped dorsal shield (see Table 3). That would explain in part the apparent dual identity of *Iphis haemisphaericus*, associated with two phylogenetically distinct genera, *Stylochirus* (Ologamasidae) and *Ololaelaps* (see Remarks for the genus above). Unfortunately, Koch (1839b) illustrated only the dorsal aspect of that mite. Another similarity is that ologamasids also tend to be strongly sclerotized ventrally, and that may have added to the confusion. Old species names of uncertain identity (Table 3: *Zercon festivus*, *Iphis globulus*, *Eumaeus inornatus*) may have been historically associated with (valid) *Ololaelaps* species for similar reasons. Some Eviphididae also have subglobular, domed idiosomas (Mašán and Halliday 2010).

As explained in Kazemi and Beaulieu (2016), the recently described monotypic genus *Persicolaelaps* shares many features with *Ololaelaps*, notably the dome-like dorsal shield bearing attenuate setae, and well-developed exopodal strips that are fused anteriorly with the sternal shield's anterolateral arms (via endopodal elements). Note that such (anterior) fusion of exopodal-sternal shields occurs in other laelapids (e.g., *Alloparasitus oblongus* (Halbert); Evans and Till 1966). A pair of sclerotized presternal platelets, a three-tined palp-apotele, and well-developed parapodal plates characterize *Ololaelaps* as well as species of other hypoaspidine genera, especially of *Pseudoparasitus* and *Gymnolaelaps* (Hunter 1966, Joharchi et al. 2011, Nemati and Gwiazdowicz 2016). In addition to both having a reduced third (proximal) tine in their palp apotele (in contrast to a well-developed proximal tine in at least some *Gymnolaelaps*), *Pseudoparasitus* and *Ololaelaps* are also similar in having setae JV1 and JV2 inserted on the genital shield, but remotely from the lateral margins (vs on or near the shield margins in *Gymnolaelaps* or *Laelaspis*) (Joharchi et al. 2011). A three-tined palp-apotele was used as one of the main characters defining previous concepts of the family Neoparasitidae (Vitzthum 1943, Evans 1957, Mašán and Halliday 2014: 51) which was composed of various genera now scattered in at least four relatively distant families of Gamasina.

An additional set of features that further distinguish some *Ololaelaps* species from other laelapid genera is the various fusions of the peritrematal, parapodal, metapodal and hologastric shields. Even for groups with opisthogastric (i.e., genitiventral) shields such as *Laelaspis* and *Pseudoparasitus*, we are not aware of such fusion among shields. The peritrematal and parapodal shields, however, are coalesced in a few other laelapids, such as *Nidilaelaps annectans* (Womersley) (Shaw 2012).

The female of some *Ololaelaps* species have seta *st4* and poroid *iv3* on the sternal shield. This is rare in laelapids, although common within other groups, especially Rhodacaroidea. Seta *st4* is also born on the sternal shield (complex) in groups where the shield is fused posteriorly with endopodals (e.g., many ologamasids and pachylaelapids). However, in *Ololaelaps*, this feature seems associated with the anterolateral expansion of the genital shield, which leaves little soft cuticle available for the insertion of st4 and iv3. In other genera where the genital shield is more pronounced anteriorly, st4 has even disappeared (Kazemi and Beaulieu 2016). This 'weaker' seta, formed only during the deutonymphal stage, is also repressed in the adults or even the deutonymphs of other gamasines (Evans and Till 1965, Karg 2000, Lindquist 2003, Kazemi and Beaulieu 2016).

The males of *Ololaelaps* are not as distinctive as females, although they can be distinguished from those of most other laelapid genera by the degree of development of the holoventral shield posterolaterally and its fusion to parapodal-exopodal shields, and sometimes to the peritrematal shields. However, a similar ventral shield arrangement occurs in the males of other laelapids, for instance *N. annectans* (Shaw 2012) and *Pseudoparasitus missouriensis* (Ewing) (as *P. austriacus* (Sellnick), Hunter 1966). The ventrolateral extensions of the dorsal shield is an additional feature facilitating genus diagnosis (occurring in both sexes of *Ololaelaps*), which is uncommon in Laelapidae, and perhaps otherwise limited to species of *Gymnolaelaps* (Evans and Till 1966, Joharchi and Halliday 2013). Also, the peritrematal shield is fused to the dorsal shield along most of its length in the male of some species (e.g., *O. ussuriensis*).

Species-level delineation

While it may be easy to identify a given *Ololaelaps* mite to genus, it is more difficult to identify it to species. Examination of types, as well as a critical assessment of intraspecific variation based on additional specimens will be necessary to clarify species boundaries and uncover synonymies. In particular, the following characters should be scrutinized during species (re)descriptions.

The type of fusion between metapodal, peritrematal, parapodal, and hologastric plates appears as a useful starting point to initiate species identification, because it sorts species into broad groups, which are phylogenetically meaningful in some cases (Table 2). Bregetova and Koroleva (1964) implied, in their key, the existence of two species groups, which have been further defined by Evans and Till (1966) based on a limited number of species: the *venetus* and *placentula* groups. The *venetus* group represents a small cluster of similar species (*O. venetus*, *placidus*, *sellnicki*) that nonetheless need further study. It is herein defined by five characters, some of which are likely derived (apomorphic), relative to the ancestor of the genus (Table 2):

(1) Fused peritrematal-hologastric-parapodal shields by way of the metapodal platelet. Note that the parapodal plate ranges from clearly to ambiguously fused to, or merely tightly contiguous with, the metapodal 'bridge' (e.g., compare figs 74–76 in Hennessey and Farrier (1988), figs 17, 21 in Bregetova and Koroleva (1964), and figs 49–50 in Evans and Till (1966)). Regarding this character, *O. hemisphaera* (Berlese 1916b) appears similar to species of the *venetus* group because its parapodal plate, albeit free, is (nearly) contiguous with the peritrematal shield (or metapodal bridge) (based on Ryke 1962). The peritrematal shield is also fused to the hologastric shield in *O. interruptus* and *O. leptochelae*, but the parapodal plate is clearly free of the fusion. Note that the original illustration of *O. venetus* by Berlese (1889; as misidentified "*Laelaps tumidulus* (Koch)") shows both the peritrematal and parapodal plates free from the hologastric shield, which is discordant with all other descriptions of *O. venetus* (or syn. *O. halaskovae*; Table 2). However, the illustration of the male spermatodactyl (Berlese 1889) shows a sinuous groove, like that of *O. venetus* and related species.

(2) Spermathecal ducts (= tubuli annulati, Evans 1992) well sclerotized, conspicuous, and similarly shaped in *O. venetus*, *O. placidus* and *O. sellnicki*. The spermathecae were also illustrated for *O. translineatus* (Barilo 1991) and *O. mooiensis* (including the sacculus foemineus; Marais and Loots 1972, Jordaan and Loots 1987), but they seem distinct from those of the *venetus* group of species. Hennessey and Farrier (1988) synonymized *O. venetus* with *O. placidus* certainly in part based on their similarity in the shape of the spermathecal ducts. They have indeed similar ducts, but the variation that we have observed between females of *O. placidus*, and between *O. placidus* and one or more undescribed, closely related species suggests that the shapes of the spermathecal ducts may overlap between species. The distinction between the spermatheca of *O. sellnicki* vs *O. venetus* or *O. placidus* may also not be so straightforward, given that the short subapical appendage characteristic of the ducts of *O. venetus* and *O. placidus* is not always discernible, and also that the ducts of all three species can be seen as apically 'closed' and rounded, or open-ended (Bregetova and Koroleva 1964; Hennessey and Farrier 1988; FB, pers. obs.).

(3) Spermatodactyl with a sinuous duct, and a subapical hump or bend (Bregetova and Koroleva 1964; Evans and Till 1966; F.B. pers. obs. for *O. placidus*). In contrast, the males of *O. formidabilis*, *O. placentula*, *O. translineatus* and *O. ussuriensis* have spermatodactyls of various lengths with a straight duct and no hump subapically;

the spermatodactyl of *O. rectagoni* also has a straight duct and is swollen subapically (Karg 1994).

(4) Dorsal shield with narrow, smooth epipleura (i.e., ventrolateral extensions of the dorsal shield) vs broad, lineate-reticulate epipleura of the *placentula* group. Other species may have narrow epipleura, smooth or reticulate but descriptions are often lacking in such details, in part because determining the extent of the epipleura is most readily done before slide-mounting of the specimen (Barilo 1991) or on slide-mounted specimens with unbroken dorsal shield.

(5) A fifth character associated with the *venetus* group is the insertion of setae *JV3* and *ZV2* off the hologastric shield in *O. sellnicki* and in some individuals of *O. venetus* and *O. placidus* (Table 2; Ryke (1962), Bregetova and Koroleva (1964); FB, pers. obs. for *O. placidus*). This contrasts with all other known species, described with JV3 and ZV2 on the hologastric shield. Two other deviations from normal are seen in the illustrations of *O. obovatus* (Womersley 1960) and *O. platensis* (in Ryke 1962), both lacking ZV1, and of *O. rectagoni* (Karg 1993b) having ZV3 inserted on the shield.

The *placentula* group was defined by four characters (three mentioned by Evans and Till (1966), a fourth one only by Bregetova and Koroleva (1964)), none of which are clearly apomorphic, considering their (albeit poorly known) distribution across species in the genus (Table 2):

(1) six other species have the metapodal platelet fused to the hologastric shield (and free from parapodal/peritrematal plates), making this type of fusion relatively common in the genus (Table 2);

(2) a poorly sclerotized (i.e., inconspicuous) spermatheca may characterize other species, given that it has been described in five species only (see above);

(3) at least two other species have the spermatodactyl with a non-sinuous duct (see above); and

(4) several other species have reticulate or lineate-reticulate epipleura that at least superficially resemble those of the *placentula* group of species. The ventral extent of the epipleura and its exact type of ornamentation should be scrutinized for each species. Members of the *placentula* group, *O. placentula*, *O. ussuriensis* and presumably *O. caucasicus* (note that *O. ussuriensis* and *O. caucasicus* were not illustrated dorsally) have a dorsal shield smooth or faintly reticulate, in contrast to conspicuously lineate-reticulate epipleura, which are relatively well extended ventrally (Table 2); this lineation-reticulation of the epipleura extends also anterodorsally to the region of setae j1–j2 and z1–z2. *Ololaelaps dililoensis* appears to have all diagnostic characters of the *placentula* group, but also has a clearly reticulate dorsal shield, at least in its posterior half. In *O. formidabilis*, the dorsal shield is only narrowly extending ventrally, but that region is conspicuously reticulated, in contrast (similarly to the *placentula* group) to the light, inconspicuous reticulation of the dorsal region of the shield.

Ololaelaps burdwanensis, *O. translineatus*, and *O. wangi* represent a cluster of very similar species. Finally, the last grouping in Table 2 (*O. bregetovae* and following species) may also represent a natural group, but given the intraspecific variation observed elsewhere (in *O. mooiensis*, see below; Table 2), it seems yet inappropriate to define a group based on the absence of fusion of shields (metapodal etc.) alone, especially given that all of these species need redescription.

The degree of fusion of the metapodal platelet with the various surrounding shields may vary significantly intraspecifically, as seen in *O. mooiensis* (incl. syn. *O. gamagarensis*; Nemati et al. 2018) where the metapodal platelet is exceptionally free from the hologastric shield in some individuals (Table 2). Some variation in the degree of fusion of the metapodal platelet with the hologastric shield also occurs in other species, such as *O. placentula* (Ryke 1962, Bregetova and Koroleva 1964, Evans and Till 1966); we have also observed, exceptionally, a specimen of that species with a metapodal platelet narrowly fused to the parapodal plate! Other examples are (1) *O. formidabilis*, having its metapodal platelet contiguous with, to indistinctly fused to, the hologastric shield (Fig. 3A, C–E), and (2) species in the *venetus* group, where the parapodal plate is clearly to ambiguously fused with the bridge (= metapodal) between the peritrematal and hologastric shields. Barilo (1991) also mentions that the 'exopodal shields' (= exopodal-parapodal) could be free or partly connected with the genitiventrianal shield in *O. translineatus*. Such intraspecific variation in shield fusion calls for caution when identifying species or sorting species into groups (as those presented in Table 2).

Intraspecific variation in shield fusions may occur in males too. For instance, some males that we identified as *O. placidus* have the peritrematal shield fused to the hologastric shield, just like the male of *O. venetus*, and others have the peritrematal shield free posteriorly, like that of the male of *O. sellnicki* (Bregetova 1977a).

At present, the chaetotaxy and the ornamentation of the dorsal shield are not clearly described for most *Ololaelaps* species (Table 2). At least some species (*O. formidabilis*; *O. placentula*, Evans and Till (1966); *O. mooiensis*, Marais and Loots (1972)) have a complete (or normal) dorsal chaetotaxy for a Laelapidae (sensu Evans and Till 1965). The illustrations of several other species indicate a slightly reduced dorsal chaetome. However, this should be verified, especially for setae apparently missing from marginal areas, in the r and S series, because these setae are difficult to discern in *Ololaelaps* species, which typically have slender setae and dark, heavily sclerotized dorsal shields. The presence of a single unpaired seta Jx is common in the genus; at least ten described species have it, four of which (*O. formidabilis*, *caucasicus*, *mooiensis*, *placidus*) have Jx present in some individuals, but absent in others. We suspect that this pliable character also varies in other species and that a Jx seta is expressed in some individuals only. The ornamentation of the dorsal shield is difficult to discern for species with light reticulation (e.g., *O. formidabilis*). Clearing the specimens thoroughly or slide-mounting some specimens dorsal side up should help; crushing selected specimens on the slide or dissecting their dorsal shield from the ventral idiosoma are other options.

Presently, differences in dimensions of the dorsal, sternal, and hologastric shields are only useful to separate species with marked differences, i.e., with elongate (e.g., *O. tasmanicus*) vs broad shields (e.g., *O. placentula*), because intraspecific variation is not sufficiently known. Ratios of length/width could be particularly useful, but they also vary intraspecifically, e.g., the sternal shield of *O. venetus* appears to have a length/width ratio of 0.8–1.0 (Bregetova and Koroleva 1964, Evans and Till 1966).

The position of seta st4 and poroid iv3 is difficult to use as a diagnostic character because it is not easy to determine whether they are on the shield margin, on the adjacent soft cuticle, or on the endopodal plate. This body region being the point of meeting of three shields (sternal, endopodal, hologastric) renders its study more difficult, obscuring the position of st4 and iv3, especially if they are inserted on soft cuticle, which can be folded above or underneath shields' margins. Examining several specimens for each species can help, as well as making observations at different focal depths. We suspect that in most cases where st4 (and iv3) appears on the endopodal plate (e.g., *O. burdwanensis*, *O. sitalaensis*, *O. translineatus*), it is actually inserted on soft cuticle that overlaps the plate. Note that the position of st4 and iv3 are relatively stable within genera or even families of Gamasina, whether on soft cuticle, on metasternal platelets or (more rarely) on the sternal shield (e.g., Kazemi et al. 2008, Lindquist et al. 2009, Moraza and Linquist 2011).

The ornamentation of the hologastric shield shows species-specific patterns, such as inverted V or U-shaped ridges in *O. formidabilis* and undescribed species, as well as the shape of cells in the reticulation pattern (e.g., Barilo 1991). However, inter- and intraspecific variability needs to be ascertained, including for *O. placidus*, *O. venetus* and *O. sellnicki*. Bregetova and Koroleva (1964) and Bregetova (1977a) distinguished *O. sellnicki* from its close relative *O. venetus*, as well as *O. caucasicus* from *O. ussuriensis*, based on the hologastric shield having cells elongate transversally (*O. sellnicki*, *O. caucasicus*) vs regular cells or scales (*O. venetus*, *O. ussuriensis*). However, Evans and Till (1966) did not mention such distinction between *O. sellnicki* and *O. venetus*, perhaps because the distinction is not so straightforward. The cells of the reticulation also vary in shape, size, and conspicuousness (i.e., in the strength of the ridges) across the longitudinal (anterior to posterior) axis, and this 'gradient' may differ between species (Bregetova and Koroleva 1964). There is also interspecific differences in patterns of ridges on the sternal shields (Barilo 1991, Table 2; unpubl. data on undescribed species).

Our knowledge of the gnathosoma of *Ololaelaps* indicates limited variation between species. For instance, the internal malae have two pairs of projections in the females of all species where the hypostome has been described (*O. caucasicus*, *dililoensis*, *formidabilis*, *mooiensis*, *placentula*, *placidus*, *sellnicki*, *ussuriensis*, *venetus*, *wangi*) except for *O. sitalaensis* which lacks the lateral pair, based on the illustration in Bhattacharyya (1978). In contrast, the lateral pair of projections is missing in the males of all species where the hypostome have been described and the median projections are more fimbriate than those of females (*O. formidabilis*, Fig. 7; *O. sellnicki*, Bregetova and Koroleva 1964, Evans and Till 1966; *O. placidus*, unpubl. data). The number of rows of deutosternal denticles apparently varies at least intraspecifically (5–6 in *O. formidabilis*; 6–7 in *O. placidus*). On the other hand, there seems to be some interspecific variation in the number of denticles per rows, although often overlapping, with some species having six or fewer denticles per row (e.g., *O. formidabilis*, *ussuriensis*, *wangi*) and others having 5–10 denticles per row (*O. caucasicus*, *placentula*) (Bregetova and Koroleva 1964, Evans and Till 1966, Barilo 1991, Keum et al. 2017). Variation in cheliceral dentition is most notable for *O. interruptus* and *O. leptochelae* (see Table 2).

Idiosomal adenotaxy differs between laelapid species (Kazemi et al. 2014). Although the adenotaxy of only a few species of *Ololaelaps* has been studied, we have noticed variation in the position and shape of gland openings gd4 and gd9. This may prove to be useful in distinguishing species, especially as they often are easy to locate, being usually on or near the shield margin (on the ventrolateral extension) (e.g., figs 5, 13 in Bregetova and Koroleva (1964); Hassan 1989). Interestingly, the putatively related genus *Pseudoparasitus* has at least some members (*Pseudoparasitus* sp. near *centralis* Berl.; unpubl. data) with gd4 and gd9 in similar positions, on the shield margin.

While the legs of *Ololaelaps* species mostly bear simple and slender setae, there is interspecific variation in the shape of setae. This should be investigated and exploited for species diagnostics (see examples in the genus description above).

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New species of the *Rhaconotus jacobsoni* group (Hymenoptera, Braconidae, Doryctinae) from Vietnam

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Abstract

Four new species of the genus *Rhaconotus* Ruthe from Vietnam are described and illustrated – *Rhaconotus directus* Long, **sp. nov**., *R. laevigatus* Long, **sp. nov.**, *R. robustus* Long, **sp. nov.**, and *R. simulatus* Long, **sp. nov.** A key to species of *Rhaconotus jacobsoni* group from the Oriental region is provided.

Keywords

Ichneumonoidea, Rhaconotini, Afrotropical, Oriental, systematics

Introduction

Rhaconotus Ruthe, 1854 is one of the largest genera of the doryctine tribe Rhaconotini, with more than 100 described species (Belokobylskij 2001; Jasso-Martínez et al. 2019). Most of the known species of *Rhaconotus* occur in the Oriental and Afrotropical regions (Belokobylskij and Chen 2004; Belokobylskij and Maetô 2009; Yu et al. 2012), and recently Belokobylskij and Zaldívar-Riverón (2015) described four new species of this genus from Neotropical region.

Rhaconotus jacobsoni group is one of several groups of this genus divided by Belokobylskij (2001) and separated from other *Rhaconotus* groups by having metasoma with six visible tergites and length of first metasomal tergite 2.3–2.8 × apical width. Currently, this group contains four described species from the Oriental region; of those

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only one species, *R. thayi* Belokobylskij, was known from Vietnam (Yu et al. 2013; Belokobylskij and Chen 2004; Long and Belokobylskij 2003). In this paper, four new species of the *Rhaconotus jacobsoni* group from Vietnam are described.

Materials and methods

The specimens were mainly collected in Malaise traps and some by using sweep nets. The material was stored in 70% or 96% ethanol, prepared with the AXA method (van Achterberg 2009; van Achterberg et al. 2010) and glued on card points. Observations and descriptions were made with an Olympus SZ61 binocular microscope under fluorescent lamps. Measurements were made with a binocular microscope (Olympus SZ40), and photographs were taken with a Sony 5000 digital camera attached to an Nikon SMZ 800N binocular microscope connected to a PC at IEBR. The scale-lines of the plates indicate in mm. Sculpture terms are based on Harris (1979), terminology used in this paper follows the modified Comstock-Needham system (van Achterberg 1993). For the identification of the East Palaearctic genera of Doryctinae see Belokobylskij and Maetô (2009); for division of *Rhaconotus* species groups see Belokobylskij (2001). Abbreviations used in this paper are as follows:

OD	diameter of posterior ocellus;
OOL	ocular-ocellar line;
POL	postocellar line;
"**Doryc.+number**"	code number indexing for specimens of the Doryctinae in the collection;
MT	Malaise trap.

The holotypes are kept in the parasitoid collections of Department of Insect Ecology, the Institute of Ecology and Biological Resources, Ha Noi, Vietnam (**IEBR**).

Systematics

Checklist and distribution of *Rhaconotus jacobsoni* group species

Rhaconotus ceylonicus Belokobylskij, 2001 / Sri Lanka
Rhaconotus directus Long, sp. nov. / Vietnam
Rhaconotus jacobsoni (Szepligeti, 1908) / Indonesia
Rhaconotus laevigatus Long, sp. nov. / Vietnam
Rhaconotus longithorax Belokobylskij, 2001 / Philippines
Rhaconotus robustus Long, sp. nov. / Vietnam
Rhaconotus simulatus Long, sp. nov. / Vietnam
Rhaconotus thayi Belokobylskij, 2001 / China, Vietnam

Key to species of *Rhaconotus jacobsoni* group from Vietnam

The Vietnamese species of *Rhaconotus jacobsoni* group are distinguished from other species by having the distance from pronotal carina to mesonotum equal or subequal to distance from carina to anterior margin of pronotum and can be inserted in the key by Belokobylskij (2001) as follows:

1 Hind tibia entirely dark brown to black (female), yellow or brownish yellow (male); distance from carina to mesonotum equal to distance from carina to anterior margin of pronotum; vertex and mesonotum more or less with dense and long setae......... **2**

– Hind tibia entirely reddish yellow or yellow basally (female); distance from carina to mesonotum about 1.5 × distance from carina to anterior margin of pronotum; vertex and mesonotum with sparse and shorter setae .... **three species of *R. jacobsoni* group**[*]

2 Metanotum in lateral view with long pointed tooth (Fig. 5a); vein cu-a almost interstitial, vein 1-CU1 nearly quadrate (Fig. 10); propodeum with short median carina in basal 0.3; basolateral area of propodeum not emarginate posteriorly (Fig. 12); second tergite without lenticular apical area (Fig. 8). Body length 6.5 mm .... ***R. directus* Long, sp. nov.**

– Metanotum in lateral view with short pointed tooth; vein cu-a distinctly postfurcal; vein 1-CU1 equal or subequal to vein cu-a (Figs 23, 35, 46); propodeum with median carina in basal 0.5–0.6 (Figs 21, 32, 44); basolateral area of propodeum emarginate posteriorly (not emarginated in *R. thayi* and *robustus*); second tergite with lenticular apical area (Figs 19, 43) **3**

3 Male, hind tibia yellow or brownish yellow (Fig. 34); vertex and mesonotum with sparse short setae (Figs 26, 30); hind femur robust, 2.75 × its maximum width (Fig. 34); propodeum without posterior emarginate areola, almost foveolate-rugose apically (Fig. 32). Body length 6.2 mm.......... ***R. robustus* Long, sp. nov.**

– Female, hind tibia entirely black or blackish brown (Fig. 49); vertex and mesonotum with rather dense and long setae (Figs 14, 16, 40, 42); hind femur slender, 3.2–4.5 × its maximum width (Figs 20, 48); propodeum with posterior emarginate areola (Figs 21, 44) **4**

4 Second submarginal cell of fore wing long, basal length 4.2 × its maximum width (Fig. 23); hind femur rather long, length 4.5 × as long as its maximum with (Fig. 20); mesopleuron almost smooth (Fig. 18); first metasomal tergite almost granulate coriaceous, sparsely striate apically (Fig. 19). Body length 7.5 mm .... ***R. laevigatus* Long, sp. nov.**

– Second submarginal cell of fore wing shorter, basal length 3.2–3.5 × its maximum width (fig. 46, fig. 131 in Belokobylskij, 2001); hind femur slender, length 3.2–3.4 × its maximum with (fig. 48, fig. 134 in Belokobylskij, 2001); mesopleuron granulate or granulate coriaceous; first metasomal tergite coarsely striate, granulate between striae (fig. 43, fig. 135 in Belokobylskij, 2001) **5**

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[*] see couplet 22 of the key by Belokobylskij (2001)

5 Mesosoma 2.7–2.9 × as long as high; precoxal sulcus wide, crenulate (fig. 129 in Belokobylskij, 2001); basolateral area of propodeum not emarginate posteriorly; length of first metasomal 2.5–2.8 × apical width (fig. 135 in Belokobylskij, 2001). Body length 5.7–8.1 mm; frons coarsely rugose. Body length 5.7–8.1 mm......... ....***R. thayi*** **Belokobylskij**

– Mesosoma 2.5 × as long as high; precoxal sulcus narrow, punctate (Fig. 42); basolateral area of propodeum emarginate posteriorly, foveolate-rugose apically (Fig. 44); length of first metasomal 2.2 × apical width (Fig. 43); frons finely granulate. Body length 6.7 mm..............................***R. simulatus*** **Long, sp. nov.**

Descriptions of species

Rhaconotus directus **Long, sp. nov.**

http://zoobank.org/58A6D8BA-7804-43BE-93A3-0B80975B4D18
Figs 1–12

Material. Holotype, female, "Doryc.035", (IEBR), NW Vietnam: Hoa Binh, Mai Chau, Pa Co, forest, 1100 m, 26.iv.2002, KD Long.

Diagnosis. Occipital carina complete medio-dorsally, obliterated below and not fused with hypostomal carina (Fig. 3); frons almost flat, finely granulate; vertex and temple finely granulate; distance from pronotal carina to mesonotum equal to distance from carina to anterior margin of pronotum; in lateral view, metanotum with long pointed tooth (Fig. 5a); precoxal sulcus long, narrow, crenulate (Fig. 5); mesopleuron and metapleuron finely granulate; notauli shallow, sparsely crenulate anteriorly, widened posteriorly, with median crenulate depression (Fig. 6); propodeum with median carina in basal 0.3; pterostigma 4.5 × as long as wide; fore wing vein 3-SR 5.0 × vein r; vein 1-CU1 very short, nearly quadrate; vein cu-a almost interstitial (Fig. 10); second submarginal cell parallel-sided, basal length 2.9 × its maximum width and 0.9 × subdiscal cell (Fig. 10); vein 1-M of hind wing 6.3 × vein 1r-m (Fig. 11); inner side of fore tibia with four spines; hind coxa finely and densely granulate; hind tibia 7.7 × its maximum width; first metasomal tergite gradually widened from base to apex, 2.4 × its apical width (Fig. 8); second tergite with lenticular apical area weakly delineated with shallow furrows (Fig. 8); second-third tergites coarsely longitudinally striate; fourth-fifth tergites longitudinally striate basally, finely striate apically; sixth tergite with semi-circular striae in its apical half.

Description. Female, body length 5.4 mm; fore wing length 4.5 mm; ovipositor sheath 3.4 mm (Fig. 1).

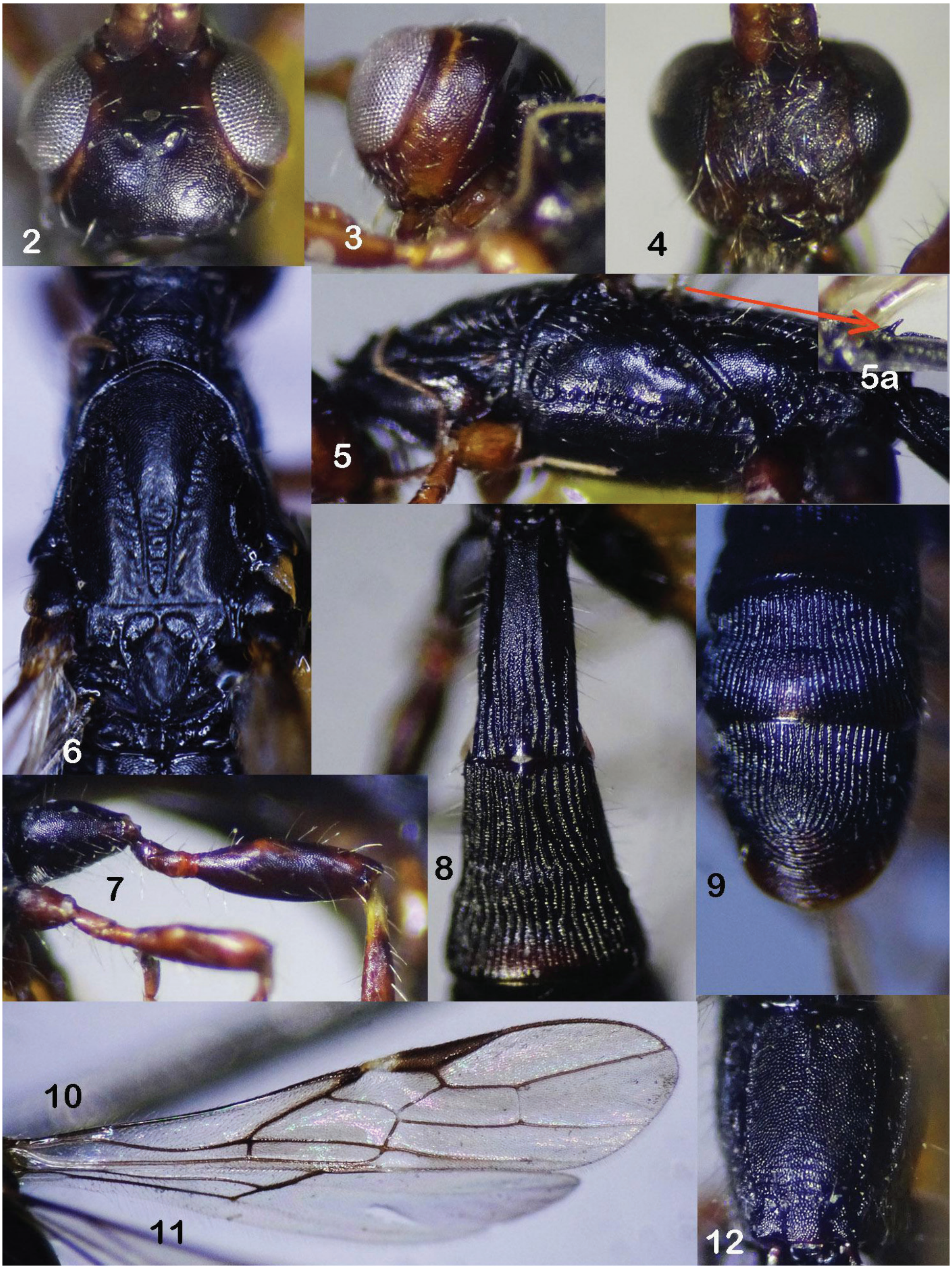
Head. Antenna incomplete, with 45 segments remaining; scapus length dorsally 1.8 × as long as its maximum width; third antennal segments 1.1 × as long fourth segment; in dorsal view, temple roundly narrowed behind eye; head width 1.3 × its median length; median length of head 3.0 × as long as temple; height of eye 1.9 × temple (Fig. 2); in lateral view, transverse diameter of eye 1.4 × length of temple (13 : 9); eye length

Figure 1. *Rhaconotus directus* Long, sp. nov., female, holotype (habitus, lateral view).

1.4 × its width (18 : 13) (Fig. 3); ocelli small, basal side of ocellar triangle 1.5 × lateral sides; POL 1.5 × OD and 0.5 × OOL (Fig. 2); in frontal view, eye 2.1 × as high as broad; malar space height 0.5 × height of eye, and 1.3 × basal width of mandible; face width 1.3 × height of eye, and 1.8 × height of face and clypeus combined (Fig. 4); hypoclypeal depression width 1.3 × as long distance from edge of depression to eye, 4.0 × as wide as face, and 1.6 × as wide as basal width of mandible; distance between tentorial pits 1.5 × as long as long distance from pit to eye; occipital carina complete medio-dorsally, obliterated below and not fused with hypostomal carina above base of mandible (Fig. 3); length of maxillary palp 1.45 × height of head (without mandible); frons almost flat, finely granulate; vertex and temple finely granulate; face setose, granulate (Fig. 4).

Mesosoma. Distance from pronotal carina to mesonotum equal to distance from carina to anterior margin of pronotum; length of mesosoma 2.9 × its height (Fig. 5); in lateral view, metanotum with long pointed tooth (Fig. 5a); pronotal trough crenulate anteriorly, with transverse striae posteriorly; precoxal sulcus long, narrow, crenulate (Fig. 5); mesopleuron and metapleuron finely granulate; mesoscutum finely granulate; notauli shallow, sparsely crenulate anteriorly, widened posteriorly with crenulate depression (Fig. 6); scutellar depression 0.4 × as long as scutellum; scutellum finely granulate (Fig. 6); propodeum with lateral carinae, median carina in basal 0.3 of propodeum (Fig. 12); propodeum almost finely granulate; apex of propodeum with 2–3 transverse rugosities (Fig. 12).

Wings. Fore wing 4.35 × as long as its maximum width; pterostigma 4.5 × as long as wide; vein r arising from middle of pterostigma; vein 1-R1 1.2 × as long as pterostigma; vein 3-SR 5.0 × vein r, and 0.5 × vein SR1, and 1.4 × vein 2-SR; vein m-cu postfurcal; second submarginal cell of fore wing parallel-sided, basal length 2.9 × as long as its maximum width (Fig. 10), and 0.9 × as long as subdiscal cell; subdiscal



Figures 2–12. *Rhaconotus directus* Long, sp. nov., female, holotype **2** head, dorsal view **3** head, lateral view **4** head, frontal view **5** mesopleuron **6** mesonotum, dorsal view **7** hind coxa and femur **8** metasomal tergites 1–3, dorsal view **9** metasomal tergites 5–6 **10** fore wing **11** hind wing **12** propodeum.

cell roundly closed on level of vein m-cu; vein 1-CU1 very short, nearly quadrate; vein cu-a almost interstitial (Fig. 10); hind wing 5.0 × as long as its maximum width; vein M+CU 0.3 × vein 1-M ; vein 1-M 6.3 × vein 1r-m (Fig. 11).

Legs. Fore tarsus 1.2 × as long as fore tibia; inner side of fore tibia with four spines; hind coxa with baso-ventral tooth (Fig. 7), finely and densely granulate; hind femur, tibia and basitarsus 3.3, 7.7, and 6.7 × their maximum width, respectively; dorsal side of hind femur with short sparse semi-erected setae (Fig. 7), length of seta about 0.5 × as long as maximum width of femur; outer side of hind tibia with sparse semi-erected setae, length of seta as long as maximum width of hind tibia; inner hind tibial spur 0.2 × as long as hind basitarsus; hind tarsus 0.9 × as long as hind tibia; basitarsus 0.7 × as long as second-fifth tarsal segments combined (20:33); second tarsal segment 0.5 × as long as basitarsus (10 : 20), and 2.0 × as long as fifth tarsal segment (without pretarsus); fourth tarsal segment 0.6 × fifth tarsal segment.

Metasoma. Metasoma 1.4 × as long as head and mesosoma combined; first tergite gradually widened from base to apex; maximum width of first tergite 1.4 × its minimum width (Fig. 8); length of first metasomal tergite 2.4 × apical width, and 1.45 × length of propodeum; second suture indistinct because of straight longitudinal striae; second tergite with lenticular apical area weakly delineated with wide shallow furrows (Fig. 8); second tergite with apical area 2.45 × as long as length of third tergite (Fig. 8); first metasomal tergite with dorsal carinae, granulate basally, longitudinally striate apically (Fig. 8); second-third tergites coarsely longitudinally striate; fourth-fifth tergites largely longitudinally striate basally, finely striate apically; sixth tergite with semi-circular striae in its apical half (Fig. 9).

Colour. Body black; head dark brown; antenna brownish yellow, palpi brown, except apical segment of maxillary palp pale yellow; fore and middle legs brownish yellow, except tarsus yellow, hind coxa dark brown; hind femur and tibia brown; hind tarsus yellow; tegula brown; wing veins yellowish brown; pterostigma brown, cream white basally (Fig. 10).

Male. Unknown.

Biology. Unknown.

Etymology. From *directus* (Latin for "set straight", "arrange in a straight line"), because of the interstitial vein cu-a of fore wing.

Rhaconotus laevigatus **Long, sp. nov.**

http://zoobank.org/FD83916A-D100-4251-95BE-9D1990976C66
Figs 13–24

Material. Holotype, female, "Doryc.080" (IEBR), NE Vietnam: Vinh Phuc, Me Linh, Tam Dao foothill, forest, 13.v.2002, KD Long.

Diagnosis. Occipital carina finely complete medio-dorsally, not fused with hypostomal carina above base of mandible (Fig. 16); frons almost flat, with transverse fine striae (Fig. 14); vertex and temple shiny, smooth; distance from pronotal carina to mesonotum equal to distance from carina to anterior margin of pronotum; in lateral view, metanotum with short pointed tooth; precoxal sulcus narrow, almost smooth (Fig. 18); mesopleuron and metapleuron finely granulate; notauli shallow, sparsely crenulate anteriorly, widened posteriorly, with median more or less shallow depression (Fig. 17);

propodeum with median carina in basal 0.6 (Fig. 21); pterostigma 3.3 × as long as wide; fore wing vein 3-SR 3.0 × vein r; vein 1-CU1 0.05 × vein 2-CU1; basal length of second submarginal cell 2.9 × its maximum width and 0.9 × subdiscal cell (Fig. 23); vein 1-M of hind wing 4.2 × vein 1r-m (Fig. 24); inner side of fore tibia with six spines; hind coxa finely and densely granulate; hind tibia 11.1 × its maximum width; first metasomal tergite 2.7 × its apical width, granulo-coriaceous; second tergite with lenticular apical area delineated with furrows (Fig. 19); second-third tergites coarsely longitudinally striate, but finely striate apically; fourth tergite largely striate basally contrast to fine striate apex; fifth tergite striate medially, granulo-punctate apically; sixth tergite fine basally, finely rugose medially, with fine semi-circular striae at apex (Fig. 22).

Description. Female, body length 7.6 mm; fore wing length 5.7 mm; ovipositor sheath 3.9 mm (Fig. 13).

Head. Antenna incomplete, with 54 segments remaining; scapus length dorsally 1.5 × as long as its maximum width; third antennal segment 1.1 × as long fourth segment; in dorsal view, temple roundly narrowed behind eye; median length of head 2.7 × as long as temple; height of eye 1.6 × as long as temple (Fig. 14); in lateral view, transverse diameter of eye 1.5 × length of temple; eye 1.2 × longer than its width (Fig. 16); ocelli small, basal side of ocellar triangle 1.5 × lateral sides; POL 1.5 × OD, and 0.4 × OOL (Fig. 14); in frontal view, eye twice as high as broad; malar space 0.5 × height of eye, and 1.25 × as long as basal width of mandible; face width 1.1 × height of eye, and 1.4 × height of face and clypeus combined (Fig. 15); hypoclypeal depression as long as distance from edge of depression to eye, 0.5 × as wide as face, and 1.5 × as wide as basal width of mandible; distance between tentorial pits 1.6 × as long as long distance from pit to eye; occipital carina finely complete medio-dorsally, not fused below with hypostomal carina above base of mandible (Fig. 16); head below eyes roundly narrowed below eyes (Fig. 14); length of maxillary palp 1.4 × height of head (without mandible); frons almost flat, with transverse fine striae anteriorly, smooth posteriorly; vertex and temple shiny smooth; face setose, finely punctate (Fig. 15).

Mesosoma. Distance from pronotal carina to mesonotum equal to distance from carina to anterior margin of pronotum; mesoscutum more or less depressed posteriorly; length of mesosoma 2.6 × its height (Fig. 18); in lateral view, metanotum with short pointed tooth; pronotal side deep, almost smooth; mesoscutum granulo-coriaceous; notauli narrow, punctate (Fig. 17); scutellar depression 0.4 × as long as scutellum, with one median carina (Fig. 17); scutellum finely granulate; precoxal sulcus narrow, smooth (Fig. 18); mesopleuron almost smooth; subalar depression wide, deep, with sparse crenulae (Fig. 18); propodeum with carina in its basal 0.6 (Fig. 21).

Wings. Fore wing 4.7 × as long as its maximum width; pterostigma 3.3 × as long as wide; vein r arising behind middle of pterostigma (distance from apex of pterostigma to vein r 0.8 × distance from vein r to base of pterostigma); vein 1-R1 1.1 × as long as pterostigma (Fig. 23); vein 3-SR 3.0 × vein r, 0.2 × vein SR1, and 1.5 × vein 2-SR; vein m-cu distinctly postfurcal; basal length of second submarginal cell of fore wing 4.7 × as long as its maximum width (42 : 9), and 0.9 × as long as subdiscal cell; subdiscal cell roundly closed on level of vein m-cu; vein 1-CU1 0.7 × vein cu-a, and 0.05 × vein

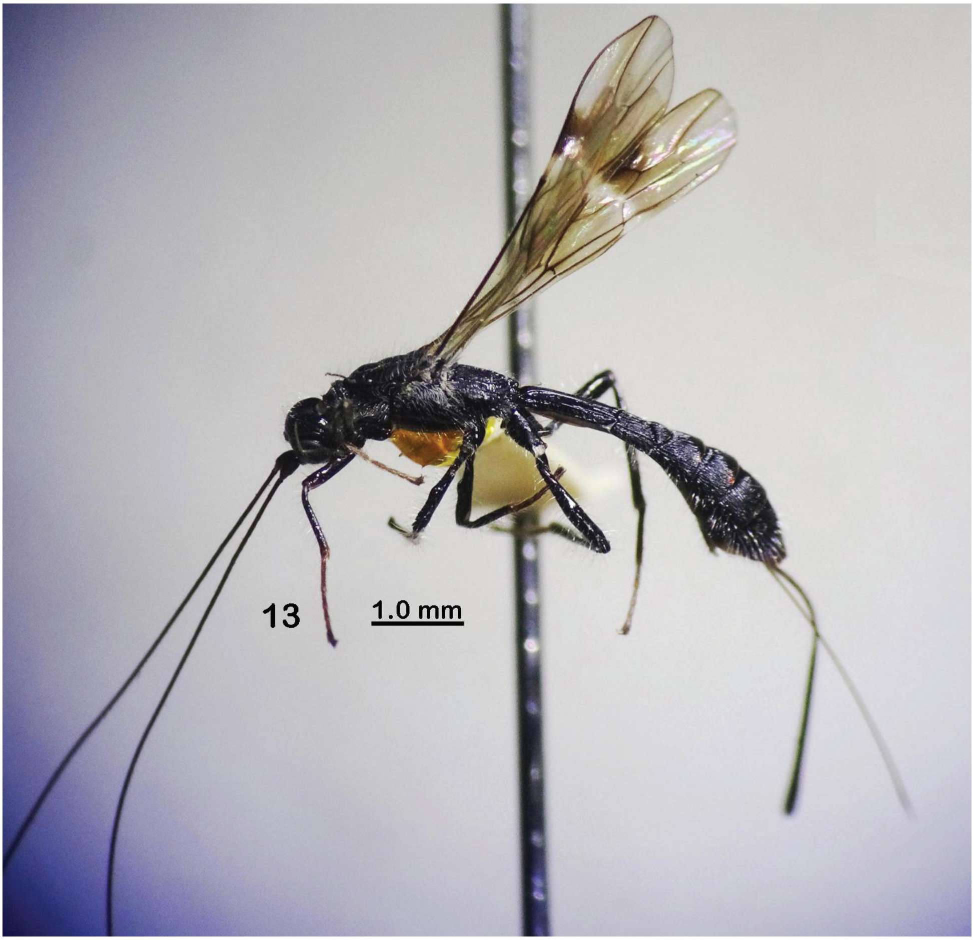
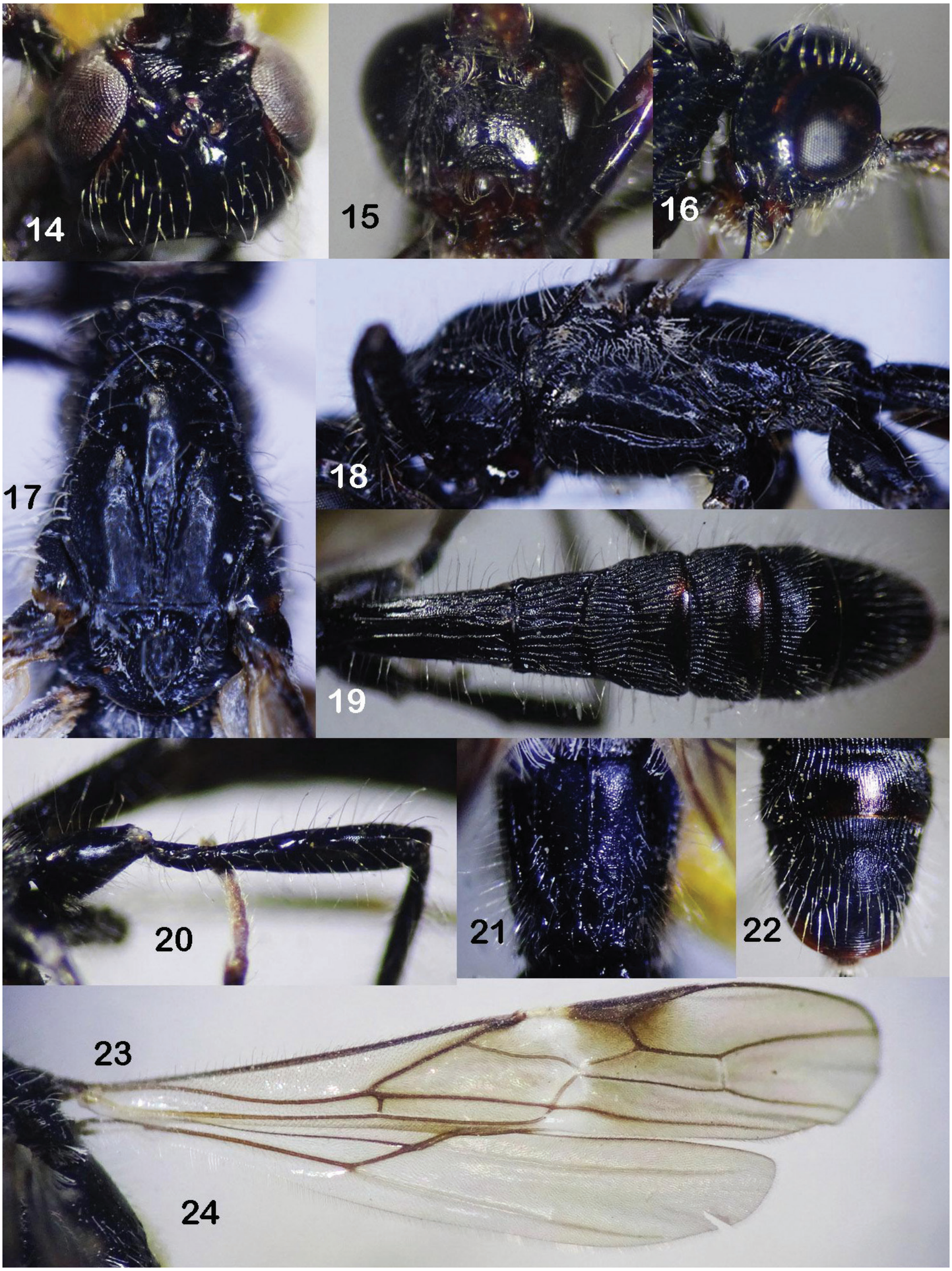


Figure 13. *Rhaconotus laevigatus* Long, sp. nov., female, holotype (habitus, lateral view).

2-CU1 (Fig. 23); hind wing 6.1 × as long as wide; vein M+CU 0.2 × vein 1-M; vein 1-M 4.2 × vein 1r-m (Fig. 24).

Legs. Fore tarsus 1.4 × as long as fore tibia; inner side of fore tibia with six spines; outside of fore tibia with long erected setae, length of seta twice as long width of fore tibia; hind coxa with baso-ventral tooth; hind femur, tibia and basitarsus 5.6, 11.1 and 8.0 × their maximum width, respectively; dorsal side of hind femur with long semi-erected setae, length of seta 1.6 × as long as maximum width of hind tibia (Fig. 20); outside of hind tibia with long erected setae, length of seta twice as long as maximum width of hind tibia; inner hind tibial spur 0.3 × as long as hind basitarsus; hind tarsus 1.2 × as long as hind tibia; basitarsus 0.8 × as long as second-fifth tarsal segments combined; second tarsus 0.4 × as long as basitarsus, and 1.4 × as long as fifth tarsus (without pretarsus); fourth tarsus 0.6 × fifth tarsus; hind coxa with sparse setae, finely granulate.



Figures 14–24. *Rhaconotus laevigatus* Long, sp. nov., female, holotype **14** head, dorsal view **15** head, frontal view **16** head, lateral view **17** mesonotum, dorsal view **18** mesopleuron **19** metasomal tergites 1–4, dorsal view **20** hind coxa and femur **21** propodeum **22** metasomal tergites 5–6, dorsal view **23** fore wing **24** hind wing.

Metasoma. Metasoma 1.5 × as long as head and mesosoma combined; maximum width of first tergite 1.5 × its minimum width; length of first metasomal tergite 2.7 × apical width, and 1.7 × length of propodeum; second tergite with lenticular apical area separated with distinct wide crenulate furrow (Fig. 19); length of separated area 0.75 × length of second tergite, and 0.9 × third tergite; length of second tergite 0.6 × as long as its basal width, and 1.2 × length of third tergite; first metasomal tergite with long straightly erected setae laterally, with two almost parallel dorsal carina running from base to apex (Fig. 19); first tergite almost granulo-coriaceous; second tergite coarsely striate; third-fourth tergites largely striate basally, finely striate apically (Fig. 19); fifth tergite striate basally, granulo-punctate apically; sixth tergite setose, finely striate basally, finely rugose medially, with fine semi-circular striae apically (Fig. 22);

Colour. Black, antenna brown; palpi brown; all legs dark brown to black, expect tarsus yellowish brown; tegula brown; wing veins brown; pterostigma brown, cream white basally, surrounding vein r beneath pterostigma smoky brown (Fig. 23); ovipositor sheath brown.

Male. Unknown.

Biology. Unknown.

Etymology. From *laevis* (Latin for smooth, polished), because of vertex, temple and mesopleuron shiny smooth.

Rhaconotus robustus Long, sp. nov.

http://zoobank.org/368DE76C-6AA0-4FFC-A4DF-57384123A56F
Figs 25–36

Material. Holotype, male, "Doryc.722" (IEBR), NW Vietnam: Hoa Binh, Mai Chau, Tan Son, orchard, MT, 20°43'10.3"N 104°59'47.0"E, 950m, 1-5.v.2010, KD Long.

Diagnosis. Antenna with 46 segments (male); occipital carina finely complete medio-dorsally, fading below distal to hypostomal carina above base of mandible (Fig. 27); frons slightly depressed, with sparse fine striae (Fig. 26); vertex and temple shiny, smooth; distance from pronotal carina to mesonotum equal to distance from carina to anterior margin of pronotum; in lateral view, metanotum with short pointed tooth; precoxal sulcus narrow, straight, crenulate (Fig. 30); mesopleuron and metapleuron finely granulate; notauli shallow, sparsely crenulate anteriorly, slightly widened posteriorly, with two longitudinal convergent carinae running close to scutellar sulcus (Fig. 29); propodeum with baso-lateral areas emarginated by carina (Fig. 32); median carina in basal 0.5; pterostigma 4.4 × as long as wide; fore wing vein 3-SR 2.7 × vein r; vein 1-CU1 0.12 × vein 2-CU1 (Fig. 35); second submarginal cell slightly widened apically, basal length 3.1 × its maximum width and 1.6 × subdiscal cell; vein 1-M of hind wing 4.25 × vein 1r-m (Fig. 36); inner side of fore tibia with six spines; hind coxa finely granulate; hind tibia robust, 8.5 × its maximum width; first metasomal tergite nearly parallel-sided, 2.5 × its apical width (Fig. 33), finely granulate basally, longitudinally striate apically; second-fifth tergites longitudinally striate; sixth tergite rugo-striate basally, almost smooth apically (Fig. 31).

Description. Male, body length 5.9 mm; fore wing length 3.7 mm (Fig. 25).

Head. Antenna with 46 segments; scapus dorsally 1.3 × longer than its maximum width; third antennal segment 1.1 × as long fourth segment; in dorsal view; temple

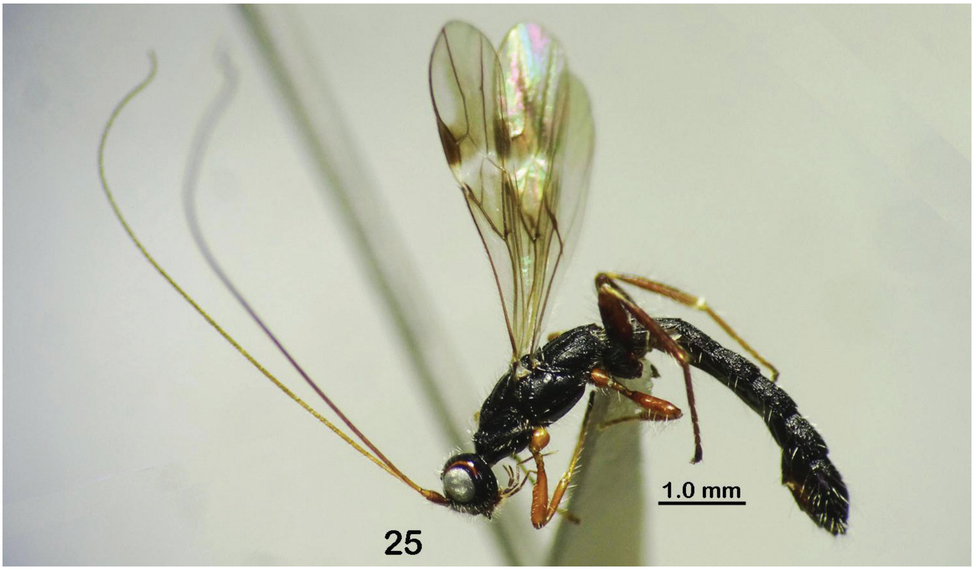
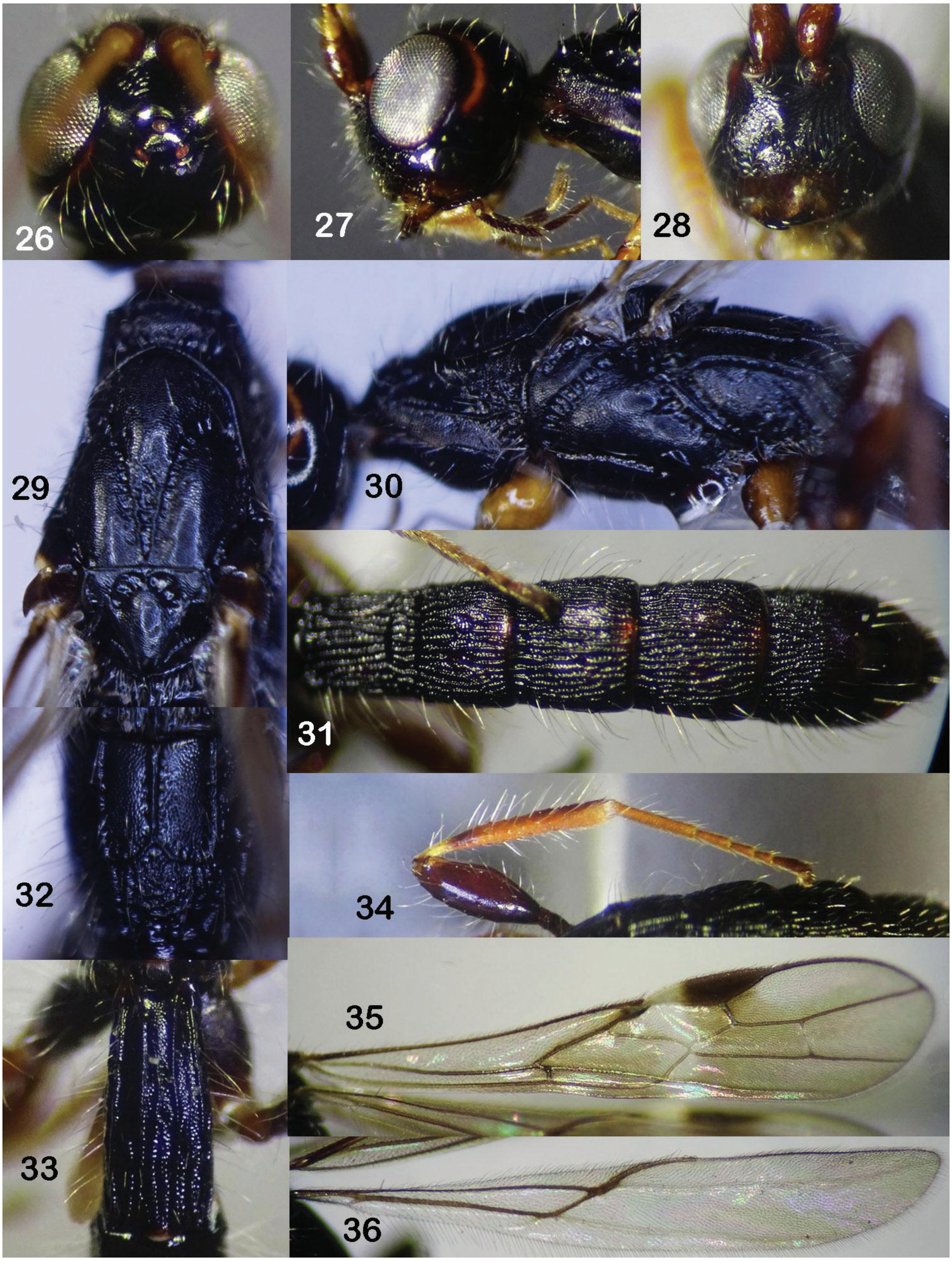


Figure 25. *Rhaconotus robustus* Long, sp. nov., male, holotype (habitus, lateral view).

roundly behind eye; head width 1.3 × its median length (Fig. 26); median length of head 1.8 × as long as temple; height of eye 1.3 × temple; in lateral view, transverse diameter of eye 1.2 × length of temple; eye 1.4 × longer than its width (Fig. 27); ocelli small, basal side of ocellar triangle 1.5 × lateral sides; POL 1.5 × as long as OD, and 0.6 × OOL (Fig. 26); in frontal view, eye 2.3 × as high as broad; malar space 0.4 × height of eye, 1.3 × as long as basal width of mandible (Fig. 28); face width 1.1 × height of eye, and 1.3 × height of face and clypeus combined; width of hypoclypeal depression 0.8 × as long distance from edge of depression to eye, 0.4 × as wide as face, and 1.2 × as wide as basal width of mandible; distance between tentorial pits 1.1 × as long as long distance from pit to eye; occipital carina complete, fading below distal to hypostomal carina above base of mandible (Fig. 27); head with long sparse setae, roundly narrowed below eyes (Fig. 26); length of maxillary palp 1.4 × height of head (without mandible); frons slightly depressed medially, with sparse fine striae; vertex and shiny, smooth (Fig. 26); face rugo-coriaceous; clypeus rugose (Fig. 28).

Mesosoma. Mesosoma depressed, its dorsal side almost flat; length 2.1 × its height (Fig. 30); pronotum with median transverse carina; notauli narrow, sparsely crenulate anteriorly, slightly widened posteriorly with two longitudinal convergent carinae running close to scutellar sulcus (Fig. 29); pronotal side almost flat, coriaceous medially, coarsely rugose posteriorly, finely granulate ventrally; precoxal sulcus long, narrow, crenulate; subalar depression largely crenulate; mesopleuron finely granulate (Fig. 30); mesoscutum and scutellum finely granulate; propodeum with baso-lateral areas emarginated by carinae (Fig. 32); median carina in basal 0.5 of propodeum; baso-lateral area finely granulate; propodeal areola rugose.

Wings. Fore wing 4.1 × as long as its maximum width; pterostigma 4.4 × as long as wide; vein r arising behind middle of pterostigma (distance from apex of pterostigma



Figures 26–36. *Rhaconotus robustus* Long, sp. nov., male, holotype **26** head, dorsal view **27** head, lateral view **28** head, frontal view **29** mesonotum, dorsal view **30** mesopleuron **31** tergites 2–6, dorsal view **32** propodeum **33** first metasomal tergite **34** hind femur and tibia **35** fore wing **36** hind wing.

to vein r 0.7 × distance from vein r to base of pterostigma); vein 1-R1 1.2 × as long as pterostigma; vein 3-SR 2.7 × vein r, and 0.6 × vein SR1, and 1.3 × vein 2-SR; vein m-cu distinctly postfurcal; second submarginal cell of fore wing slightly widened apically (Fig. 35), basal length 3.1 × as long as its maximum width, and 1.6 × as long as subdiscal cell; subdiscal cell roundly closed on level of vein m-cu; vein 1-CU1 equal to vein cu-a, and 0.12 × vein 2-CU1 (Fig. 35); hind wing 6.7 × as long as wide; vein M+CU 0.3 × vein 1-M; vein 1-M 4.25 × vein 1r-m (Fig. 36).

Legs. Fore tarsus 1.5 × as long as fore tibia; inner side of fore tibia with six spines; hind coxa with baso-ventral tooth, finely granulate; hind femur robust (Fig. 34), length of hind femur, tibia and basitarsus 2.5, 8.5 and 10.5 × their maximum width, respectively; outer side of hind tibia with long semi-erected setae, length of seta 1.5 × maximum width of tibia (Fig. 34); inner hind tibial spur 0.3 × as long as hind basitarsus; hind tarsus 0.9 × as long as hind tibia; basitarsus 0.8 × as long as second-fifth tarsal segments combined; second tarsus 0.4 × as long as basitarsus, and 1.1 × as long as fifth tarsus (without pretarsus); fourth tarsus 0.6 × fifth tarsus.

Metasoma. Metasoma 1.3 × as long as head and mesosoma combined; first metasomal tergite nearly parallel-sided (Fig. 33); length of first metasomal tergite 2.5 × apical width, and 1.4 × length of propodeum; second metasomal tergite with narrow lenticular apical area separated with shallow crenulate furrow, length of lenticular apical area 0.3 × length of second tergite (Fig. 31); length of second tergite 0.9 × as long as its basal width, and 0.7 × length of third tergite; first metasomal tergite with two dorsal carinae in basal 0.5 of tergite; finely granulate basally, longitudinally striate apically (Fig. 33); second-fifth tergites longitudinally striate; sixth tergite sparsely setose, rugo-striate basally, almost smooth apically (Fig. 31).

Colour. Body black, antenna yellow, but brown apically; scapus brownish yellow; head black with yellow semi-circular stripe around eye dorso-laterally (Fig. 27); palpi brown, except apical segment of labial palp and two apical segments of maxillary palp yellow; fore and middle legs yellow; hind coxa and femur yellowish brown; hind tibia and tarsus yellow; tegula brownish yellow; wing veins pale brown; pterostigma pale brown, cream white basally (Fig. 35); wing membrane hyaline with smoky spots medially.

Female. Unknown.

Biology. Unknown.

Etymology. From *robustus* (Latin for strong), because of the robust hind femur.

Rhaconotus simulatus Long, sp. nov.

http://zoobank.org/B62850AA-A9AA-4B94-B95D-C22AE73A9E90
Figs 37–49

Material. Holotype, female, "Doryc.791" (IEBR), NW Vietnam: Son La, orchard, MT, 21°18'03.6"N 103°55'38.3"E, 671 m, 15–25.vi.2016, KD Long.

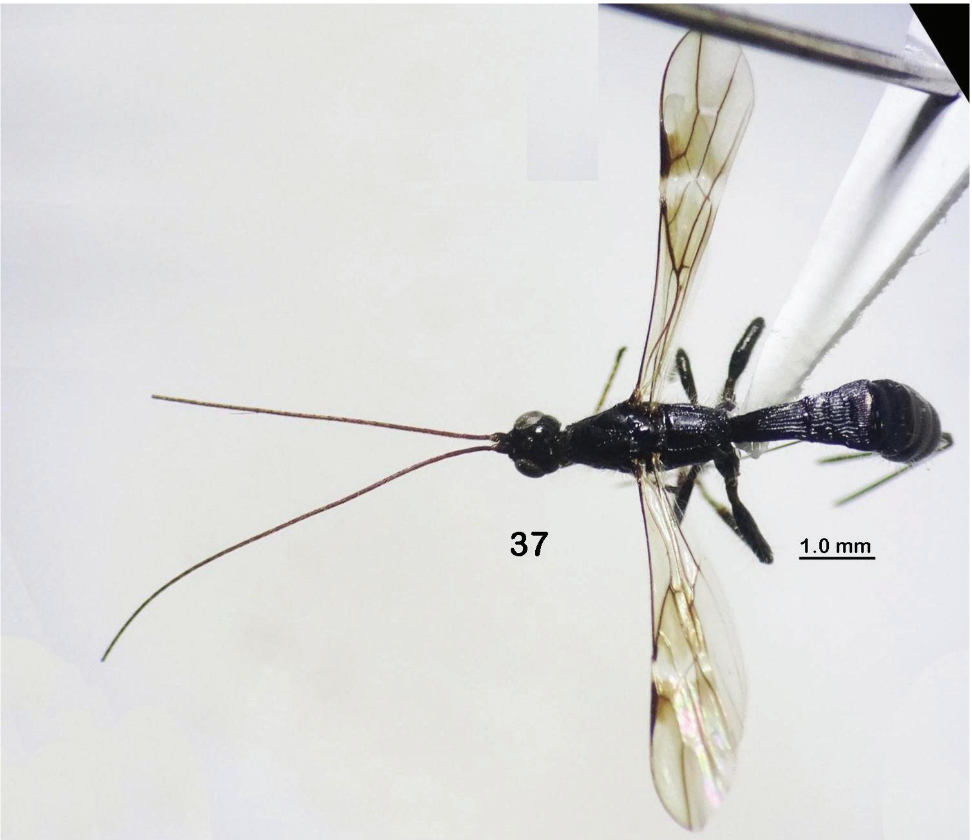
Diagnosis. Occipital carina finely complete medio-dorsally, fused with hypostomal carina above base of mandible (Fig. 40); frons slightly depressed medially, rugose anteriorly, finely granulate posteriorly; vertex and temple smooth; distance from pronotal carina to mesonotum equal to distance from carina to anterior margin of pronotum; in lateral view, metanotum with short pointed tooth; precoxal sulcus long, sinuate, crenulate (Fig. 42); mesopleuron finely granulate; notauli narrow, widened anteriorly, crenulate with two posterior convergent carinae running close to scutellar sulcus (Fig. 41); propodeum with median carina in basal 0.5; pterostigma 5.7 × as long as wide; fore wing vein 3-SR 3.4 × vein r; vein 1-CU1 0.08 × vein 2-CU1 (Fig. 46); basal length of second submarginal cell 3.8 × its maximum width and as long as subdiscal cell; vein 1-M of hind wing 4.4 × vein 1r-m (Fig. 47); inner side of fore tibia with five spines; hind coxa finely granulate; hind tibia 8.3 × its maximum width; first metasomal tergite 2.2 × its apical width (Fig. 43), longitudinally striate in apical 0.7; furrow between second and third tergites wide, crenulate; third tergite largely striate basally, densely and finely striate apically; fourth-fifth tergites longitudinally striate; sixth tergite striate basally, with fine semi-circular striae at apex (Fig. 45).

Description. Female, body length 6.6 mm; fore wing length 5.0 mm; ovipositor sheath 2.4 mm (Fig. 37).

Head. Antenna incomplete, with 30 segments remaining; scapus length dorsally 1.7 × its maximum width; third antennal segment 1.3 × as long fourth segment; in dorsal view, temple roundly narrowed behind eye; head width 1.3 × its median length (Fig. 38); median length of head 3.2 × as long as temple; height of eye 1.09 × temple; in lateral view, eye 1.3 × longer than width; transverse diameter of eye 1.6 × length of temple (Fig. 40); ocelli small, basal side of ocellar triangle 1.5 × lateral sides; POL as long as OD, and 0.5 times OOL; in frontal view, eye 2.1 × as high as broad (Fig. 39); malar space height 0.5 × height of eye, and as long as basal width of mandible; face width 1.2 × height of eye, and 1.3 × height of face and clypeus combined (Fig. 39); hypoclypeal depression width 0.6 × as long distance from edge of depression to eye, 0.4 × as wide as face; and 1.2 × as wide as basal width of mandible; distance between tentorial pits as long as long distance from pit to eye; occipital carina complete medio-dorsally, fused bellow with hypostomal carina distal to base of mandible (Fig. 40); maxillary palp 1.3 × height of head (without mandible); frons slightly depressed medially, rugose anteriorly, granulo-coriaceous posteriorly; vertex between lateral ocellus and eye margin finely granulate, vertex between lateral ocellus and eye margin finely granulate; vertex below posterior ocelli, temple smooth; face latero-ventrally and malar space coriaceous; clypeus rugose.

Mesosoma. Length of mesosoma 2.4 × its height (Fig. 42); in lateral view, metanotum with short pointed tooth; notauli narrow, widened anteriorly, crenulate with two posterior convergent carinae running close to scutellar sulcus (Fig. 41); scutellar sulcus with three carinae, 0.4 × as long as scutellum (Fig. 41); scutellum mesoscutum and scutellum finely granulate; pronotal side depressed medially, sparsely crenulate medially and anteriorly, coarsely rugose posteriorly, granulate ventrally; precoxal sulcus long, sinuate, crenulate (Fig. 42); mesopleuron finely granulate; subalar depression largely crenulate; propodeum with baso-lateral areas emarginated by carinae (Fig. 44); median carina in basal 0.5 of propodeum; baso-lateral areas finely granulate; propodeum coarsely rugose apically.

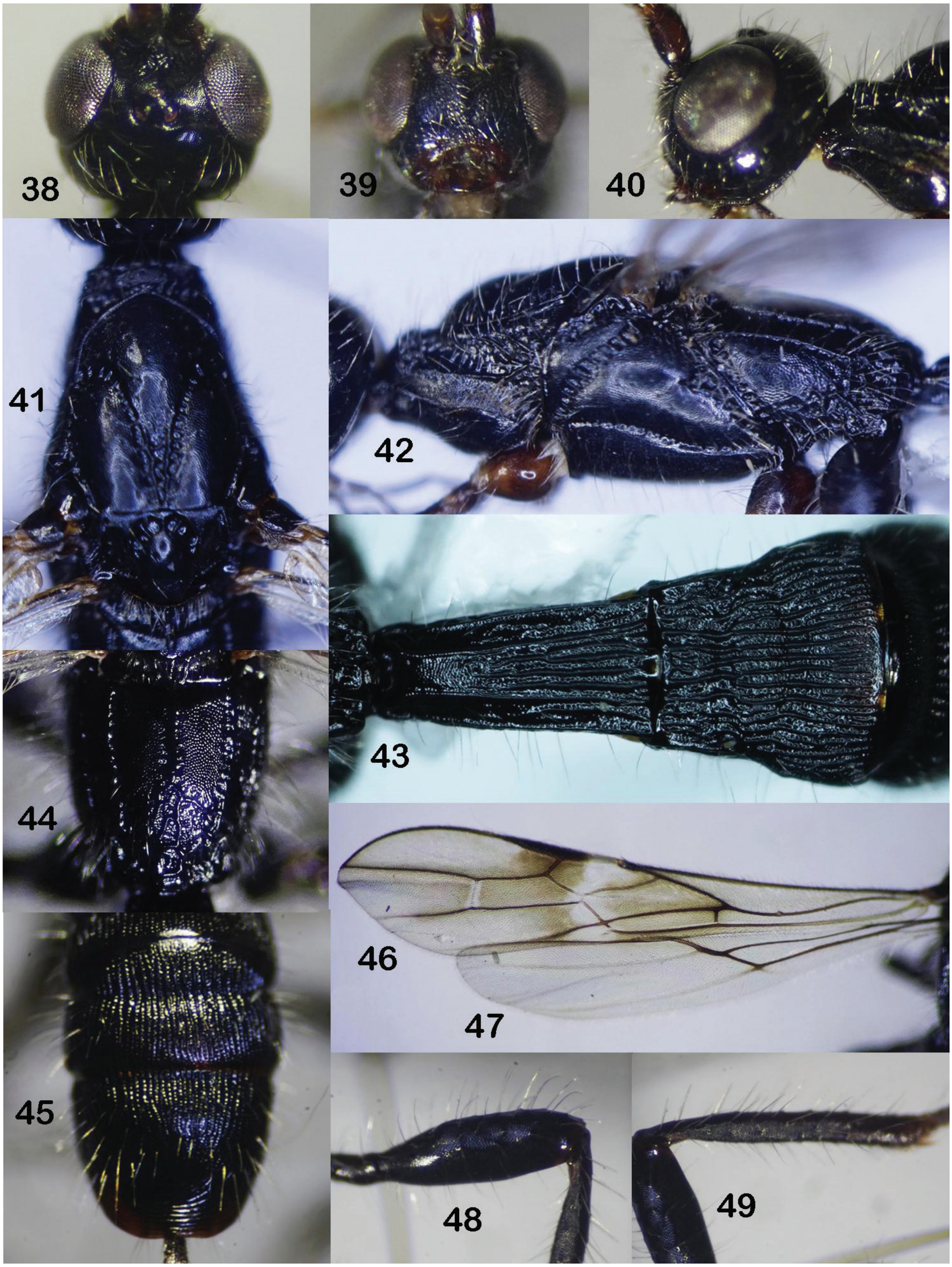
Wings. Fore wing 4.2 × as long as its maximum width; pterostigma 5.7 × as long as wide; vein r arising from middle of pterostigma; vein 1-R1 1.4 × as long as pterostigma;



Figures 37. *Rhaconotus simulatus* Long, sp. nov., female, holotype (habitus, dorsal view).

vein 3-SR 3.4 × vein r, 0.45 × vein SR1, and 2.0 × vein 2-SR; vein m-cu distinctly postfurcal; second submarginal cell parallel-sided, basal length 3.8 × as long as its maximum width, and as long as subdiscal cell (Fig. 46); subdiscal cell roundly closed on level of vein m-cu; vein 1-CU1 0.08 × vein 2-CU1, and 0.75 × vein cu-a; hind wing 7.0 × as long as wide; vein M+CU 0.3 × vein 1-M; vein 1-M 4.4 × vein 1r-m (Fig. 47).

Legs. Fore tarsus 1.6 × as long as fore tibia; inner side of fore tibia with five spines; hind coxa with baso-ventral tooth; hind coxa finely granulate; hind femur, tibia and basitarsus 3.0, 8.3 and 5.75 × their maximum width, respectively (Figs 48, 49); hind femur finely granulate; hind tibia with long semi-erected setae, length of seta as long as maximum width of tibia (Fig. 49); inner hind tibial spur 0.3 × as long as hind basitarsus; hind tarsus 0.8 × as long as hind tibia; basitarsus 0.7 × as long as second-fifth tarsal segments combined; second tarsus 0.4 × basitarsus, and as long as fifth tarsus (without pretarsus); fourth tarsus 0.2 × fifth tarsus.



Figures 38–49. *Rhaconotus simulatus* Long, sp. nov., female, holotype **38** head, dorsal view **39** head, frontal view **40** head, lateral view **41** mesonotum, dorsal view **42** mesopleuron **43** metasomal tergites 1–3, dorsal view **44** propodeum **45** metasomal tergites 5–6, dorsal view **46** fore wing **47** hind wing **48** hind femur **49** hind tibia.

Metasoma. Metasoma 1.25 × as long as head and mesosoma combined; first metasomal tergite distinctly widened at apex, with two dorsal carinae in whole length of tergite (Fig. 43); maximum width of first tergite 1.2 × its minimum width; length of first metasomal tergite 2.2 × apical width (Fig. 43), and 1.4 × length of propodeum; second tergite with more or less distinct lenticular apical area separated by furrows (Fig. 43); length of second tergite 0.44 × as long as its basal width, and 0.5 × length of third tergite; first metasomal tergite longitudinally striate in apical 0.7 of tergite (Fig. 43); furrow between second and third tergites wide, crenulate; third tergite largely striate basally, densely and finely striate apically; fourth-fifth tergites longitudinally striate (Fig. 43); sixth tergite striate basally, with fine semi-circular striae apically (Fig. 45);

Colour. Body black; antenna pale brown; palpi brown, except apical segment of maxillary palp pale yellow; fore coxa brownish yellow, fore femur and tibia yellowish brown; fore tarsus yellow; middle coxa yellowish brown; middle femur and tibia brown; middle tarsus yellow; hind leg brown, except tarsus brownish yellow; tegula brown; wing veins brown; pterostigma brown, cream white basally (Fig. 46); wing membrane yellow with brown clouds medially; ovipositor sheath brown.

Male. Unknown.

Biology. Unknown.

Etymology. From *simulo* (Latin for imitate, copy), because this new species is similar to *R. thayi* Belokobylskij.

Remarks. *R. simulatus*, sp. nov. is similar to *R. thayi* Belokobylskij, 2001, from China and Vietnam, but the new species differs from the later by having: a. Occipital carina fused bellow with hypostomal carina distal to base of mandible (Fig. 40; not fused in *R. thayi*); b. Vein 1-R1 of fore wing 1.4 × as long as pterostigma (1.1 × in *R. thayi*), and vein 3-SR 3.4 × vein r (4.0–4.8 × in *R. thayi*); c. First metasomal tergite with dorsal carinae in whole length of tergite (in basal third in *R. thayi*) and d. Precoxal sulcus sinuate, crenulate (straight and smooth medially in *R. thayi*).

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RESEARCH ARTICLE

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On the genus *Pseudocneorhinus* (Coleoptera, Curculionidae, Entiminae), with descriptions of five new species from China

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Abstract

Species of the genus *Pseudocneorhinus* occurring in or near China are reviewed, with description of five new species, *Pseudocneorhinus angustus* **sp. nov.**, *P. glaber* **sp. nov.**, *P. hlavaci* **sp. nov.**, *P. obliquehumeralis* **sp. nov.**, and *P. setosicallus* **sp. nov.** from the provinces of Beijing, Gansu, Shaanxi, Sichuan, and Zhejiang. They are illustrated and compared with similar species, and a key is provided to all presently known species of the genus. Lectotypes of the following species are designated: *Callirhopalus subcallosus* Voss, 1956 [current name *Pseudocneorhinus subcallosus* (Voss, 1956)] and *P. squamosus* Marshall, 1934. *Pseudocneorhinus squameus* Morimoto, 2015 is confirmed for the fauna of China.

Keywords

New taxa, parthenogenetic, taxonomy, Trachyphloeini, weevil

Introduction

The genus *Pseudocneorhinus* Roelofs, 1873 has been transferred between tribes several times. The genus was originally placed in Leptopsides Lacordaire, 1863 (Roelofs 1873), and subsequently in the tribes Eremnini Lacordaire, 1863 (Schenkling and

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Marshall 1931), Callirhopalini sensu Voss, 1956 (Morimoto 1962, Chao and Chen 1980), Pseudocneorhinini Kôno, 1930 (Morimoto 1989, Han et al. 2000, Morimoto et al. 2015) and Trachyphloeini Gistel, 1848 (Zherikhin and Egorov 1991, Egorov et al. 1996, Alonso-Zarazaga and Lyal 1999, Borovec 2009, 2013, Alonso-Zarazaga et al. 2017), where it is retained in this study. Alonso-Zarazaga et al. (2017) listed 14 species from China, the Russian Far East, Japan, and Korea. Species are found in a warm steppic habitat, forest litter, and also in high mountains.

Together with the species newly described herein, the genus increases to 19 species known from the same area, with *Pseudocneorhinus bifasciatus* Roelofs, 1880 having been introduced into the USA (Wheeler and Boyd 2005). The latter is comparatively well studied, with known biology, larva, and pupa (for example Allen 1959, Zepp 1978). Males are known only in nine species and the others are assumed to be parthenogenetic. Marshall (1934) and Voss (1956) studied regional collections from China, Han et al. (2000) and Han and Yoon (2000) from South Korea and Morimoto et al. (2015) from Japan.

The genus was recently redescribed by Borovec (2009). *Pseudocneorhinus* is related to genera *Rhinodontus* Faust, 1890 and *Rhinodontodes* Voss, 1967 sharing with them the ocular lobe in the lateral part of anterior pronotal margin, but it differs from both by the ocular lobe without setae, the rostrum lacking a lengthened epistome in females, the antennal scape exceeding the posterior border of eye and the apex of the protibia not enlarged laterally. The present study reviews the extensive material held by the Institute of Zoology at the Chinese Academy of Sciences Beijing, the Natural History Museum London, and the Zoological Institute Saint Petersburg, but also from some private collections. Previously published keys to the species of *Pseudocneorhinus* included those to the Korean (Han et al. 2000) and Japanese faunas (Morimoto et al. 2015), but no key to all the species has been published since Marshall's (1934) review of the genus, in which the number of recognised species is half that recognised in the current paper; a full key is given below. In addition, illustrations of diagnostically important internal structures are provided.

Materials and methods

Body length was measured in profile from the anterior margin of the eyes to the apex of the elytra, excluding the rostrum. All other measurements were taken in dorsal view: rostral length between anterior margins of eyes and anterior margin of epistome, rostral width as maximum width, pronotal and elytral length along midline, and their widths as maximum extension across. Dissected female genitalia were embedded in Solakryl BMX. Dried male genitalia were glued on the same mounting card as the insect. The terminology for rostrum and terminalia follows Oberprieler et al. (2014).

Photos of adults were taken with a Canon EOS 7D digital camera with an MP-E 65 mm macro lens and combined using CombineZP software. All habitus photos were edited with Adobe Photoshop CS3. Line drawings were made using a camera Lucida mounted on a Rathenow microscope. Maps were prepared with Simplemappr (Shorthouse 2010).

Available types of species hitherto described were studied, and lectotypes were selected when necessary according to Article 74.7.3 of the Code of Zoological Nomenclature.

Acronyms for depositories of the material are as follows:

BMNH	The Natural History Museum, London, United Kingdom [formerly British Museum (Natural History)];
CGTS	Christoph Germann collection, Rubigen, Switzerland;
GOVI	Giuseppe Osella collection, Verona, Italy;
IZCAS	Institute of Zoology, Chinese Academy of Sciences;
JSPC	Jiří Skuhrovec collection, Praha, Czech Republic;
MKBC	Michael Košťál collection, Brno, Czech Republic;
MMTI	Massimo Meregalli collection, Torino, Italy;
NHRS	Naturhistoriska Riksmuseet, Stockholm, Sweden;
NMPC	Národní muzeum, Prague, Czech Republic;
PBSP	Piotr Białooki, Sopot, Poland;
PKSC	Petr Kresl collection, Spůle, Czech Republic;
RBSC	Roman Borovec collection, Sloupno, Czech Republic;
SMTD	Senckenberg Naturhistorische Sammlungen Dresden, Germany;
SMNS	Staatliches Museum für Naturkunde, Stuttgart, Germany;
UMO	University Museum, Oxford, United Kingdom;
ZFMK	Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany;
ZIN	Zoological Institute of the USSR Academy of Sciences, Saint Petersburg, Russia.

Taxonomy

Pseudocneorhinus Roelofs, 1873

Pseudocneorhinus Roelofs, 1873: 177 (original description).

Pseudocneorhinus: Alonso-Zarazaga and Lyal 1999: 183 (catalogue); Han et al. 2000: 33 (Korean fauna); Borovec 2003: 31 (note); Borovec 2009: 76 (redescription of genus); Morimoto et al. 2015: 322 (Japanese fauna); Alonso-Zarazaga et al. 2017: 403 (catalogue).

Pseudocneorhinus angustus sp. nov.

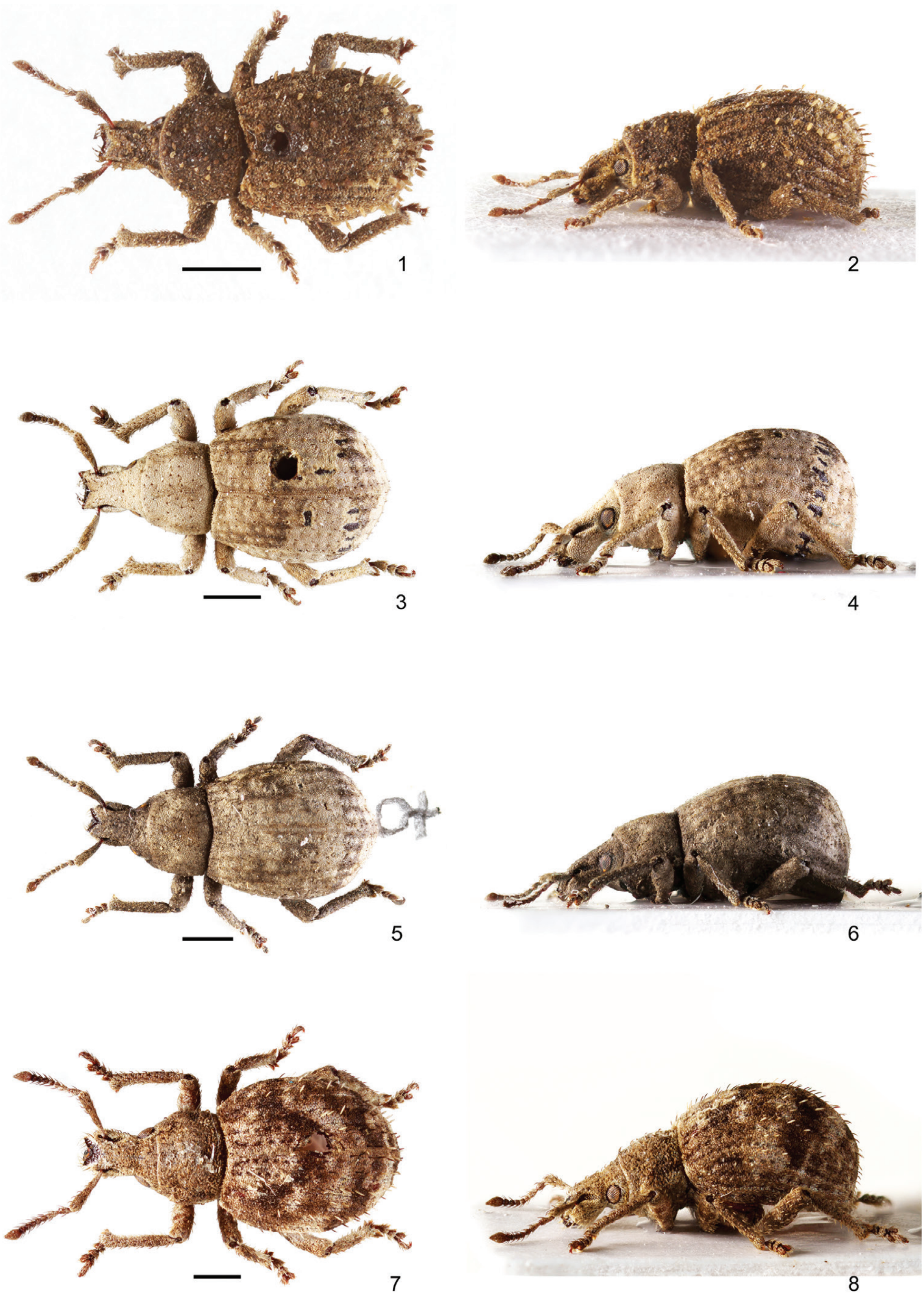
http://zoobank.org/61DDA9DF-3031-4340-812E-8135D54416C7

Figs 1, 2, 31

Type locality. Valley of Fubianhe river (China: Sichuan).

Material examined. Holotype. CHINA – **Sichuan Prov.** ♂; valley of Fubianhe river; 2 Aug. 1893; Potanin leg.; ZIN.

Paratype. CHINA – **Sichuan Prov.** 1 ♂; same data as for holotype; 5 Aug. 1893; ZIN.



Figures 1–8. Habitus of *Pseudocneorhinus* species **1, 2** *Pseudocneorhinus angustus* sp. nov., male, paratype, dorsal and lateral view **3, 4** *P. glaber*, sp. nov., male, holotype, dorsal and lateral view **5, 6** *P. glaber* sp. nov., female, paratype, dorsal and lateral view **7, 8** *P. hlavaci* sp. nov., female, holotype, dorsal and lateral view. Scale bars: 1 mm.

Description. Body length: Holotype 3.41 mm, paratype 3.50 mm.

Body (Figs 1, 2) blackish, basal half of antennal scape, funicle and tarsi reddish brown, mucro and claws reddish. Appressed scales covering antennae, head, pronotum, elytra and legs, except antennal club; scales on elytra small, irregularly angular, with indistinct depression in the middle; 4–6 scales across interval width, somewhat sparse, narrowly separate; scales light brownish with V-shaped transverse stripe from greyish scales on elytral declivity. Raised elytral setae conspicuous, erect, long and wide, spatulate, positioned in single dense row only on odd intervals, with short longitudinal clumps of intervals 3 and 5 on declivity; setae white greyish and blackish, alternating irregularly. Semierect setae on pronotum, head and rostrum half as long and wide as elytral ones, irregularly scattered. Antennae and legs except for basal half of scape with semierect moderately long setae, prominent from outline.

Rostrum (Figs 1, 2) long and slender, 1.09–1.11 × as long as wide, abruptly widened from base to basal one-fourth, then weakly tapered anteriad, with straight sides. Epifrons somewhat tapered from base to apex, with straight sides, longitudinally depressed along the whole length. Epistome short and wide, apices distinctly wider than anterior part of epifrons, separated from frons by indistinct slender carina. Frons squamose with three pairs of stout, yellowish setae. Antennal scrobe in dorsal view almost invisible; in lateral view curved, short, directed towards eyes. Rostrum in lateral view strongly convex, indistinctly separated from head by shallow transverse depression. Eyes hardly prominent from outline of head.

Antennae slender with robust scape. Scape as long as funicle, weakly curved, regularly but distinctly enlarged apicad in apical half, at apex 1.4–1.6 × as wide as club. Funicle segment 1 as long as and slightly wider than segment 2, both conical; segment 1 twice as long as wide; segment 2 2.3–2.4 × as long as wide; segments 3 and 4 1.1–1.2 × as long as wide; segments 5 and 6 isodiametric; segment 7 1.1–1.2 × as wide as long; club 1.7–1.8 × as long as wide.

Pronotum (Figs 1, 2) 1.26–1.27 × as wide as long, with weakly rounded sides, widest at midlength, more tapered anteriad than posteriad. Disc regularly convex. Anterior border in lateral view sinuose, ocular lobes well developed. Base weakly convex.

Elytra (Figs 1, 2) slender, elongate oval, 1.25–1.29 × as long as wide, widest behind midlength, not wider at shoulders. Striae distinct, weakly curved on elytral disc. Even intervals wider and more elevated than odd intervals, mainly in basal part and on elytral declivity. Base straight laterally, sinuate only in middle between third intervals. Elytra in lateral view moderately convex.

Protibiae rounded at apex, with fringe of very short yellowish setae, mucronate. Inner side of all tibiae without teeth. Metatibial corbels squamose. Tarsi robust; segment 2 1.2–1.3 × as wide as long; segment 3 1.3–1.4 × as wide as long and 1.3–1.4 × as wide as segment 2; onychium 1.1–1.2 × as long as segment 3. Claws fused in basal half.

Penis (Fig. 31) short with weakly rounded sides; apex distinctly tapered, subtriangular with concave sides. Penis in lateral view short and wide, obtuse with slender elongated apex in ventral side.

Female genitalia unknown.

Biology. Unknown.

Distribution. China: Sichuan (Fig. 52).

Etymology. The name is a Latin adjective meaning narrow and used to refer to the unusually slender elytra.

Differential diagnosis. *Pseudocneorhinus angustus* is similar to *P. hirsutus* (Formánek, 1916) and *P. squamosus* Marshall, 1934 in having distinctly enlarged antennal scapes, squamose frons, only medially (between third intervals) sinuate elytral base and small body size. It is possible to distinguish it from both these species by raised setae confined to odd intervals (*P. hirsutus* and *P. squamosus* have setae on all intervals), rostrum 1.1 × longer than wide (*P. hirsutus* and *P. squamosus* have rostrum isodiametric), epifrons tapered apicad with straight sides (*P. hirsutus* and *P. squamosus* have epifrons parallel-sided, at base weakly concave), epistome with apices distinctly wider than anterior part of epifrons (*P. hirsutus* and *P. squamosus* have epistome with apices distinctly narrower than anterior part of epifrons) and elytra slender, interval 1 at declivity much wider than on the disc (*P. hirsutus* and *P. squamosus* have elytra wider with interval 1 equally wide along the whole length). Other similar species with raised setae only on odd intervals are *P. alternans* Marshall, 1934, *P. setosicallus* sp. nov. and *P. subcallosus* (Voss, 1956). *P. angustus* can be distinguished from all these three species by smaller body size, long and wide spatulate raised elytral setae and apically distinctly enlarged scapes (apex wider than club). *Pseudocneorhinus angustus* is most similar to *P. setosicallus* because of long erect setae on the elytra; they can be distinguished by the characters specified in the key below.

Pseudocneorhinus glaber sp. nov.

http://zoobank.org/C3880FA1-F1EA-4050-835D-9588C617CA3D

Figs 3–6, 32, 37

Type locality. Anji County, Longwang Mountain (China: Zhejiang).

Material examined. Holotype. CHINA – **Zhejiang Prov.** ♂; Anji, Longwangshan [安吉龙王山]; 450 m a.s.l.; 16 May 1996; H. Wu leg. [吴鸿]; IZCAS, IOZ(E)1965363.

Paratypes. CHINA – **Zhejiang Prov.** 2 ♂♂; same data as for holotype; IZCAS, IOZ(E)1965355, IOZ(E)1965364; 1 ♀; same data as for holotype; IZCAS, IOZ(E)1786461; 1 ♂; same data as for holotype; 600 m a.s.l.; 13 Jun. 1996; W.Z. Li leg. [李文柱]; IZCAS, IOZ(E)1965354; 1 ♂; same data as for holotype; 11 Jun. 1996; W.Z. Li leg. [李文柱]; IZCAS, IOZ(E)1965353; 14 ♂♂; Lin'an, West Tianmushan, Longwangshan Gang [临安西天目山龙王山岗]; 30°13.027'N, 119°24.929'E; 1452 m a.s.l.; 25 Jul. 2011; N. Yang leg. [杨妮]; IZCAS, IOZ(E)1965337–1965345, IOZ(E)1965347–1965349, IOZ(E)1965351, IOZ(E)1965362; 4 ♀♀; same data as for preceding; IZCAS, IOZ(E)1965346, IOZ(E)1965350, IOZ(E)1965352, IOZ(E)1965361; 1 ♂; Lin'an, West Tianmushan, skyline drive [临安西天目山盘山公路]; 600 m a.s.l.; 26 Jul. 2011; N. Yang leg. [杨妮]; IZCAS, IOZ(E)1965336;

1 ♂; Lin'an, West Tianmushan, Xiaoshilin [临安西天目山小石林]; 1450 m a.s.l.; 30 Jul. 2011; N. Yang leg. [杨妮]; IZCAS, IOZ(E)1965335; 1 ♂; West Tianmushan, Xianrending [西天目山仙人顶]; 1500 m a.s.l.; 6 Jun. 1998; H. Wu leg. [吴鸿]; IZCAS, IOZ(E)1798071; 1 ♀; West Tianmushan, Sanliting [西天目山三里亭]; 25 Aug. 1998; H. Wu leg. [吴鸿]; IZCAS, IOZ(E)1798081; 1 ♀; West Tianmushan, Kaishan Laodian [西天目山开山老殿]; 1050 m a.s.l.; 23 Jun. 1998; H. Wu leg. [吴鸿]; IZCAS, IOZ(E)1798094; 1 ♂; West Tianmushan, Sanmuping [西天目山三亩坪]; 30 Jul. 1998; H. Wu leg. [吴鸿]; IZCAS, IOZ(E)1798099; 3 ♂♂; Lin'an City, Qingliangfeng county, Shunxi village [临安市清凉峰镇顺溪村]; 30°03.041'N, 118°56.550'E; 400 m a.s.l.; 9 Aug. 2008; J. Yang leg. [杨娟]; IZCAS, IOZ(E)1965311, IOZ(E)1965312, IOZ(E)1965356; 2 ♂♂; same data as for preceding; 10 Aug. 2008; IZCAS, IOZ(E)1965313, IOZ(E)1965314; 1 ♀; same data as for preceding; IOZ(E)1965357; 2 ♂♂; West Qianqingtang [西千顷塘]; 30°18.023'N, 119°07.037'E; 1140 m a.s.l.; 6 Aug. 2008; J. Yang leg. [杨娟]; beat sheet [振布]; IZCAS, IOZ(E)1965315, IOZ(E)1965320; 2 ♀♀; same data as for preceding; IZCAS, IOZ(E)1965358, IOZ(E)1965360; 9 ♂♂; same data as for preceding; 7 Aug. 2008; IZCAS, IOZ(E)1965316, IOZ(E)1965321–1965323, IOZ(E)1965326, IOZ(E)1965329, IOZ(E)1965330, IOZ(E)1965333, IOZ(E)1965359; 10 ♀♀; same data as for preceding; IZCAS, IOZ(E)1965317–1965319, IOZ(E)1965324, IOZ(E)1965325, IOZ(E)1965327, IOZ(E)1965328, IOZ(E)1965331, IOZ(E)1965332, IOZ(E)1965334.

Description. Body length: 4.63–5.19 mm, holotype 4.75 mm.

Body (Figs 3–6) blackish, mucro and fringe of setae on protibia yellowish to reddish, claws brownish. Appressed scales covering antennae, head, pronotum, elytra and legs, except antennal club; scales on dorsal part of body small, irregularly angular, depressed in the middle, 8–9 scales across elytral interval width, narrow separate; scales light greyish with feeble pearly sheen, on elytra with slender transverse dark brownish stripe at anterior third and wider dark brownish stripe at apical third. Semiappressed elytral setae inconspicuous, strongly inclined, piliform to bristle-shaped, about as long as half of width of elytral interval, visible only in apical part or at base of elytra. Pronotum and head capsule and rostrum with identical semiappressed setae, these sparse and irregularly scattered, on pronotum directed transversely. Antennae and legs except for basal half of scape with semierect moderately long setae, prominent from outline.

Rostrum (Figs 3–6) in males longer and more slender than in females, in males 1.17–1.20 × as long as wide, in females 1.04–1.07 × as long as wide, regularly enlarged from base to midlength, then tapered anteriad with regularly rounded sides. Epifrons tapering from base to midlength and widened again with slightly rounded sides at basal and apical half, at apex narrower than at base, longitudinally widely and shallowly depressed. Epistome V-shaped, long, conspicuous, separated by slender carina from frons, in females at apex narrower than epifrons at apex, in males lengthened and curved along anterior border of rostrum, wider than epifrons at apex. Frons as a very narrow glabrous strip along epistome, bearing four pairs of stout and long apical setae, obliquely directed anteriad. Scrobe in doral view invisible; in lateral view narrow, subparallel-sided, long, weakly curved, directed towards middle of eyes. Rostrum in lateral view somewhat convex, in males longer and more slender than in females, separated from head by shallow transverse depression. Eyes hardly prominent from outline of head.

Antennae slender, funicle 1.2 × as long as scape. Scape slender, gradually and regularly enlarged apicad, at apex as wide as club. Funicle segments 1 and 2 conical, long, funicle segment 1 slightly longer and wider than segment 2, the both 1.6–1.7 × as long as wide; segments 3 and 4 1.1 × as long as wide; segments 5 and 6 isodiametric; segment 7 1.1–1.2 × as long as wide.

Pronotum (Figs 3–6) 1.26–1.31 × as wide as long, widest at basal third, with distinctly rounded sides, more strongly tapered anteriad than posteriad. Disc regularly convex. Base weakly convex. Pronotum in lateral view moderately convex, ocular lobes well developed.

Elytra (Figs 3–6) 1.21–1.31 × as long as wide, ovoid, widest at apical third; shoulders absent, elytra at base hardly wider than base of pronotum, behind base with straight to slightly concave sides. Striae wide and distinct, punctate, punctures wide and completely hidden by appressed scales; intervals weakly convex, odd intervals slightly more so than even ones, equally wide, weakly wider than striae. Elytra in lateral view distinctly convex.

Protibiae rounded at apex, with fringe of short and fine yellowish setae, mucronate, inner margin with 3–4 very small black, almost indistinct teeth. Metatibiae not denticulate; metatibial corbels densely squamose. Tarsi short, segment 2 1.4–1.5 × as wide as long; segment 3 1.4–1.5× as wide as long and 1.4–1.5 × as wide as segment 2; onychium 0.7–0.8 × as long as segment 3. Claws solidly fused in basal half, almost parallel-sided in apical half.

Penis (Fig. 32) short and wide, in ventral view slightly and regularly enlarged apicad, with straight sides, apex triangular with small triangular ends on sides; in lateral view almost straight, distinctly enlarged apicad, apex slender, elongate, dorsal border lengthened, lobe-like.

Female genitalia. Sternite VIII umbrella-shaped with short apodeme. Gonocoxites flat, subtriangular, with long apical styli, laterally prominent, armed with setae. Spermatheca (Fig. 37) with cornu long and regularly curved; corpus enlarged oval, ramus and nodulus not differentiated.

Biology. Unknown.

Distribution. China: Zhejiang (Fig. 52).

Etymology. The Latin name, meaning smooth and without setae, refers to body with barely visible, inconspicuous, short piliform semi-appressed setae.

Differential diagnosis. *Pseudocneorhinus glaber* has inconspicuous elytral vestiture consisting of short, piliform setae that are semi-appressed and barely visible at apex and base in lateral view; all other species have elytra with conspicuous, moderate to very long setae of various widths and shapes, which are always more or less erect and well visible even in dorsal view. *Pseudocneorhinus glaber* resembles also species of the genus *Rhinodontodes* in having a long rostrum and medially constricted epifrons, but the epistome does not exceed the outline of the rostrum and the protibiae are straight.

Pseudocneorhinus hlavaci **sp. nov.**

http://zoobank.org/AD7ABB15-DC0A-4A7C-8D41-B7A0A247E8FE
Figs 7, 8, 38

Type locality. Dongling Mountains, Xiaolongmen, Liu Lang Yu (China: Beijing).

Material examined. Holotype. CHINA – **Beijing** ♀; Dongling Mountains, Xiaolongmen, Liu Lang Yu; 39°58.2'N, 115°25.8'E; 1400 m a.s.l.; 15 Jun. 2001; J. Cooter & P. Hlaváč leg.; Litter; BMNH.

Paratypes. CHINA – **Beijing** 1 ♀; same data as for holotype; BMNH; 1 ♀; Xiaolongmen forestry station, Nan'gou [小龙门林场南沟]; 1140 m a.s.l.; 30 May–2 Jun. 2001; X.D. Yu leg. [于晓东]; *Larix* forest, pitfall trap [落叶松林, 杯诱]; IZCAS, IOZ(E)1965213; 2 ♀♀; Mentougou, Xiaolongmen [门头沟小龙门]; 39°57.6'N, 115°25.8'E; 1164–1210 m a.s.l.; 5 Jul. 2011; K.Y. Zhang leg. [张魁艳]; IZCAS, IOZ(E)1965297, IOZ(E)1965301; 1 ♀; same data as for preceding; G.X. Qiao & J. Chen leg. [乔格侠, 陈军]; IZCAS, IOZ(E)1965300; 1 ♀; Xiaolongmen forestry station, Nan'gou [小龙门林场南沟]; 1140 m a.s.l.; 18–21 Jul. 1999; X.D. Yu leg. [于晓东]; *Larix* forest, pitfall trap [落叶松林, 杯诱]; IZCAS, IOZ(E)1965194; 1 ♀; Xiaolongmen [小龙门]; 1200–1350 m a.s.l.; 19 Aug. 1999; W.P. Xie leg. [谢为平]; IZCAS, IOZ(E)1965309; 1 ♀♀; Dongling Shan, 100 km W of Beijing; 1500 m a.s.l.; 12–15 Jun. 2000; Zd. Jindra leg.; NMPC; 3 ♀♀; same data as for preceding; RBSC; 1 ♀; same data as for preceding; UMO.

Description. Body length: Holotype 5.25 mm, paratype 4.95–5.56 mm.

Body (Figs 7, 8) blackish, only antennal club and basal part of first tarsal segment, mucro, fringe of setae at apex of protibia, and claws reddish. Appressed scales on body dense, hiding integument, oval, weakly imbricate, finely longitudinally striate, 5–6 scales across interval width; scales dark brownish with small light brownish spots irregularly scattered on elytra. Raised elytral setae semierect, slender, lanceolate, somewhat shorter than width of one elytral interval, with single sparse, regular row on each interval, setae greyish and blackish, alternating irregularly. Semierect setae on pronotum somewhat shorter than elytral ones, sparse, irregularly scattered. Semiappressed setae on head and rostrum half as long as pronotal setae. Antennae and legs except of basal half of scape with semierect moderately long setae, prominent in outline.

Rostrum (Figs 7, 8) long, 1.09–1.13 × as long as wide, regularly distinctly enlarged from base to antennal insertion, then rounded around apex, without abrupt widening at base. Epifrons tapered from base to midlength and widened again, at apex as wide as at base, longitudinally depressed, with somewhat swollen borders. Epistome V-shaped, long, conspicuous, separated by slender carina from frons, at apex as wide as epifrons in narrowest part. Frons glabrous, V-shaped, as a strip along epistome, bearing five pairs of stout, long apical setae, obliquely directed anteriad. Scrobe in dorsal view visible only in apical part as slender furrow; in lateral view narrow, short, curved, directed towards eye. Rostrum in lateral view somewhat convex, long and slender, separated from head by shallow transverse depression. Eyes weakly prominent from outline of head.

Antennae slender. Scape as long as funicle, straight, weakly and regularly enlarged to apex, at apex only slightly wider than club. Funicle segment 1 as long as and only slightly wider than segment 2, both conical; segment 1 1.7–1.8 × as long as wide; segment 2 1.9–2.0 × as long as wide; segment 3 1.2 × as long as wide; segment 4 1.1 × as long as wide; segments 5 and 6 isodiametric; segment 7 1.1 × as wide as long; club 1.6–1.7 × as long as wide.

Pronotum (Figs 7, 8) 1.42–1.47 × as wide as long, regularly convex on the disc, widest at midlength, with weakly rounded sides, more strongly tapered anteriad than posteriad. Base indistinctly convex, almost straight. Pronotum in lateral view convex, ocular lobes well developed.

Elytra (Figs 7, 8) regularly oval, 1.19–1.24 × as long as wide, widest at midlength; shoulders regularly rounded. Striae distinct; intervals almost flat, equally wide and convex. Elytra in lateral view distinctly convex.

Protibiae rounded at apex, with fringe of short and fine reddish setae, mucronate, on inner margin with 4–5 black, very small and indistinct teeth. Metatibiae with 1–3 black, very small and indistinct teeth in apical half; metatibial corbels squamose. Tarsi robust, segment 2 1.1–1.2 × as wide as long; segment 3 1.4–1.5 × as wide as long and 1.5–1.6 × as wide as segment 2; onychium equally long to 1.1 × as long as segment 3. Claws fused in basal half.

Male genitalia unknown.

Female genitalia. Sternite VIII umbrella-shaped with short apodeme. Gonocoxites flat, weakly sclerotised with short apical styli, armed with setae. Spermatheca (Fig. 38) with cornu long and regularly curved; ramus short twice as wide as long; nodulus short as ramus, half as wide as ramus, returned.

Biology. The specimens were sifted from forest litter.

Distribution. China: Beijing (Fig. 52).

Etymology. The newly described species is dedicated to the collector, our friend Peter Hlaváč (Prague, Czech Republic), well-known specialist of Staphylinidae (Pselaphinae, Scydmaeninae) and also Curculionidae.

Differential diagnosis. *Pseudocneorhinus hlavaci* is most similar to *P. sellatus* Marshall, 1934 in terms of size, overall shape, regular intervals, and dorsal contour of rostrum (i.e., evenly enlarged apically, base not abruptly widened). It is easily distinguishable from it by elytral setae conspicuous and semierect, rostrum slightly longer than wide with straight sides in basal half and epifrons without longitudinal carina.

***Pseudocneorhinus obliquehumeralis* sp. nov.**

http://zoobank.org/A6963E03-622F-4F29-92ED-355101704F84

Figs 9, 10

Type locality. Xinglongshan b. Yuzhong, loc. Yangzhai (China: Gansu).

Material examined. Holotype. CHINA – **Gansu Prov.** ♀; Xinglongshan b. Yuzhong, Yangzhai; 2500–3000 m a.s.l.; 22–26 Jul. 1993; Heinz leg.; SMNS.

Paratype. CHINA – **Shaanxi Prov.** 1 ♀; Qing Ling Shan mts., road Baoji – Taibai vill., Pass 40 km S Baoji; 21–23 Jul. 1998; Z. Jindra leg.; RBSC.

Figures 9–16. Habitus of *Pseudocneorhinus* species **9, 10** *P. obliquehumeralis* sp. nov., female, paratype, dorsal and lateral view **11, 12** *P. setosicallus* sp. nov., male, holotype, dorsal and lateral view **13, 14** *P. setosicallus* sp. nov., female, paratype, dorsal and lateral view **15, 16** *P. alternans*, female, dorsal and lateral view. Scale bars: 1 mm.

Description. Body length: holotype 5.31 mm, paratype 5.44 mm.

Body (Figs 9, 10) blackish, only very short basal part of scape, club, mucro, and claws brownish and fringe of short setae at apex of protibiae yellowish. Appressed scales on body except pronotum, head capsule, rostrum and club imbricate, oval, small, finely longitudinally striate; 6–7 scales across interval width. Pronotum, head capsule and rostrum with appressed scales assembling on margins, irregularly tricuspid, narrowly separate. Club finely setose. Scales light brownish, elytra with narrow, transverse dark brownish stripe V-shaped at anterior third and straight at declivity. Elytra with narrow, subspatulate, longitudinally finely striate setae, appressed on disc, semiappressed on declivity, forming regular dense row on each odd interval, and very sparse, hardly visible row on even intervals, about as long as half width of one interval, light grey brownish, on even intervals dark brownish. Pronotum, head capsule and rostrum with identical appressed setae, on pronotum orientated transversely, on rostrum longitudinally, sparsely irregularly scattered. Scape and femora with moderately long semierect setae; funicle, tibiae. and tarsi with identical semierect setae, prominent from outline.

Rostrum (Figs 9, 10) short and wide, 1.02–1.04 × as wide as long, narrowest at base, regularly moderately enlarged apicad with almost straight sides. Epifrons in basal almost two thirds tapered anteriad, in anterior third slightly enlarged again, in both parts with weakly convex sides, longitudinally shallowly depressed. Epistome V-shaped, moderately sized, separated by slender carina from frons, at apex distinctly narrower than apical part of epifrons. Frons as very slender glabrous strip along epistome, bearing 3–4 pairs of long, stout setae, obliquely directed anteriorly. Scrobe in dorsal view visible as very slender furrow in apical part; in lateral view short, weakly curved, narrow, directed towards middle of eyes. Rostrum in lateral view weakly convex, separated from head by shallow transverse depression. Eyes weakly prominent from outline of head.

Antennae slender; scape slender, weakly curved, regularly enlarged apicad, at apex same width as club. Funicle 1.2–1.3 × as long as scape; funicle segments 1 and 2 equally long, conical, segment 1 slightly wider than segment 2; segment 1 1.5–1.6 × as long as wide; segment 2 1.8–2.0 × as long as wide; segments 3 and 4 1.2–1.3 × as long as wide; segments 5 and 6 isodiametric, segment 7 1.1 × as wide as long.

Pronotum (Figs 9, 10) 1.53–1.58 × as wide as long, widest at midlength, with moderately rounded sides, distinctly more tapered anteriad than posteriad. Disc regularly convex. Base V-shaped. Pronotum in lateral view almost flat, ocular lobes weakly developed.

Elytra (Figs 9, 10) 1.27–1.33 × as long as wide, long-oval; shoulders angulate to base and to lateral margins, obliquely subtruncate; sides sub-parallel; apex broadly rounded. Striae punctate, punctures small, hidden by appressed scales. Stria 1 at base curved laterally, sutural interval at base enlarged. Odd intervals flat, wide; even intervals weakly elevated, intervals 3, 5 and 7 enlarged at declivity and with low but distinct longitudinal prominence, the biggest at interval 3. Base arched. Elytra in lateral view weakly convex.

Protibiae moderately slender, with straight lateral margin, rounded at apex, with fringe of short and fine yellowish setae, mucronate and not denticulate. Metatibiae with four very small, almost indistinct denticles at apical half; metatibial corbels densely squamous with two, equally long mucros, curved inside. Tarsi slender; segment 2 1.1–1.2 × as wide as long; segment 3 1.3–1.4 × as wide as long and 1.5–1.6 × as wide as previous segment; onychium 1.1 × as long as segment 3. Claws solidly fused in basal half, weakly separate in apical half.

Male genitalia unknown.

Female genitalia. Sternite VIII umbrella-shaped with short apodeme. Gonocoxites flat, moderately slender with long apical styli with setae, prominent laterally. Spermatheca not examined.

Biology. Unknown.

Distribution. China: Gansu, Shaanxi (Fig. 52).

Etymology. The Latin name, meaning with oblique shoulders, refers to obliquely subtruncate shoulders, angled to elytral base and sides.

Differential diagnosis. *Pseudocneorhinus obliquehumeralis* is similar to *P. alternans* by the following characters: oval elytra with distinct shoulders, slender antennal scapes, and raised elytral setae on odd intervals only. It can be distinguished from *P. alternans* by angular rather than regularly oblique shoulders, subdistally distinctly enlarged intervals 3 and 5 each with low longitudinal prominence, and more elongate funicular segments 3 and 4.

***Pseudocneorhinus setosicallus* sp. nov.**

http://zoobank.org/D09575D3-9616-43A2-8C66-E315CEA8F149
Figs 11–14, 33, 39

Type locality. Wanxian County, Wang'erbao Natural Reserve (China: Chongqing).

Material examined. Holotype. CHINA – **Chongqing** ♂; Wanxian county, Wang'erbao [万县王二包]; 1200 m a.s.l.; 27 May 1994; Y.W. Zhang leg. [章有为]; IZCAS, IOZ(E) 1786276.

Paratypes. CHINA – **Chongqing** 11 ♂♂; same data as for holotype; IZCAS, IOZ(E)1786279, IOZ(E)1786280, IOZ(E)1786282–1786286, IOZ(E)1786301, IOZ(E)1786302, IOZ(E)1786374, IOZ(E)1786375; 4 ♀♀; same data as for holotype; IZCAS, IOZ(E)1786278, IOZ(E)1786281, IOZ(E)1786287, IOZ(E)1786288; 2 ♂♂; same data as for holotype; J. Yao leg. [姚建]; IZCAS, IOZ(E)1786316, IOZ(E)1786317; 5 ♂♂; same data as for holotype; W.Z. Li leg. [李文柱]; IZCAS, IOZ(E)1786320, IOZ(E)1786321, IOZ(E)1786362–1786364; 3 ♀♀; same data as for preceding; IZCAS, IOZ(E)1786318, IOZ(E)1786319, IOZ(E)1786322; 2 ♂♂; same data as for holotype; X.K. Yang leg. [杨星科]; IZCAS, IOZ(E)1786334, IOZ(E)1786348; 3 ♀♀; same data as for preceding; IZCAS, IOZ(E)1786335, IOZ(E)1786349, IOZ(E)1786350; 12 ♂♂; same data as for preceding; 28 May 1994; IZCAS, IOZ(E)1786273, IOZ(E)1786274, IOZ(E)1786326, IOZ(E)1786327, IOZ(E)1786330, IOZ(E)1786331, IOZ(E)1786337–1786340, IOZ(E)1786342, IOZ(E)1786343; 8 ♀♀; same data as for preceding; IZCAS, IOZ(E)1786328, IOZ(E)1786329, IOZ(E)1786332, IOZ(E)1786333, IOZ(E)1786341, IOZ(E)1786345–1786347; 6 ♂♂; same data as for holotype; 28 May 1994; IZCAS, IOZ(E)1786304, IOZ(E)1786306, IOZ(E)1786307, IOZ(E)1786376–1786378;

5 ♀♀; same data as for preceding; IZCAS, IOZ(E)1786303, IOZ(E)1786305, IOZ(E)1786379–1786381; 2 ♂♂; same data as for preceding; W.Z. Li leg. [李文柱]; IZCAS, IOZ(E)1786324, IOZ(E)1965620; 1 ♀; same data as for preceding; IZCAS, IOZ(E)1786323; 1 ♀; same data as for preceding; J. Yao leg. [姚建]; IZCAS, IOZ(E)1786313; 2 ♀♀; same data as for holotype; 29 May 1994; W.Z. Li leg. [李文柱]; IZCAS, IOZ(E)1786365, IOZ(E)1786366; 1 ♂; same data as for preceding; J. Yao leg. [姚建]; IZCAS, IOZ(E)1786314; 1 ♂; same data as for preceding; 27 Sep. 1994; IZCAS, IOZ(E)1965239; 1 ♂; same data as for preceding; 1300 m a.s.l.; S.M. Song leg. [宋士美]; IZCAS, IOZ(E)1965257; 3 ♀♀; same data as for holotype; 28 Sep. 1994; J. Chen leg. [陈军]; IZCAS, IOZ(E)1965235, IOZ(E)1965236, IOZ(E)1965244; 2 ♂♂; same data as for holotype; 29 Sep. 1994; F.S. Li leg. [李法圣]; IZCAS, IOZ(E)1786372, IOZ(E)1786373; 1 ♂; same data as for preceding; J. Chen leg. [陈军]; IZCAS, IOZ(E)1965256; 1 ♂; same data as for holotype; 30 Sep. 1994; J. Yao leg. [姚建]; IZCAS, IOZ(E)1965254; 3 ♂♂; same data as for preceding; 1300 m a.s.l.; S.M. Song leg. [宋士美]; IZCAS, IOZ(E)1965237, IOZ(E)1965242, IOZ(E)1965262; 2 ♀♀; same data as for preceding; IZCAS, IOZ(E)1965258, IOZ(E)1965263; 7 ♂♂; same data as for holotype; 30 Sep. 1994; J. Chen leg. [陈军]; IZCAS, IOZ(E)1965232, IOZ(E)1965234, IOZ(E)1965240, IOZ(E)1965241, IOZ(E)1965243, IOZ(E)1965259, IOZ(E)1965261; 3 ♀♀; same data as for preceding; IZCAS, IOZ(E)1965233, IOZ(E)1965238, IOZ(E)1965255; 3 ♂♂; same data as for holotype; 22 May 1993; S.Y. Wang leg. [王書永]; IZCAS, IOZ(E)1786309, IOZ(E)1786367, IOZ(E)1786369; 2 ♀♀; same data as for preceding; IZCAS, IOZ(E)1786308, IOZ(E)1786368; 2 ♀♀; same data as for holotype; 10 Jul. 1993; R.Z. Huang leg. [黄润质]; IZCAS, IOZ(E)1786310, IOZ(E)1786311; 1 ♂; same data as for preceding; X.L. Chen leg. [陈小琳]; IZCAS, IOZ(E)1786371; 1 ♂; same data as for preceding; J. Yao leg. [姚建]; IZCAS, IOZ(E)1786315; 1 ♀; same data as for preceding; IZCAS, IOZ(E)1786312; 3 ♂♂; same data as for holotype; 13 Aug. 1993; X.K. Yang leg. [杨星科]; IZCAS, IOZ(E)1786275, IOZ(E)1786290, IOZ(E)1786299; 7 ♂♂; same data as for preceding; 14 Aug. 1993; IZCAS, IOZ(E)1786292, IOZ(E)1786293, IOZ(E)1786296, IOZ(E)1786298, IOZ(E)1786355, IOZ(E)1786358, IOZ(E)1786359; 12 ♀♀; same data as for preceding; IZCAS, IOZ(E)1786289, IOZ(E)1786294, IOZ(E)1786295, IOZ(E)1786300, IOZ(E)1786336, IOZ(E)1786344, IOZ(E)1786351–1786354, IOZ(E)1786356, IOZ(E)1786357; 1 ♂; same data as for holotype; 11 Jun. 1993; W.Z. Li leg. [李文柱]; IZCAS, IOZ(E)1786325; 1 ♂; same data as for holotype; 15 Aug. 1993; X.K. Yang leg. [杨星科]; IZCAS, IOZ(E)1786297; 2 ♀♀; same data as for preceding; IZCAS, IOZ(E)1786277, IOZ(E)1786291; 2 ♀♀; same data as for preceding; 1300 m a.s.l.; IZCAS, IOZ(E)1786360, IOZ(E)1786361; 1 ♂; same data as for preceding; B.W. Sun leg. [孙宝文]; IZCAS, IOZ(E)1786370. – **Sichuan Prov.** 1 ♀; Nanjiang; 21–23 May 2002; E. Kučera leg.; PBSP.

Description. Body length: 4.19–5.75 mm, holotype 5.38 mm.

Body (Figs 11–14) blackish, only short basal part of scape, mucro, fringe of setae at apex of protibia, and claws brownish. Appressed scales on body dense, hiding integument, irregularly angular, small, 8–9 scales across interval width, with small depression in the middle, only narrowly separate. Scales light brownish, elytra in the middle with wide lighter transverse stripe, wider towards sides, elytral declivity with straight transverse dark brownish stripe. Elytra with conspicuous erect setae, longer than half of interval width, lanceolate, apically pointed, longitudinally finely striate, whitish and blackish, with one sparse row on each odd interval and only sporadic setae on even intervals. Setae denser on interval 1 on apical declivity, creating large and wide tuft of setae on prominence on elytral declivity on interval 3, consisting of 18–20 setae and smaller tuft on prominence on interval 5, consisting of 8–10 setae, anterior part of setae on prominence whitish, posterior part blackish. Semierect setae on pronotum and head with rostrum more slender and shorter than elytral setae, sparsely irregularly scattered. Antennae and legs except of basal half of scape with semierect moderately long setae, prominent from outline.

Rostrum (Figs 11–14) short and wide, in males slightly longer than in females, in males 1.03–1.06 × as long as wide, in females isodiametric, from base regularly enlarged to midlength, then tapered anteriad with rounded sides. Epifrons with concave sides, narrowest at midlength, at apex narrower than at base, longitudinally depressed, with somewhat swollen borders. Epistome V-shaped, long, conspicuous, separated by slender carina from frons, in females slightly narrower at apex than apical part of epifrons, in males at apex wider than apical part of epifrons. Frons creating very slender glabrous strip along epistome, bearing five pairs of long, stout setae, obliquely directed anteriorly. Scrobe in dorsal view visible only in apical part as very slender furrow; in lateral view narrow, long, weakly curved, directed towards middle of eyes. Rostrum in lateral view somewhat convex, separated from head by shallow transverse depression. Eyes weakly prominent from outline of head.

Antennae slender. Scapes slender, regularly enlarged in basal half, parallel-sided in apical half, at apex as wide as club. Funicle 1.2–1.3 × as long as scape; funicle segment 1 as long as and as wide as segment 2, each 1.8–1.9 × as long as wide; segments 3–6 1.1 × as long as wide; segment 7 isodiametric.

Pronotum (Figs 11–14) 1.18–1.26 × as wide as long, widest at midlength, in basal half subparallel-sided, weakly tapered anteriad, with rounded sides. Disc regularly convex. Base weakly convex. Pronotum in lateral view almost flat, ocular lobes well developed.

Elytra (Figs 11–14) 1.15–1.20 × as long as wide, ovoid in dorsal view, at base about as wide as base of pronotum, shoulders not developed; elytra distinctly enlarged posteriad, widest at apical third. Striae distinctly punctate, punctures wide, completely hidden by appressed scales. Even intervals almost flat, odd intervals convex, intervals 3 and 5 at elytral declivity enlarged, forming short longitudinal prominence, on interval 3 larger than on interval 5. Elytra in lateral view distinctly convex.

Protibiae rounded at apex, with fringe of short and fine yellow-brownish setae, mucronate, not denticulate, with straight lateral margin. Metatibiae not denticulate; metatibial corbels densely squamose. Tarsi short, segment 2 1.2–1.3 × as wide as long; segment 3 1.5–1.6 × as wide as long and 1.5–1.6 × as wide as segment 2; onychium 0.8–0.9 × as long as segment 3. Claws solidly fused at basal half, almost parallel-sided at apical half.

Penis (Fig. 33) short and wide, in ventral view subparallel-sided with weakly concave sides, base and apex about equally wide, apex truncate with triangular point at the middle; in lateral view short and very wide, slightly curved, equally wide along the whole length with slender, moderately long elongate apex.

Female genitalia. Sternite VIII with plate umbrella-shaped and with short apodeme. Gonocoxites flat, moderately slender with long apical styli with setae, prominent laterally. Spermatheca (Fig. 39) with cornu short and wide, almost straight, corpus large, rounded; ramus subtriangular, about as long as wide, nodulus small, hump-shaped.

Biology. Unknown.

Distribution. China: Chongqing, Sichuan (Fig. 52).

Etymology. The Latin name, meaning with setae on prominence, refers to the conspicuous tuft of setae on prominence on the elytral declivity.

Differential diagnosis. *Pseudocneorhinus setosicallus* is similar to *P. alternans* and *P. subcallosus* because of its large size and erect setae on odd intervals. From *P. alternans*, currently known only from females, this species is easily separated mainly by having ovoid elytra without shoulders, with the greatest width in the apical third, long erect elytral setae, conspicuous longitudinal subapical prominence on intervals 3 and 5 bearing very dense tufts of whitish and blackish setae and by slender pronotum. From *P. subcallosus*, a species with very similar body shape, *P. setosicallus* is distinguishable by its long, lanceolate erect elytral setae, clearly visible in dorsal as well as in lateral view, while *P. subcallosus* has elytral setae appressed, subspatulate, barely visible only in lateral view. The subapical tuft on interval 3 consists of at least 15 setae in *P. setosicallus* but at most 10 in *P. subcallosus*. As stated below in the key, *P. setosicallus* also has a longer rostrum and second funicular segment. From *P. angustus*, a generally smaller species with similar long, conspicuously erect elytral setae, *P. setosicallus* is distinguishable by shorter, in basal half enlarged rostrum, at mid-length more constricted epifrons, narrower pronotum and other characters given in the key.

Other *Pseudocneorhinus* species examined

Pseudocneorhinus adamsi Roelofs, 1879

Figs 34, 40

Pseudocneorhinus adamsi Roelofs, 1879: liii (original description); Han et al. 2000: 34 (Korean fauna); Borovec 2009: 76 (check-list); Borovec 2013: 418 (catalogue); Morimoto et al. 2015: 338 (Japanese fauna); Alonso-Zarazaga et al. 2017: 403 (catalogue).

Material examined. Other material. CHINA; 1 ♀; S. Manchuria, Chikuanshan; BMNH.

SOUTH KOREA; 25 ♂♂ ♀♀; Jinju, Witae, Sobae Mts.; 35°09.9'N, 127°49.4'E; 400 m a.s.l.; 16 May 2014; M. Košťál leg.; MKBC.

Pseudocneorhinus alternans Marshall, 1934

Figs 15, 16, 41

Pseudocneorhinus alternans Marshall, 1934: 7 (original description); Borovec 2009: 76 (check-list); Voss 1956: 24 (note); Borovec 2013: 418 (catalogue); Alonso-Zarazaga et al. 2017: 403 (catalogue).

Type material examined. The original description was based on material from "China: S. Kansu, 1 ♀, 26.vi.1930, 1 ♀, 4.x.30 (Dr. Hummel)". There is one specimen lacking head with rostrum in Marshall's collection (BMNH) pinned on very slender and short paper label. This specimen is labelled as follows: Cotype [printed, circular label with yellow margin] / Kina S. Kansu [printed] / Sven Hedins Exp. Ctr. Asien Dr Hummel [printed] / Pres. by Imp. Inst. Ent. B. M. 1934-130. [printed] / 4/10 [handwritten] / Pseudocneorrhinus alternans Mshl. COTYPE ♀ [Marshall's handwriting]. We have not designated the examined syntype specimen as lectotype in the view of the fact that it is incomplete and the species was described from two specimens.

Material examined. Other material. CHINA – **Beijing** 1 ♀; Xiaolongmen forestry station, Nan'gou [小龙门林场南沟]; 1140 m a.s.l.; 25–28 Jun. 1999; X.D. Yu leg. [于晓东]; *Larix* forest, pitfall trap [落叶松林, 杯诱]; IZCAS, IOZ(E)1965163; 3 ♀♀; same data as for preceding; 30 May–2 Jun. 2001; IZCAS, IOZ(E)1965170–1965172; 2 ♀♀; Xiaolongmen forestry station, Nan'gou [小龙门林场南沟]; 1225 m a.s.l.; 18–21 Jul. 1999; X.D. Yu leg. [于晓东]; *Quercus wutaishanica* forest, pitfall trap [辽东栎林, 杯诱]; IZCAS, IOZ(E)1965165, IOZ(E)1965166; 1 ♀; Xiaolongmen [小龙门]; 1400 m a.s.l.; 14 Jun. 2001; S.Q. Ge leg. [葛斯琴]; IZCAS, IOZ(E)1965174; 1 ♀; North of Xiaolongmen forestry station [小龙门林场北]; 1190 m a.s.l.; 26–29 Jun. 1999; X.D. Yu leg. [于晓东]; *Pinus tabulaeformis* forest, pitfall trap [油松林, 杯诱]; IZCAS, IOZ(E)1965178; 1 ♀; Xiaolongmen, Dongling Mountains; 39°58.2'N, 115°25.8'E; 1400 m a.s.l.; 15 Jun. 2001; J. Cooter & P. Hlaváč leg.; Liu Lang Yu Litter; BMNH; 3 ♀♀; Xiaolongmen; 39°58.074'N, 115°25.882'E; ca 1100 m a.s.l.; 9–13 Jun. 2004; J. Cooter leg.; BMNH; 1 ♀; Xialongmen, National Forest Reserve, 120 km W Beijing; 1100 m a.s.l.; 27 May 2005; M. Ritschard leg.; CGTS. – **Heilongjiang Prov.** 1 ♀; Qing Yuan, S Lang Xian, ca 30 km; 46°47.002'N, 129°04.349'E; 500–600 m a.s.l.; 26 May 2004; J. Cooter leg.; stream side; BMNH

Pseudocneorhinus bifasciatus Roelofs, 1880

Figs 17, 18, 35, 42

Pseudocneorhinus bifasciatus Roelofs, 1880: 12 (original description); Marshall 1934: 10 (note); Voss 1956: 24 (note); Han et al. 2000: 35 (Korean fauna); Han and Yoon 2000: 259 (note); Borovec 2009: 76 (check-list); Borovec 2013: 418 (catalogue); Morimoto et al. 2015: 327 (Japanese fauna); Alonso-Zarazaga et al. 2017: 403 (catalogue).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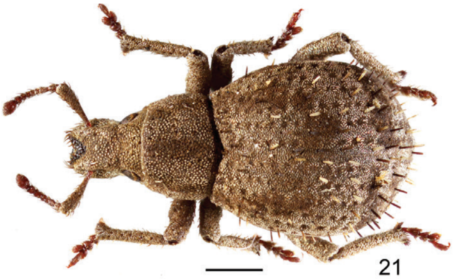
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Figures 17–24. Habitus of *Pseudocneorhinus* species **17, 18** *Pseudocneorhinus bifasciatus*, male, dorsal and lateral view **19, 20** *P. hirsutus*, female, dorsal and lateral view **21, 22** *P. longisetosus*, female, dorsal and lateral view **23, 24** *P. minimus*, female, dorsal and lateral view. Scale bars: 1 mm.

Type material examined. This species was described from “Plusieurs individus, par M. Lewis, du Japon”. We have studied one female specimen, 5.06 mm long, deposited in Marshall’s collection (BMNH), with the labels: Type [printed, circular label with red margin] / Japan G. Lewis 1910-320. [printed] / bifasciatus [handwritten].

Material examined. Other material. CHINA – **Fujian Prov.** 1 ♀; Chong’an, Chengguan [崇安城关]; 240 m a.s.l.; 15 Jul. 1960; F.J. Pu leg. [蒲富基]; IZCAS, IOZ(E)1786483; 1 ♀; Chong’an, Xingcun, Tongmuguan [崇安星村桐木关]; 900 m a.s.l.; 10 Aug. 1960; Y. Zuo leg. [左永]; IZCAS, IOZ(E)1788386; 1 ♂; Jianyang, Huangkeng, Aotou [建阳黄坑坳头]; 950 m a.s.l.; 3 Jul. 1965; IZCAS, IOZ(E)1786480; 1 ♂; Jianyang, Huangkeng, Dazhulan [建阳黄坑大竹欄]; 900–1100 m a.s.l.; 7 May 1960; S.Q. Jiang leg. [姜勝巧]; IZCAS, IOZ(E)1788387; 1 ♀; Jianyang, Dazhulan [建阳大竹岚]; 4 Jul. 1965; IZCAS, IOZ(E)1788426; 1 ♂; Wuyi [武夷]; 27 Jun. 1982; K.C. Zhang leg. [张可池]; IZCAS, IOZ(E)1965245; 2 ♀♀; Jiangle, Longxishan [将乐龙栖山]; 800 m a.s.l.; 6 Aug. 1991; X.C. Zhang leg. [张晓春]; IZCAS, IOZ(E)17886463, IOZ(E)17886464; 1 ♂; Jiangle, Longxishan [将乐龙栖山]; 14 May 1991; R.Z. Zhang leg. [张润志]; IZCAS, IOZ(E)17886462; 3 ♀♀; Shaowu, Wushi [邵武乌石]; 6 Jun. 1965; IZCAS, IOZ(E)1786187, IOZ(E)1786189, IOZ(E)1786190; 1 spec.; Shaowu, Tachuland; 20 Jun. 1942; T. C. Maa leg.; BMNH; 6 ♀♀; Kuatun; Jun. 1946; Tschung Sen leg.; RBSC. – **Jiangsu Prov.** 1 spec.; Soochow; 18 Aug.1965; P. M. Hammond leg.; BMNH. – **Zhejiang Prov.** 13 spec.; Chusan is.; J. J. Walker leg.; BMNH; 1 spec.; Chusan, Pwanche; BMNH.

JAPAN; 5 spec.; G. Lewis leg.; BMNH.

Pseudocneorhinus hirsutus (Formánek, 1916)

Figs 19, 20, 43

Rhinodontus hirsutus Formánek, 1916: 33 (original description).

Pseudocneorhinus hirsutus: Marshall 1934: 8 (note); Borovec 2003: 49 (note); Borovec 2013: 418 (catalogue); Alonso-Zarazaga et al. 2017: 403 (catalogue).

Material examined. Other material. CHINA – **Qinghai Prov.** 3 ♀♀; TIBET, Kuku-Nor; 3200 m a.s.l.; 1898; Hauser leg.; GOVI.

Pseudocneorhinus longisetosus Morimoto, 2015

Figs 21, 22, 44

Pseudocneorhinus longisetosus Morimoto, 2015: 339 (original description); Alonso-Zarazaga et al. 2017: 403 (catalogue).

Material examined. Other material. RUSSIA; 8 ♀♀; Siberia or. mer., Primorje, Sichote – Alin Mts, Sokolči; 1–15 Jul.1990; S. Kadlec & J. Voříšek leg.; JSPC, RBSC;

19 ♀♀; Siberia or. Mer., Primorje, Ussuri res.; 20 Jul. 1990; S. Kadlec leg.; RBSC; 1 ♀; Siberia or. mer., Primorje, Komarovka flum, Kamenushka env., 300 m a.s.l.; May 1992; Vořìšek leg.; RBSC; 1 ♀; Siberia or. mer., Kamenushka at Ussuriysk; 2 Aug.1992; J. Sawoniewicz leg.; RBSC; 1 ♀; Siberia or., Chechcir chrebet; 7 Jul.1977; Gottwald leg.; RBSC; 4 ♀♀; USSR, Chabarovsk; 7 Jul. 1981; Mejzlík leg.; RBSC; 1 ♀; Khabarovsk; 4 Jul.1977; Rataj leg.; MMTI.

Pseudocneorhinus minimus **Roelofs, 1879**

Figs 23, 24, 45

Pseudocneorhinus minimus Roelofs, 1879: liii (original description); Marshall 1934: 7 (note); Han et al. 2000: 36 (Korean fauna); Borovec 2009: 76 (check-list); Borovec 2013: 418 (catalogue); Morimoto et al. 2015: 333 (Japanese fauna); Alonso-Zarazaga et al. 2017: 403 (catalogue).

Type material examined. This species was described from an unspecified number of specimens from “Japon”. We have studied one probably female specimen, well preserved and 2.94 mm long, deposited in Marshall’s collection (BMNH), labeled as follows: Type [printed, circular label with red margin] / Japan G. Lewis 1910-320. [printed] / minimus [handwritten].

Material examined. Other material. CHINA – **Fujian Prov.** 1 ♀; Fenanina env., NW slope of Yunwu Shan; 1200 m a.s.l.; 3 Jun. 2000; Z. Jindra leg.; PKSC.

JAPAN; 3 ♀♀; G. Lewis leg.; BMNH.

Pseudocneorhinus obesus **Roelofs, 1873**

Figs 25, 26, 46

Pseudocneorhinus obesus Roelofs, 1873: 177 (original description); Marshall 1934: 9 (note); Voss 1956: 24 (note); Alonso-Zarazaga and Lyal 1999: 183 (catalogue); Han et al. 2000: 34 (Korean fauna); Borovec 2009: 76 (check-list); Borovec 2013: 418 (catalogue); Morimoto et al. 2015: 331 (Japanese fauna); Alonso-Zarazaga et al. 2017: 403 (catalogue).

Type material examined. This species was described from “Quelques individus. Nagasaki”. There is one well preserved, 5.25 mm long, probably female specimen in Marshall’s collection (BMNH) below the name *Pseudocneorhinus obesus*, labeled as follows: Type H. T. [printed, circular label with red margin] / Japan G. Lewis 1910-320. [printed].

Material examined. Other material. JAPAN; 2 ♀♀; G. Lewis leg.; BMNH; 1 ♀; Honshu, Akira Mt., Fyokai-San; 1 Jun. 1972; Takizava leg.; MMTI.

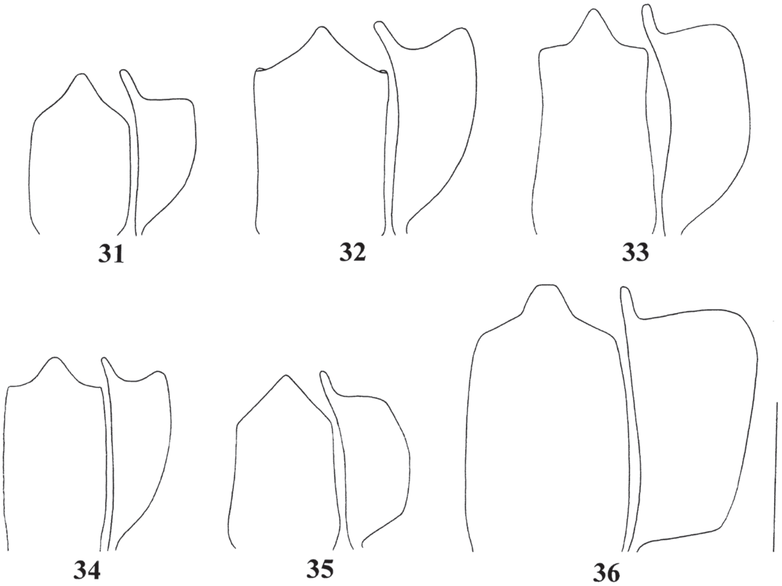
Figures 25–30. Habitus of *Pseudocneorhinus* species **25, 26** *Pseudocneorhinus obesus*, female, dorsal and lateral view **27, 28** *P. sellatus*, female, dorsal and lateral view **29, 30** *P. squameus*, female, dorsal and lateral view. Scale bars: 1 mm.

Pseudocneorhinus sellatus **Marshall, 1934**

Figs 27, 28, 47

Pseudocneorhinus sellatus Marshall, 1934: 8 (original description); Borovec 2009: 76 (check-list); Borovec 2013: 418 (catalogue); Alonso-Zarazaga et al. 2017: 403 (catalogue).

Material examined. Other material. CHINA – **Beijing**; 2 ♀♀; Mentougou, Xiaolongmen [门头沟小龙门]; 39°57.6'N, 115°25.8'E; 1164–1210 m a.s.l.; 5



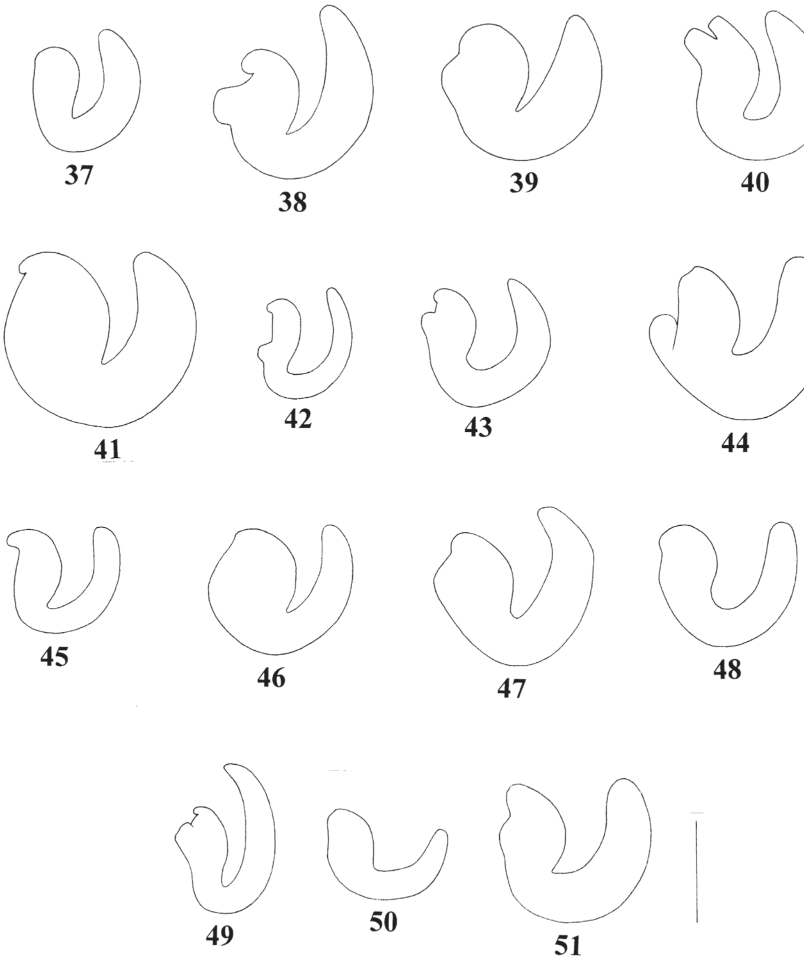
Figures 31–36. Penis in ventral and lateral view of *Pseudocneorhinus* species **31** *Pseudocneorhinus angustus* sp. nov. **32** *P. glaber* sp. nov. **33** *P. setosicallus* sp. nov. **34** *P. adamsi* **35** *P. bifasciatus* **36** *P. subcallosus*. Scale bar: 0.50 mm.

Jul. 2011; G.X. Qiao & J. Chen leg. [乔格侠, 陈军]; IZCAS, IOZ(E)1965155, IOZ(E)1965156; 1 ♀; same data as for preceding; K.Y. Zhang leg. [张魁艳]; IZCAS, IOZ(E)1965154; 1 ♀; Xiaolongmen forestry station, Nan'gou [小龙门林场南沟]; 19 Jul. 1999; T.H. Luo leg. [罗天宏]; heap of grass trap [堆诱]; IZCAS, IOZ(E)1965153; 1 ♀; North of Xiaolongmen forestry station [小龙门林场北]; 1190 m a.s.l.; 26–29 Jun. 1999; X.D. Yu leg. [于晓东]; *Pinus tabulaeformis* forest, pitfall trap [油松林, 杯诱]; IZCAS, IOZ(E)1965152; 2 ♀♀; Xiaolongmen [小龙门]; 20 Jul. 1999; H.Z. Zhou leg. [周红章]; IZCAS, IOZ(E)1965150, IOZ(E)1965151; 1 ♀; Xiaolongmen, Dongling Mts.; 39°58.2'N, 115°25.8'E; 1450 m a.s.l.; 13 Jun. 2001; J. Cooter leg.; BMNH; 2 ♀♀; Xiaolongmen, Dongling Mts., Liu Lang Yu; 39°58.2'N, 115°25.8'E; 1400 m a.s.l.; 6 Jun. 2001; J. Cooter leg.; BMNH; 18 ♀♀; Dongling Shan, 100 km W of Beijing; 1500 m a.s.l.; 12–15 Jun. 2000; Z. Jindra leg.; NMPC, PKSC, RBSC. – **Sichuan Prov.**; 1 ♀; Nanping, Juizhaigou; 7–12 Jun. 2009; E. Kučera leg.; RBSC.

Pseudocneorhinus setosus Roelofs, 1879

Fig. 48

Pseudocneorhinus setosus Roelofs, 1879: liii (original description); Marshall 1934: 9 (note); Voss 1956: 24 (note); Han et al. 2000: 35 (Korean fauna); Borovec 2009: 76 (check-list); Borovec 2013: 418 (catalogue); Morimoto et al. 2015: 334 (Japanese fauna); Alonso-Zarazaga et al. 2017: 403 (catalogue).



Figures 37–51. Spermatheca of *Pseudocneorhinus* species **37** *Pseudocneorhinus glaber* sp. nov. **38** *P. hlavaci* sp. nov. **39** *P. setosicallus* sp. nov. **40** *P. adamsi* **41** *P. alternans* **42** *P. bifasciatus* **43** *P. hirsutus* **44** *P. longisetosus* **45** *P. minimus* **46** *P. obesus* **47** *P. sellatus* **48** *P. setosus* **49** *P. squameus* **50** *P. squamosus* **51** *P. subcallosus*. Scale bar: 0.25 mm.

Type material examined. This species was described from an unspecified number of specimens from "Japon". We have studied one probably female specimen, well preserved and 4.88 mm long, deposited in Marshall's collection (BMNH), with the labels: Type [printed, circular label with red margin] / Japan G. Lewis 1910-320. [printed] / Lewis [handwritten] / Pseudocn. setosus R. Japon L. [handwritten].

Material examined. Other material. CHINA – **Fujian Prov.** 1 ♀; Kuatun; Jun. 1946; Tschung Sen leg.; RBSC.

JAPAN; 1 ♀; Nagasaki; BMNH.

Remarks. Morimoto et al. (2015) split *P. setosus* to two species, *P. setosus* and his newly described *P. squameus*. Morimoto studied only Japanese material, but he cited for both species the original distribution of *P. setosus* – Japan, Korea and China. Material cited in earlier literature must therefore be revised to check the identity of the specimens. The species can be distinguished by their elytral setae and also by the different shape of the spermatheca. However, we can not confirm that elytral setae are a stable distinguishing character, because material from places other than Japanese islands seems to be variable in this character, but the spermatheca seems to be useable. Based on the spermatheca, we can confirm the occurrence of the both species, *P. setosus* and *P. squameus*, in China.

***Pseudocneorhinus squameus* Morimoto, 2015**

Figs 29, 30, 49

Pseudocneorhinus squameus Morimoto, 2015: 336 (original description); Alonso-Zarazaga et al. 2017: 403 (catalogue).
Pseudocneorhinus squamous (lapsus): Morimoto et al. 2015: 336 (Japanese fauna).

Material examined. Other material. CHINA – **Beijing**; 1 ♀; Mentougou, Xiaolongmen [门头沟小龙门]; 39°57.6'N, 115°25.8'E; 1164–1210 m a.s.l.; 5 Jul. 2011; G.X. Qiao & J. Chen leg. [乔格侠, 陈军]; IZCAS, IOZ(E)1965222; 5 ♀♀; Xiaolongmen, Dongling Mountains, Liu Lang Yu; 39°58.2'N, 115°25.8'E; 1400 m a.s.l.; 15 Jun. 2001; Litter; J. Cooter leg.; BMNH; 1 ♀; Xiaolongmen, Dongling Shan; 39°57.688'N, 115°26.342'E; 1150 m a.s.l.; 11 Jun. 2004; J. Cooter leg.; swept by stream; BMNH; 1 ♀; Dongling Shan, 100 km W of Beijing; 1500 m a.s.l.; 12–15 Jun. 2000; Z. Jindra leg.; PKSC. – **Hebei Prov.** 2 ♀♀; Chengde, Wuling (shan) Mts., Longtan Scenic Spot; 40°35.72'N, 117°27.4'E; 1365 m a.s.l.; 8 Aug. 2016; P. Kment leg.; NMPC. – **Shanxi Prov.** 1 ♀; Lüliang Shan, road Fangshan – Jiaocheng, Hengjian env.; 1000 m a.s.l.; 9 Jun. 2000; Z. Jindra leg.; PKSC.

***Pseudocneorhinus squamosus* Marshall, 1934**

Fig. 50

Pseudocneorhinus squamosus Marshall, 1934: 6 (original description); Borovec 2009: 76 (check-list); Borovec 2013: 418 (catalogue); Alonso-Zarazaga et al. 2017: 403 (catalogue).

Type material examined. Marshall (1934) based the description on specimens from "China: S. Kansu, 1 ♂, 1 ♀, 4.x. (Dr. Hummel)". We studied one female, 3.47 mm long, from Marshall's collection (BMNH), recently remounted and dissected by the second author. Lectotype ♀, here designated, with the labels: Cotype [printed, circular label with yellow margin] / Kina S. Kansu [printed] / Sven Hedins Exp. Ctr. Asien Dr Hummel [printed] / Pres. by Imp. Inst. Ent. B. M. 1934-130. [printed] / 4/10 [handwritten] / Pseudocneorrhinus squamosus Mshl. COTYPE ♀ [Marshall's handwriting] / LECTOTYPUS Pseudocneorhinus squamosus Marshall, R. Borovec des. 2014 [red, printed].

Pseudocneorhinus subcallosus (Voss, 1956)

Figs 36, 51

Cillirhopalus [sic] *subcallosus* Voss, 1956: 23 (original description).
Pseudocneorhinus subcallosus: Borovec 2009: 76 (check-list); Borovec 2013: 418 (catalogue); Alonso-Zarazaga et al. 2017: 403 (catalogue).

Type material examined. Voss (1956) described this species based on six specimens from "Kwangtseh (10, 23–25.VII.1937), Shaowu (28.VII.1937)" without a type designation. We studied four of the specimens (ZFMK). Lectotype, here designated, with the labels: Kwangtseh-Fukien, J. Klapperich O, 23.7.1937 [violet, handwritten] / Callirhopalus subcallosus n. sp. [handwritten] / Holotypus Callirhopalus subcallosus n. sp. Voss 1949 [red, partly printed, partly handwritten] / LECTOTYPUS Pseudocneorhinus subcallosus Voss, R. Borovec des. 2019 [red, printed]. The other three have the following label data: one specimen with the same violet label as the holotype (without year) and labeled Paratypoid; one female with the same labels as the previous one but 24.7.1937; and one male with locality label Shaowu – Fukien, (500m) J. Klapperich 28.6.7.1937 and the same red "Paratypoid" label. Two specimens, one male and one female, were remounted by us. All these three specimens are designated here as Paralectotypes and provided with one more red and printed label PARALECTOTYPUS Pseudocneorhinus subcallosus Voss, R. Borovec des. 2019.

Key to the *Pseudocneorhinus* species

The following key separates the new species from all previously described ones. An asterisk (*) after the name means that species has not been studied by us and we know it only from the description.

1 Metatibiae clearly denticulate on almost whole inner margin. Elytra with distinct longitudinal prominence distally at end of interval 2, visible mainly in lateral view **2**

– Metatibiae not denticulate on inner margin, only in *P. adamsi* and *P. longisetosus* with 3–5 minute denticles in apical half on inner face. Interval 2 of elytra without longitudinal prominence **4**

2 Elytra in females as long as wide, in males slightly wider than long. Some intervals with two irregular rows of suberect setae. Size: 4.5–6.4 mm. Japan .... ***P. meshimanus* Morimoto***

– Elytra in both sexes slightly longer than wide. Each interval with regular row of suberect setae **3**

3 Space behind epistomal carina with round, iridescent scales. Elytra widest at anterior third. Size: 3.3–4.9 mm. China, Japan, Korea, Russia .... ***P. bifasciatus* Roelofs**

– Space behind epistomal carina without round, iridescent scales. Elytra widest at middle. Size: 3.6–4.2 mm. Korea .... ***P. soheuksandoensis* Han & Yoon***

4 Dorsal part of body with inconspicuous, short, piliform, semiappressed greyish setae, hardly visible in lateral view, mainly at apical part of elytra (Figs 3–6). Size: 4.6–5.2 mm. China .... ***P. glaber* sp. nov.**

– Dorsal part of body with conspicuous short to long, piliform to spatulate, semierect to erect setae, clearly visible also in dorsal view (Figs 7–30) **5**

5 Scape distinctly widened distally, at apex distinctly wider than club and as wide as diameter of eye in lateral view **6**

– Scape moderately gradually widened distally, at apex as wide as or only slightly wider than club and conspicuously more slender than diameter of eye in lateral view **7**

6 Raised elytral setae wide, subtriangular, truncate at apex. Rostrum at base abruptly enlarged. Funicle segment 3 1.1 × as long as wide; segments 4 and 5 isodiametric. Onychium equally long as tarsal segment 3. Size: 3.0–3.5 mm. China .... ***P. squamosus* Marshall**

– Raised elytral setae slender, subspatulate, rounded at apex. Rostrum at base gradually enlarged. Funicle segments 3–5 wider than long. Onychium 1.2–1.3 × as long as tarsal segment 3. Size: 3.5–3.8 mm. China..... ***P. hirsutus* (Formánek)**

7 Raised elytral setae only on odd intervals or those on odd intervals more conspicuous, longer and distinctly denser (Figs 1, 11, 13). Odd intervals somewhat more elevated, at least on declivity **8**

– Raised elytral setae present equally on odd and even intervals (Figs 25–29). Odd intervals equally flat or convex **12**

8 Elytra ovoid, widest in posterior third, shoulders not defined (Figs 1, 11, 13). Metatibial corbel with one long and one short mucro **9**

– Elytra oval, sides sub-parallel, widest at midlength, with distinct shoulders (Figs 9, 15). Metatibial corbel with two subequal mucros **11**

9 Elytral setae inconspicuous, appressed, hardly visible mainly in lateral view. Rostrum 1.1 × as wide as long. Funicle segment 2 more robust, 1.4–1.6 × as long as wide. Size: 5.1–5.6 mm. China .... ***P. subcallosus* (Voss)**

– Elytral setae conspicuous, perpendicularly erect, clearly visible in dorsal and lateral view. Rostrum 1.1 × as long as wide. Funicle segment 2 thinner, at least 1.8 × as long as wide **10**

10 Smaller, 3.4–3.5 mm. Erect elytral setae half as wide as interval, spatulate (Fig. 1). Elytra more slender, 1.25–1.29 × as long as wide (Fig. 1). Onychium 1.1–1.2 × as long as segment 3. Scape with apex distinctly wider than club. Penis with larger, sharply pointed triangular apex (Fig. 31). China ....***P. angustus* sp. nov.**

– Larger, 4.2–5.8 mm. Erect elytral setae one fourth as wide as interval, lanceolate (Figs 11, 13). Elytra wider, 1.15–1.20 × as long as wide (Figs 11, 13). Onychium 0.8–0.9 × as long as segment 3. Scape with apex as wide as club. Penis with smaller, rounded triangular apex (Fig. 33). China .... ***P. setosicallus* sp. nov.**

11 Shoulders regularly rounded (Fig. 15). Elytral intervals 3 and 5 at declivity slightly enlarged and elevated. Funicle segments 3 and 4 isodiametric. Size: 4.2–5.8 mm. China.. ***P. alternans* Marshall**

– Shoulders obliquely truncate (Fig. 9). Elytral intervals 3 and 5 at declivity distinctly enlarged with low longitudinal prominence. Funicle segments 3 and 4 1.2 × longer than wide. Size: 5.3–5.4 mm. China ..***P. obliquehumeralis* sp. nov.**

12 Funicle segments 4 and 5 longer than wide **13**

– Funicle segments 4 and 5 wider than long.. **15**

13 Rostrum almost parallel-sided (Fig. 25). Funicle segments 5–7 longer than wide. Size: 3.7–5.0 mm. China, Korea, Japan, Russia..................... ***P. obesus* Marshall**

– Rostrum with apex distinctly and regularly enlarged (Figs 11, 27). Funicle segments 5 and 6 isodiametric, segment 7 slightly wider than long **14**

14 Raised elytral setae inconspicuous, semiappressed, shorter than half width of interval (Fig. 27). Rostrum isodiametric, with weakly rounded sides (Fig. 27). Epifrons with longitudinal slender carina in middle. Size: 5.2–6.7 mm. China ... . ***P. sellatus* Marshall**

– Raised elytral setae conspicuous, semierect, shorter than interval wide (Fig. 7). Rostrum 1.1 × as long as wide, with straight sides in basal half (Fig. 7). Epifrons without longitudinal carina. Size: 5.3–5.6 mm. China...............***P. hlavaci* sp. nov.**

15 Elytra widest at middle (Fig. 23). Ocular lobes weakly developed. Size: 3.0–3.3 mm. China, Japan, Korea.. ***P. minimus* Roelofs**

– Elytra widest behind middle (Fig. 29). Ocular lobes well developed **16**

16 Setae on elytra squamiform, obtuse or truncate at tip, absent or much less numerous on intervals 4 and 6. Spermatheca with cornu long and slender, laterally extending beyond level of nodulus (Fig. 49). Size: 4.5–5.1 mm. China, Japan, Korea.. ***P. squameus* Morimoto**

– Setae on elytra much narrower, acuminate, present on all intervals. Spermatheca with cornu more robust, not extending beyond level of nodulus (Figs 40, 44) **17**

17 Metatibiae not denticulate on inner face. Epistome accompanied by narrow glabrous area. Size: 3.3–5.8 mm. China, Japan, Korea, Russia. ***P. setosus* Roelofs**

– Metatibiae with 3–5 minute denticles in apical half on inner face. Epistome accompanied by wide glabrous area **18**

18 Epistome shorter, almost rectangular posteriorly, posterior corners shortly and narrowly rounded. Spermatheca with ramus slightly larger than nodulus, placed next to it (Fig. 40). Size: 4.1–5.7 mm. China, Japan, Korea ... ***P. adamsi* Roelofs**

– Epistome longer, sharply triangular posteriorly. Spermatheca with ramus distinctly smaller than nodulus, placed at its base (Fig. 44). Size: 4.9–5.6 mm. Japan, Russian Far East .... ***P. longisetosus* Morimoto**

Discussion

There are 16 species of *Pseudocneorhinus* recorded from China, accounting for 84% of the species presently known in the Palaearctic Region. All species inhabit elevations between 240 and 3200 m; most of them were found around 1000 m. Ten species are Chinese endemics, except *P. alternans* and *P. sellatus* with, apparently, highly

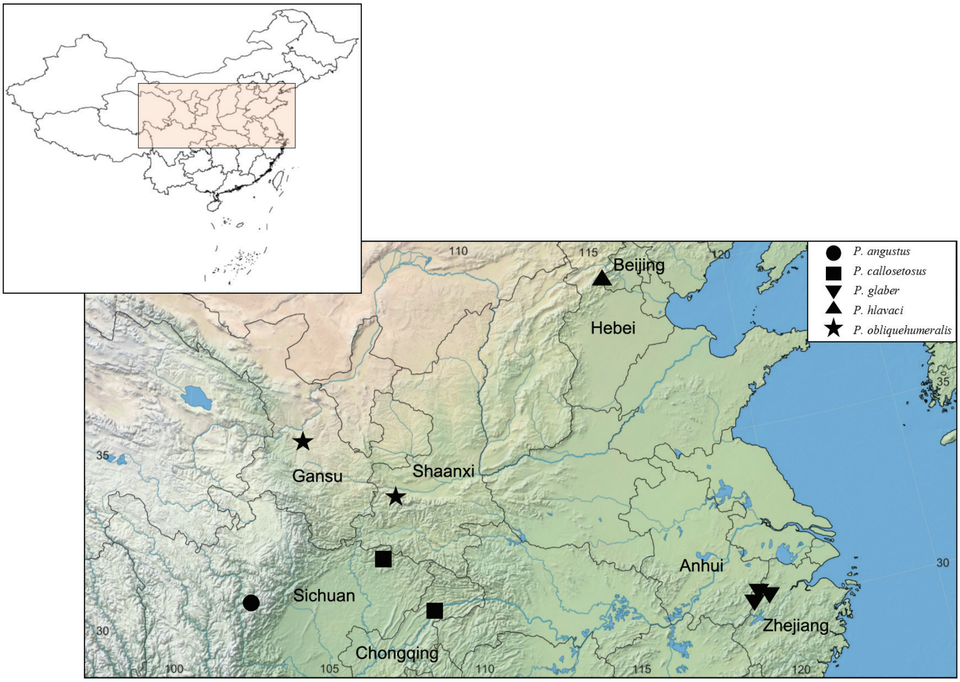


Figure 52. Geographical distribution of new species of *Pseudocneorhinus* in China.

restricted distributions. Only five species are widely distributed between China and eastwards into the Korean Peninsula, the Russian Far East and Japan. We recognize two main distributional ranges in China. One is a longitudinally wide corridor from Heilongjiang to Fujian provinces in the Northeast and the eastern coastal areas. The other is in the Southwest, mainly southern Kansu, southern Shaanxi, Chongqing, and Sichuan provinces. All new species described herein have been discovered in mountainous localities (Fig. 52).

Marshall (1934) stated that *Pseudocneorhinus hirsutus* was found at Kuku-Nor, Tibet. Alonso-Zarazaga et al. (2017) interpreted this locality as Xizang Autonomous Region. The specimens of *P. hirsutus* examined by us bear the label "China, THIBET, Kuku-Nor, 3200 m, 1898, Hauser lgt." However, Kuku-Nor is the Mongolian name for Qinghai Lake, in Qinghai province. This means that Marshall (1934) referred to the Qinghai-Tibet Plateau rather than to a place in Xizang Autonomous Region. Consequently, the known occurrence of this species is corrected here to Qinghai, Kuku-Nor, which is possibly collected on the lakeside. Morimoto et al. (2015) reported *P. squameus* from China but gave no locality data from there. Here we confirm that *P. squameus* occurs in Beijing Municipality and Shanxi province. Other new records are Fujian province for *P. minimus* and Sichuan province for *P. sellatus*.

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RESEARCH ARTICLE

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Biogeography of predaceous diving beetles (Coleoptera, Dytiscidae) of Mongolia

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Abstract

The bio-geographical composition and spatial distribution patterns of dytiscid assemblages in Mongolia are relatively unexplored. In this study, we compiled a list of 99 dytiscid species belonging to 20 genera and five subfamilies recorded in Mongolia and investigated species richness, spatial distribution and bio-geographical composition of the Mongolian dytiscid fauna. This study encompasses the information of currently recorded species and their geographic localities in Mongolia based on our own data and literature sources. We examined how dytiscid species richness was related to sub-basins of surface water network, as well as to geographical elevations within Mongolia. The majority of the Mongolian dytiscid fauna was associated with the sub-basins belonging to Arctic Ocean (80 species, 80.8%) and Central Asian Inland (60 species, 60.6%) basins. Only a few species of dytiscids belonged to the remaining river basins. Species richness of dytiscids and total area of sub-basins were not correlated, but species composition of dytiscids differed significantly among the sub-basins.

We observed that most of the species (77 species or 77.8% of total fauna) were recorded in a wide range of elevations and mid-altitudes (1000–2000 m a.s.l.) and showed the greatest diversity of dytiscids. Regarding the bio-geographical composition, species with wide geographical distributions (27.3% of dytiscids), were Palearctic species, while species of Arctic origin (21.2%) together with Boreal elements (16.2%) comprised a large proportion of the dytiscid fauna in Mongolia.

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Keywords
Geographical distribution, altitudinal pattern, dytiscid, range, river sub-basin

Introduction

Under global change, natural ecosystems in Mongolia are experiencing greater-than-global average rate of climate change, as well as shifting anthropogenic influences. The country has a large landlocked territory covering an area of 1,564,118 square kilometers in Inner Asia. It is located on the Mongolian Plateau with an average elevation of 1580 m (range of elevation: 560–4374 m), and about 85% of its area lies over 1000 m above sea level (Murzaev 1952).

The country has a large variety of geographic features including high mountains in the west, forests in the north, deserts in the south and plain steppes in the central and eastern regions, with various environmental and geographic formations. Insect biogeographic studies have been done only for a few groups of terrestrial insects of Mongolia (Namkhaidorj 1974; Myagmarsuren 1979, 1996; Bielawski 1984; Puntsagdulam 1994; Bayartogtokh et al. 2014; Buyanjargal et al. 2016). There are no reports of biogeographic studies of aquatic insects, particularly aquatic Coleoptera undertaken in Mongolia. The principal difficulty with any zoogeographical analysis of these groups of insects in Mongolia has been the paucity of taxonomic and distribution data. This situation has improved steadily through the years thanks to the accumulation of more published information such as Brinck (1943), Guéorguiev (1965, 1968a, b, 1969, 1972), Brancucci (1982) and Bellstedt (1985). More recently, some papers by Shaverdo and Fery (2001), Fery (2003) and Shaverdo (2004) have focused on the systematics and taxonomy of dytiscids in Mongolia.

A large number of water beetles were collected in June–July in 2003–2006 and 2008–2011 during the Selenge River Basin and Mongolian Aquatic Insect Survey Expeditions, respectively, as well as in 2009–2015 by Mongolian and Russian researchers within the framework of the Mongolian-Russian Biological Expedition.

Several works on dytiscids have been published based on these studies (Shaverdo and Fery 2006; Enkhnasan 2006, 2008; Shaverdo et al. 2008; Prokin et al. in press), with new faunistic data and new species of dytiscids that were obtained through the expeditions mentioned above. As a result of the latest research efforts on the dytiscid fauna of Mongolia, over 20 species were recorded as new for the country by Shaverdo et al. (2008), and 15 species and two genera by Prokin et al. (in press). Additionally, *Zaitsevhydrus* is recently described in a revision by Fery and Ribera (2018).

Although all of the above-mentioned studies pointed out only general distributions and taxonomy of the dytiscids; a comprehensive overview of the zoogeography of the Mongolian aquatic Coleoptera has not yet been done. In this paper, we attempt to make bio-geographical analyses of dytiscids known for Mongolia, in relation to the country's surface water network and geographical features.

Materials and methods

Study area

Mongolia has an extreme continental climate, with four distinctive seasons. Temperature fluctuates greatly, both daily and annually, with low rainfall (Natsagdorj and Dagvadorj 2010). Average annual temperature ranges between 8.5 °C in the Gobi and -7.8 °C in the high mountains of the Mongolian Altai, Khangai and Khentii ranges. Average annual precipitation is low (200–220 mm) with a range of between 38.4 mm in the Gobi Desert and 389 mm in the North. Seventy percent of Mongolia's water resources have their source in the Altai, Khangai,and Khentii ranges, the Khuvsgul mountains and the higher part of Ikh Khyngan range, which covers 30% of the Mongolian territory (Natsagdorj 2014). Surface water resources in Mongolia are limited, unevenly distributed (Batnasan 2003) and also highly vulnerable to climatic conditions.

Our database consists of dytiscid samplings from ten sub-basins belonging to three water basins. Mongolia is situated on three international river basins (Davaa and Jambaljav 2014): the Arctic Ocean Basin (AOB), Pacific Ocean Basin (POB) and Central Asian Internal Drainage Basin (CAIB), which are subdivided into 10 regional basins. Three of these sub-basins, Selenge (SRB), Shishkhed (ShRB) and Bulgan (BRB) are included in the Arctic Ocean Basin; three sub-basins, Kherlen (KhRB), Onon (ORB) and Khalkh gol (KhGRB) belong to Pacific Ocean Basin; while four sub-basins, namely Tes (TRB), Depression of Great Lakes (DGLB), Valley of Lakes (VLRB) and Gobi (GRB) are in the Central Asian Inland Basin (Fig. 1).

Rivers belonging to AOB are most extensively developed in the north and constitute the country's major river system, i.e., the Selenge River system, which drains via Lake Baikal to the Arctic Ocean. Some tributaries of Siberia's Yenisei River, which also flows to the Arctic Ocean, originate in the mountains of northwestern Mongolia (Davaa 2015).

Many rivers of western Mongolia end at lakes in the CAIB, most often in those of the Great Lakes Depression. The depression is named so because it contains six major Mongolian lakes: the saline Uvs Nuur, Khyargas Nuur, Durgun Nuur and the fresh water Khar-us Nuur, Khar Nuur and Airag Nuur, as well as number smaller ones. The major rivers are Khovd, Zavkhan, and Tes. The few streams of southern Mongolia also do not reach the sea but run into lakes or deserts (Davaa 2015).

In northeastern Mongolia, rivers of POB such as Onon, Kherlen and Khalkh gol River drain into the Pacific after joining the Shilka River in Russia and the Amur (Heilong Jiang) rivers, forming the tenth longest river system in the world (Davaa 2015).

There are about 4113 rivers in Mongolia, with a total length of 67,000 km. The longest river is the Orkhon at 1124 kilometers in length. Large rivers originate in the mountainous areas in the north and west of the country – primarily in the Mongol Altai, Khangai-Khuvsgul and Khentii mountain ranges – where small rivers and mountain streams merge to create well-developed water networks. There are also over 3000 big and small lakes, 6900 springs, 190 glaciers and 250 mineral water springs in the country (Davaa 2015).

The surface water network is of greatest density in the north of the country. In contrast, the southern, central and southeastern parts of the country have few rivers or other surface water resources. In the interior drainage basins, in the western and southern areas of Mongolia, seasonal or intermittent streams end in salt lakes or disappear into the desert. The rivers' main water sources are rainfall, groundwater, snow and glaciers, with melting snow accounting for 15–20 percent of the annual runoff (Davaa and Jambaljav 2014).

Data collection

During our study, we collected 3517 beetle specimens from 630 sampling points (Fig. 1). In addition, we complemented our own data with all previously available information on dytiscid species in Mongolia. Sampled sites covered the main habitats in all water sub-basins of Mongolia, though the number of samples in each region was different because of their different area, habitat types and remoteness (see Figure 1). The material included in our compilation was collected from different regions of Mongolia by many researchers. In total, dytiscids were collected from 1077 sampling points, which involved 6122 specimens. In this paper, we include only those specimens for which collection localities were clearly reported. This selection was necessary, because some records reported by other researchers from across Mongolia did not have clearly identifiable sampling sites. All species names were updated according to the latest catalogue of Palearctic Coleoptera (Nilsson and Hájek 2018). Generic and species names of dytiscids are listed in taxonomical order (Appendix 1).

The relative area of the water sub-basin of Mongolia was taken from the classification of Mongolian water resources (Davaa 2015). Bio-geographical analysis of dytiscid species found in Mongolia was based on our own data and literature sources that provide information on geographical ranges (Nilsson and Hájek 2018).

Predaceous diving beetle collections are currently deposited in the Laboratory of Entomology, Institute of General and Experimental Biology, Ulaanbaatar, Mongolia.

We have classified the dytiscid species of Mongolia in accordance with the earlier systematic work of Zaitsev (1972). The range of some species in Mongolia has not been exactly determined yet. The range patterns currently recognized are:

I. Palearctic. Species distributed throughout the whole Palearctic Region.
II. Holarctic. Inhabitants of the northern regions of the European Russia and Siberia (to Kamchatka i.e., tundra and taiga).
III. Oriental. Occurring at the border between Palearctic and Oriental regions: India and Pakistan, Kashmir, Himachal Pradesh, Uttar Pradesh, Nepal, Sikkim, and Darjeeling, Bhutan, Arunachal Pradesh.
IV. Arctic. Species of Arctic origin with occurrence in the tundra and the northern edge of the taiga. They are distributed in the south to Transbaikalia and in Western Europe to northern Sweden and Norway.

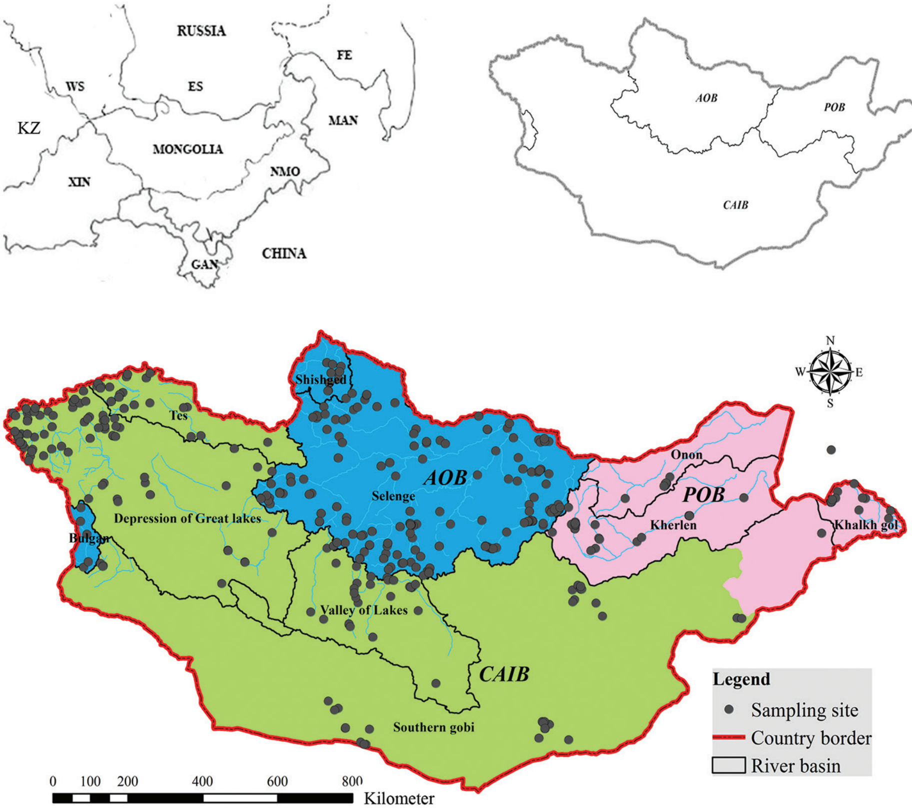

Figure 1. Watersheds and sub-basins of Mongolia. Gray dots represent all sampling points of dytiscids. Abbreviations: KZ – Kazakhstan; WS – West Siberia; ES – East Siberia; FE – Far East; MAN – Manchuria; NMO – Nei Mongol; GAN – Gansu; XIN – Xinjiang; AOB – Arctic Ocean Basin; POB – Pacific Ocean Basin; CAIB – Central Asian Inland Basin.

V. Boreal. This group is the largest. They live in the taiga and insular forests of Eurasia, in the plains. They occur in the northern and central belt of European Russia, in Siberia and highlands of the Caucasus; they also occur in northern and central Europe to eastern France and northern Italy.

VI. Mediterranean. Species widely distributed throughout the Mediterranean (southern Europe, North Africa, and Asia Minor); east Mediterranean species occur in the Balkans, Asia Minor, Syria and western Iran.

VII. Steppe. Species of the steppe zone of European Russia, western Siberia, northern Kazakhstan, eastern Transcaucasia, Turkmenia (some species of this group reach Hungary and Austria in the west).

VIII. Turanian. Species occurring in the mountains of central Asia, Sinkiang, Tien Shan.

IX. Palearchearctic. Species from Korea, China and Japan.

Data analysis

Similarities of dytiscid assemblages among the sub-basins were calculated using the Bray-Curtis' quantitative formula (Bray and Curtis 1957) and the Simple Average Linkage for hierarchical clustering of objects. The results obtained were presented in a similarity dendrogram. Similarities among objects were determined using Biodiversity Pro v.2 software (McAleece et al. 1997). Square-root transformation was used to meet the assumption of normality because the data were counts (Sokal and Rohlf 2012). The occurrences of dytiscids at different altitudes and water sub-basins were arranged in presence/absence tables. Pearson's product-moment correlation was used to determine the relationships between area sizes of each sub-basin and their species richness. The differences in dytiscid fauna among the sub-basins were clarified using one-way analysis of variance (ANOVA). All statistical analyses were performed with software R 3.1.3 for Windows (Team 2015). For all statistical tests, we considered results significant when $p < 0.05$.

Results

Diversity of dytiscids

Based on our investigations, the dytiscid fauna of Mongolia comprises 99 species belonging to 20 genera in five subfamilies. A list of dytiscid species and their occurrences in various sub-basins of Mongolia are given in Appendix 1. It is necessary to note that the sub-basins of Khalkh gol, Bulgan and Gobi region are still insufficiently investigated.

The greatest diversity of dytiscids was recorded from the Selenge River Basin and Depression of Great Lakes. The majority of dytiscid species of Mongolia was represented by two subfamilies, Hydroporinae (44 species) and Agabinae (36), that altogether comprise about 80 percent of the total dytiscid species. The other three subfamilies were Dytiscinae (11), Colymbetinae (7) and Laccophilinae (1), which were only represented by a few species in Mongolia (Appendix 1).

The most species-rich and commonly encountered genera in Mongolia were *Agabus* (25 species), *Hygrotus* (14), *Hydroporus* (14), *Ilybius* (10), *Nebrioporus* (4), *Graphoderus* (4) and *Rhantus* (4). The other genera included less than four species each. *Colymbetes*, *Dytiscus*, *Hydroglyphus* and *Oreodytes* were each represented by three species, while *Hydaticus*, *Acilius* and *Bidessus* had two species each. Six genera were represented by a single species, namely *Boreonectes*, *Laccophilus*, *Laccornis*, *Nectoporus*, *Platambus* and *Zaitsevhydrus*. Thus, few genera were species-rich, whereas the majority comprised fewer species, with the mean number per genus = 5.9 species.

Because China and Russia are large countries and have many diverse zones geographically, our analysis also focused on species composition of surrounding regions in these countries adjacent to Mongolia, in order to reveal species which are shared among them. Fauna of dytiscids in the closest seven regions of Russia and China, as

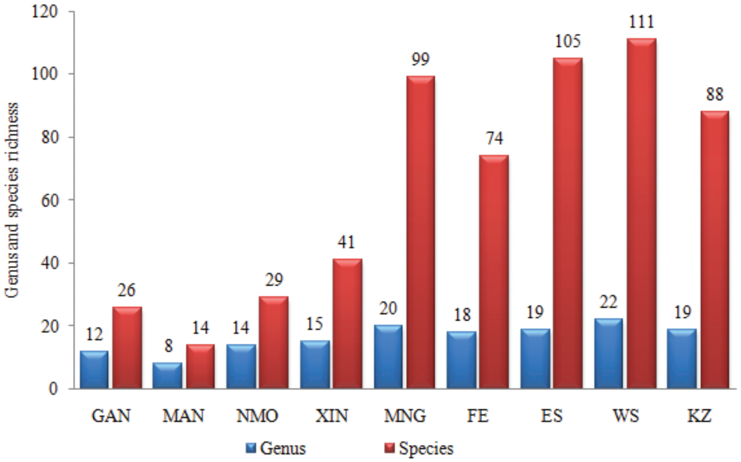

Figure 2. Generic and species richness of dytiscids in Mongolia and its surrounding regions. Abbreviations: GAN – Gansu; MAN – Manchuria; NMO – Nei Mongol; XIN-Xinjiang; MNG – Mongolia; FE-Russian Far East; ES-East Siberia; WS-West Siberia; KZ-Kazakhstan. Source: Catalogue of Palearctic Coleoptera (Nilsson and Hájek 2018).

Table 1. Similarity index of the Mongolian dytiscid fauna with neighboring regions.

	GAN	MAN	NMO	XIN	FE	ES	WS	KZ
MNG	13.0	7.1	18.9	15.9	45.3	58.4	49.0	39.8
GAN	*	0.0	25.9	24.6	10.1	10.9	4.4	10.6
MAN	*	*	4.7	7.4	9.1	6.8	9.7	3.9
NMO	*	*	*	20.3	25.2	18.0	11.5	10.3
XIN	*	*	*	*	10.5	8.3	9.3	28.1
FE	*	*	*	*	*	48.3	33.7	22.2
ES	*	*	*	*	*	*	67.3	45.8
WS	*	*	*	*	*	*	*	54.5

well as Kazakhstan were included. Based on information of the distribution of 261 species, 27 genera of dytiscids were compiled from adjacent regions and Mongolia and a presence or absence matrix for species in these regions was constructed. These analyses found that faunistic similarity coefficients between Mongolia and adjacent regions ranged from 7.1% to 58.4% (Fig. 2, Table 1).

Most of the species recorded for the dytiscid fauna of Mongolia (86 species) were common with those of the surrounding regions. The East (similarity index 58.4%, 60 species shared) and West Siberia (51 species shared) regions of Russia showed the closest similarity with the Mongolian dytiscid fauna. The Manchuria (7.1%, four species shared) region of China had the lowest faunal similarity with Mongolia (Fig. 2). Hence, Mongolian dytiscid fauna has a much closer similarity with that of the northern (Russia) than the southern regions (China).

Geographical distribution of dytiscids by water sub-basins

Dytiscids in the 10 sub-basins occurred with various numbers of species, from 5 to 79. Each of these sub-basins had a peculiar composition of dytiscids, but there were several dominant species in most of the sub-basins. Seventy-nine species were found from Selenge River Basin, 45 species from the Depression of Great Lakes, 26 species from Gobi Basin, 22 species from Tes River Basin and 21 species from Shishkhed and Valley of Lakes River Basins. The species richness of dytiscids in other sub-basins varied between 5 and 17 (see Appendix 1).

Only *Hygrotus marklini* Gyllenhal, 1813 was common to nine sub-basins, six other species, namely *H. impressopunctatus* Schaller, 1783, *H. flaviventris* Motschulsky, 1860 *Agabus adpressus* Aubé, 1837, *Laccophilus biguttatus*, *Oreodytes mongolicus* Brinck, 1943 and *Rhantus frontalis* Marsham, 1802 inhabited seven out of 10 sub-basins, which provide a variety of habitats. While other five species, *A. coxalis* Sharp, 1880, *R. notaticollis* Aubé, 1837, *Dytiscus dauricus* Gebler, 1832, *Nebrioporus airumlus* Kolenati, 1845 and *Hydroporus acutangulus* complex Thomson, 1856 were found in six sub-basins. *Agabus dichrous* Sharp, 1878, *Hygrotus unguicularis* Crotch, 1874, *Ilybius poppiusi* Zaitzev, 1907, *Nectoporus sanmarkii* Sahlberg, 1826 and *O. septentrionalis* Gyllenhal in C.R. Sahlberg, 1826 were recorded from five sub-basins, while nine other species, *A. infuscatus* Aubé, 1838, *A. pallens* Poppius, 1905, *Graphoderus austriacus* Sturm, 1834, *H. enneagrammus* Ahrens, 1833, *H. nigrolineatus* Steven in Schönherr, 1808, *I. cinctus* Sharp, 1878 and *I. lateralis* Gebler, 1832 were distributed in four sub-basins. The other 32 species were found in two or three sub-basins. From our data it is apparent that 43 species have restricted ranges within Mongolia, because of their distribution being restricted to a single sub-basin (see Appendix 1).

Based on the information of the distribution of 99 dytiscid species from different river basins in Mongolia, a presence or absence matrix for species in the nine regions was constructed, except BRB because there were only five species recorded so far (See Appendix 1). Differences between the faunal compositions of dytiscids in the various sub-basins were as theoretically expected. Most of these sub-basins that are more similar in dytiscid fauna were geographically adjacent to one another (KhGRB with ORB, 38.2%; DGLB with TRB, 39.8%), and reflected the main landscape pattern of Mongolia. The relatively low similarity was observed between distant and ecologically different sub-basins, such as SRB with KhGRB (1.3) and VLRB (3.7%); DGLB with KhGRB (4.4%) (Fig. 3).

It should be noted that because of different sampling effort, the diversity of dytiscids reported here for some basins, such as the Valley of Lakes, Bulgan River Basin and Gobi Basin etc. might not be fully representative of reality. Overall, the dytiscid fauna of the various basins was relatively distinct, confirming the well-established classification of the sub-basins in Mongolia.

Species-area relations

Given the geographic distribution in various sub-basins of Mongolia reported above, there were some mismatches between the area of each basin and the respective number

Table 2. Numbers of dytiscid species of different zoogeographical origins listed for 10 sub-basins of Mongolia.

Bio-geographical ranges	**AOB**			**CAIB**				**POB**		
	SRB	**ShRB**	**BRB**	**DGLB**	**GRB**	**TRB**	**VLRB**	**KhGRB**	**KhRB**	**ORB**
Arctic origin	19	7	1	13	5	4	6	2	5	4
Boreal	13	5	2	9	3	5	4	2	3	5
Holarctic	1	1	0	1	0	1	2	0	0	0
Turanian	5	3	0	4	3	2	2	0	1	1
Mediterranean	0	0	0	0	2	1	0	0	0	0
Oriental	0	0	0	0	0	0	0	0	0	0
Palearchearctic	2	0	0	2	1	0	1	0	1	1
Palearctic	32	4	1	10	7	7	5	0	4	2
Steppe zone	7	1	1	6	5	4	1	5	3	2
Overall species	**79**	**21**	**5**	**45**	**26**	**23**	**21**	**9**	**17**	**16**

Abbreviations: AOB – Arctic Ocean Basin: SRB – Selenge River Basin, ShRB – Shishkhed River Basin, BRB – Bulgan River Basin. CAIB – Central Asian Inland Basin: DGLB – Depression of Great Lakes Basin, GRB – Gobi River Basin, TRB – Tes River Basin, VLRB – Valley of Lakes River Basin. POB – Pacific Ocean Basin: KhGRB – Khalkh Gol River Basin, KhRB – Kherlen River Basin, ORB – Orkhon River Basin.

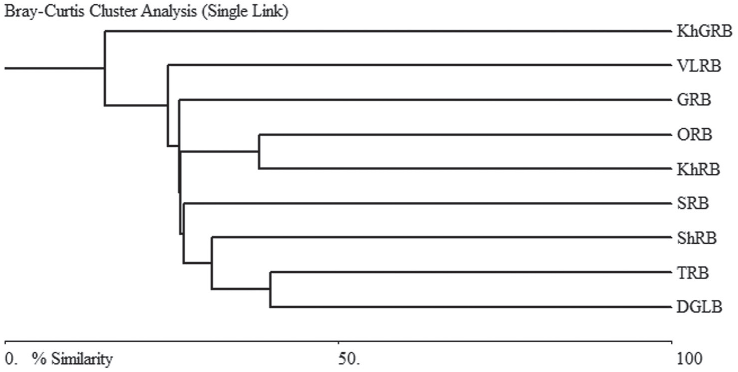

Figure 3. A dendrogram depicting the dytiscid faunal similarity among the water sub-basins of Mongolia. DGLB – Depression of Great Lakes Basin; GRB – Gobi River Basin; TRB – Tes River Basin; VLRB – Valley of Lakes River Basin; KhGRB – Khalkh Gol River Basin; KhRB – Kherlen River Basin; ORB – Orkhon River Basin; SRB – Selenge River Basin; ShRB – Shishkhed River Basin; BRB – Bulgan River Basin.

of dytiscid species. The highest number of species (79 of a total of 99 species) was recorded in the Selenge River Basin, though the total area of this region is only 18.9% of the territory of Mongolia. Forty-five species were found from the Depression of Great Lakes that covers 16.0% of the country. Twenty-one and twenty-six species were recorded in Shishkhed and Gobi basins, which comprise 1.3% and 39.9 % of the entire area of the country, respectively. Species richness of dytiscids varied also among the sub-basins. One-way ANOVA showed that significant differences were observed in the species richness ($F_{9,\ 1077} = 4.34$; $p<0.0001$) among the sub-basins. However, there was no significant relationship between the species richness of dytiscids and the total area of each sub-basin ($r = 0.46$, $p = 0.1708$).

Altitudinal patterns of diversity

Our analysis of patterns of dytiscid species distribution with altitudes was based upon collection data from 1077 different elevation points. Dytiscid community composition was different by altitudes, as most of the species were recorded in a wide range of elevations (Fig. 4).

The number of species observed in the various altitude ranges differed significantly (p = 0.0006). Twelve species, namely *Acilius sulcatus* Nicolai, 1822, *Agabus kaszabi* Guéorguiev, 1972, *A. moestus* Curtis, 1835, *Bidessus nasutus* Sharp, 1887, *Colymbetes pseudostriatus* Nilsson, 2002, *Hydaticus aruspex* Clark, 1864, *Hygrotus inaequalis* Fabricius, 1777, *Hydroporus palustris* Linnaeus, 1760, *Ilybius cinctus* Sharp, 1878, *Ilybius erichsoni* Gemminger & Harold, 1868, *Laccornis oblongus* Stephens, 1835, *Platambus maculatus* Linnaeus, 1753 occurred in the range of 801–1000 m a.s.l., while *Graphoderus zonatus verrucifer* Sahlberg, 1824, *Hydroporus angusi* Nilsson, 1990, *H. fuscipennis* Schaum & Kiesenwetter, 1867, *Ilybius balkei* Fery & Nilsson, 1993 and *I. opacus* Aubé, 1837 were restricted to lower altitudes, between 600 and 800 m a.s.l..

Several other species (i.e. *Agabus costulatus* Motschulsky, 1859, *A. lineatus* Gebler, 1848, *Boreonectes* aff. *emmerichi* Falkenström, 1936, *Hydroporus morio* Aubé, 1838 and *H. notabilis* LeConte, 1850) were reported at elevations of 2001 – 2300 m a.s.l..

Species richness was greatest between 1000 and 2000 m a.s.l., as 75 species (77.8% of total diversity) was recorded in this mid-altitude range. Thus, we found a peak of species richness between 1400 and 1600 m a.s.l.

Geographic distribution of species in Mongolia

The geographic distribution of all known species of dytiscids in Mongolia was compiled, and the species were divided into groups based upon their range. Species of Boreal (16 species, 16.8%) and Arctic origin (21 species, 22.1%) comprised a large proportion of the dytiscid fauna, due to the extremely harsh and fluctuating climate of Mongolia (Fig. 5).

Two species, *Oreodytes mongolicus* and *Agabus kaszabi* were found to be endemic to Mongolia. Although *O. mongolicus* was common throughout the whole country, it was collected mainly from sub-basins DGLB, TRB and SRB. Twenty-seven were Palearctic species (27.3% of total), namely *Acilius sulcatus*, *Agabus blatta*, *A. congener*, *Agabus kaszabi*, *A. kholini*, *A. laferi*, *Agabus svenhedini*, *A. udege*, *Bidessus unistriatus*, *Boreonectes aff. emmerichi*, *Colymbetes pseudostriatus*, *Graphoderus cinereus*, *Hydaticus continentalis*, *Hydroglyphus licenti*, *Hydroporus angusi*, *H.crinitisternus*, *H. kabakovi*, *H. palustris*, *H. uenoi*, *Hygrotus chinensis*, *H. inaequalis*, *H. parallellogrammus*, *Ilybius balkei*, *I. chishimanus*, *Oreodytes shorti*, *Platambus maculatus* and *Rhantus vermiculatus*. Twenty-one were Arctic species (22.1%), namely *Agabus adpressus*, *A. aequalis*, *A. arcticus alpinus*, *A. costulatus*, *A. coxalis*, *A. lapponicus*, *A. moestus*, *A. thomsoni*, *Colymbetes dahuricus*, *C. dolabratus*, *Dytiscus latro*, *Hydroglyphus hamulatus*, *Hydroporus acutangulus* complex, *H. sibiricus*, *H. submuticus*, *Hygrotus unguicularis*, *Ilybius lateralis*,

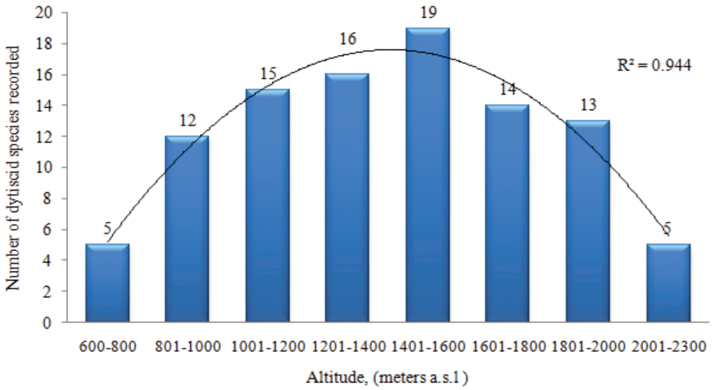

Figure 4. Altitudinal ranges of dytiscids in Mongolia, showing number of species in each category of altitudinal range, with a minimum range of 600 m and a maximum of 2300 m.

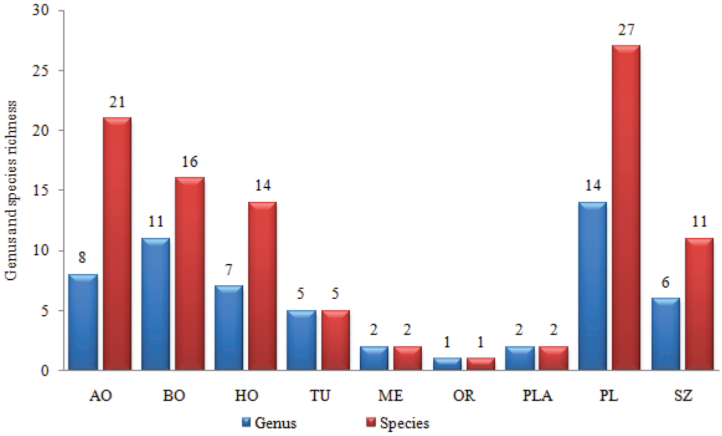

Figure 5. Relationship of generic and species diversity of dytiscids in the water sub-basins of Mongolia according to their biogeographic regions. Abbreviations: AO – species of Arctic origin; BO – Boreal species; HO – Holarctic species; TU – Turanian species; ME – Mediterranean elements; OR – Oriental; PLA – Palearchearctic; PL – species distributed throughout the whole Palearctic; SZ – species of the Steppe zone.

I. obtusus, *I. poppiusi* and *Oreodytes mongolicus*. Sixteen Boreal species (16.1%), such as *Acilius canaliculatus*, *Agabus biguttulus*, *A. discolor*, *Graphoderus zonatus verrucifer*, *G. zonatus zonatus*, *Hydroglyphus geminus*, *Hydroporus elongatulus*, *Hygrotus marklini*, *H. quinquelineatus*, *Ilybius angustior*, *Laccornis oblongus*, *Nebrioporus assimilis*, *N. depressus*, *Oreodytes septentrionalis*, *Rhantus frontalis*, and *R. notaticollis* were also found to be widely distributed in Mongolia.

The quantitatively most important bio-geographical elements were Holarctic (14 species, 14.1%), Steppe (11 species, 11.1%) and Turanian (5 species, 5.0%) species. Mediterranean (*Hygrotus confluens* and *Agabus nebulosus*) and Palearctic species (*Dytiscus dauricus*, *Nebrioporus hostiles*) were each represented by two species. Finally, only one species from the Oriental Region (*Agabus japonicus continentalis*) was recorded from Mongolia.

Discussion

Species richness

Mongolia has representatives of about 1.12% of the known world dytiscid genera and 2.3% of the currently described species (Nilsson 2015; Nilsson and Hájek 2018). Patterns of climatic and environmental conditions might be the main factor controlling dytiscid fauna in Mongolia and surrounding regions. Species composition of dytiscids in the surrounding countries and regions is similar to that of Mongolia, with Russian Far East having 74 species, East Siberia with 105, West Siberia with 111, Kazakhstan with 88 and China (altogether, including Gansu, Manchuria, Inner Mongolia and Xinjiang) with 110 species recorded respectively (Nilsson and Hájek 2018).

The Agabinae and Hydroporinae are the largest dytiscid subfamilies in the world and the dominant groups in most habitats. The prevalence of these subfamilies has been reported to increase with increasing variety of water bodies (Lawrence and Slipinski 2013; Yee 2014) . The faunal composition of dytiscids in Mongolia was also consistent with this pattern: species belonging to the Agabinae and Hydroporinae comprised more than 80% of the total number of species recorded in this study, while Dytiscinae and Colymbetinae were represented by eleven and seven species, respectively, with a single species of Laccophilinae also being recorded.

More than half of the recorded species in the Mongolian dytiscid fauna belong to the genera *Agabus*, *Hygrotus*, *Hydroporus* and *Ilybius*. Other genera containing three or more species in Mongolia were: *Dytiscus* (3 species), *Graphoderus* (4), *Nebrioporus* (4), *Oreodytes* (3), *Rhantus* (4), *Colymbetes* (3) and *Hydroglyphus* (3). Together, the eleven most diverse genera constituted nearly 88.5% of the dytiscid species known from Mongolia, while other genera, such as *Acilius*, *Hydaticus*, *Bidessus*, *Boreonectes*, *Laccophilus*, *Laccornis*, *Nectoporus*, *Platambus* and *Zaitsevhydrus* comprised a much smaller proportion of the fauna. Similar faunistic patterns were found in other regions surrounding Mongolia, e.g., Russian Far East and northern China (Jäch and Ji 1998; Nilsson and Hájek 2018). Jäch and Ji (2003) reported 31 species belonging to 13 genera from Xinjiang (China); one species from Ningxia; 16 species (nine genera) from Gansu; 10 species (eight genera) from Shanxi, and eight species (six genera) from Chinese Manchuria. Enkhnasan (2018) recorded 36 species, 16 genera from Inner Mongolia based on the collection of the Nonnaizab Entomology Center, Normal University, Inner Mongolia, as well as literature sources such as Jäch and Ji (1995; 1998; 2003), Morse et al. (1994) and Nonnaizab (1999).

Shaverdo et al. (2008) recorded 87 (without subspecies) species belonging to 15 genera from Mongolia. Among them, nine species did not include accurate geographic locality, only a distribution range given as "Mongolia" (Nilsson 2003; Shaverdo et al. 2008; Nilsson and Hájek 2018). Those species were *Agabus basalis* (Gebler, 1829), *A. brandti* Harold, 1880, *A. confinis* (Gyllenhal, 1808), *A. fulvaster* Zaitsev, 1906, *Ilybius f. fuliginosus* (Fabricius, 1792), *Rhantus bistriatus* (Bergstrasser, 1777), *R. suturalis* (Macleay, 1825), *Cybister tripunctatus lateralis* (Fabricius, 1798) and *Laccophilus minutus* (Linnaeus, 1758). Therefore, in our analysis we included only species with specific geographic locations in Mongolia collected by other researchers, while excluding the nine species above. Perhaps, these species might be confirmed in future studies for Mongolia. Prokin et al. (in press) newly recorded two genera and 15 species for the country. Also, we recorded *Agabus udege* Nilsson, 1994 and *Agabus nebulosus* Forster, 1771 as new for the country and compiled from other previous records another three species, including *Acilius canaliculatus* Nicolai, 1822, *Bidessus unistriatus* Goeze, 1777, *Nebrioporus hostilis* Sharp, 1884 (Guéorguiev 1972; Enkhnasan 2006; Prokin and Zhavoronkova 2015). In total, there were 99 species belonging to 20 genera of dytiscids recorded for Mongolia. Sampling points for 23 of these species were derived from the literature (Appendix 1).

Calosi et al. (2010) indicated that absolute thermal tolerance range is the best predictor of species' latitudinal range extent and position, while differences in dispersal ability (based on wing size) apparently are less important for European diving beetle species, with the northern and southern range limits related to their tolerance of low and high temperatures, respectively. In general, dytiscid species richness depends on the altitude and water network of the country considered. The most favoured altitude for dytiscids in Mongolia was in the range of 1400–1600 m a.s.l.; at lower or higher altitudes species richness of dytiscids decreased steadily.

Distribution in sub-basins

The "Arctic Ocean Basin" group encompasses the Selenge, Shishkhed and Bulgan River Basins. The "Pacific Ocean Basin" group includes the Kherlen, Onon and Khalkh Gol River Basin. The "Central Asian Inland Basin" group consists of the Tes, Depression of Great Lakes, Valley of Lakes and Gobi Basin. The results show that the faunal composition of dytiscids is more similar among the sub-basins due to geographical adjacency to one another, and reflect the main landscape pattern of Mongolia. In particular, the similarity of dytiscid fauna between AOB and CAIB was 36.5% and between CAIB and POB 28.6%.

It is notable that the most common species (e.g. *Hygrotus impressopunctatus*, *H. marklini*, *Agabus adpressus*, *A. coxalis*, *Oreodytes mongolicus*, *O. septentrionalis*, *Rhantus notaticollis*, *Dytiscus dauricus*, *Hydroporus acutangulus* complex, *Hygrotus flaviventris*, *Laccophilus biguttatus*) tended to be widely distributed across various sub-basins, but in contrast the uncommon and rare species (*Agabus biguttulus*, *A. clavicornis*, *A. congener*, *A. angusi*, *A. kholini*, *A. laferi*, *A. lapponicus*, *A. lineatus*, *Colymbetes dahuricus*, *C. pseudostriatus*, *Graphoderus cinereus*, *G. zonatus verrucifer*, *Hydroglyphus licenti*, *Hydroporus angusi*, *H. elongatulus*, *H. fuscipennis*, *H.kabakovi*, *H. morio*, *H. nigellus*, *H. notabilis*, *H. palustris*, *H. submuticus*, *H. uenoi*, *Hygrotus flaviventris*, *H. urgensis*, *I. balkei*, *I. chishimanus*, *I. erichsoni*, *I. opacus* and *Platambus maculatus*) were highly restricted in their distribution, generally occurring only in one basin.

Aquatic macro-invertebrate assemblages can be affected by various local and regional environmental factors, such as chemical and physical characteristics of stream water, hydrology, and geographic location, as well as climatic factors. Hayford and Gelhaus (2010) concluded that water temperature, pH, conductivity and elevation were not significant predictors of variation in aquatic insect metrics for Mongolian surface waters, but diversity in some families of aquatic insects tended to increase with increased erosion, conductivity, and pH, according to the large-scale Mongolian Aquatic Insect Survey results.

Generally, the species richness of local dytiscid communities is primarily influenced by climatic conditions (e.g. temperature regimes, precipitation), landform, and microhabitat patterns (e.g. vegetation cover, erosion, variety of water bodies). In Mongolia, however, due to the high habitat heterogeneity, species diversity of dytiscids in various sub-basins may differ as a consequence of water physico-chemical parameters that can determine whether a species is present or absent within a locality; thus, small-scale patterns of habitat distribution are important for dytiscids in Mongolia, especially in arid regions.

Altitudinal distribution

We suggest that the clear differentiation of elevational distribution observed for the majority of dytiscid species considered in this study is due to local geographic relief, as the majority of the country exhibits mountainous landscapes (about 85% of its area is over 1000 m a.s.l.), the exception being the plain grasslands of eastern Mongolia.

The mid-elevation peak in dytiscid diversity is sometimes attributed to the warmer and better wetland habitat conditions and prey resource availability at these elevations. Based on research from various regions, it has been observed that high diversity of diving beetles depends on the number of wetland types represented in a landscape, and thus it is possible to achieve high diversity in a small area by combining permanent and temporary wetlands, as well as systems located in wooded and open environments (Lundkvist et al. 2001; Bloechl et al. 2010; Mabidi et al. 2017). The absence of dytiscid species at elevations above 2300 m a.s.l. might be due to low temperature and limited water sources, both of which would preclude their distribution at high altitudes in Mongolia. It is worth noting that this is the first report on the elevational distribution of dytiscids in Mongolia, and the distinct pattern of dytiscid distribution in various elevation ranges might also be caused by different degrees of sampling effort applied during investigations in different basins of the country.

Biogeography

The biogeographic composition of dytiscid fauna in Mongolia confirms that it is one of the representative parts of the Palearctic dytiscid fauna. The majority of dytiscid species in Mongolia are widespread in the whole Palearctic region, with the addition of Holarctic elements. Thus, species of Arctic and Boreal regions are widely distributed in Mongolia and comprise more than one third of the total number of species (37.4%). The other specific characteristic of the Mongolian dytiscid fauna is the presence of species from the Oriental Region, as for instance *Agabus japonicus continentalis*.

Finally, it should be noted that the magnitude of climatic changes in temperature and precipitation are predicted to stress a variety of ecosystems directly or indirectly. Most attention has focused on how climate change will affect terrestrial ecosystems, but aquatic ecosystems (e.g., ponds, lakes, streams, and rivers) will also experience parallel changes in diel, seasonal, and annual temperature and precipitation patterns. Therefore, we need to focus on issues related to the effect of increased temperature on the characteristics of biogeographical distribution of dytiscids. Detailed biogeographical surveys play an important role in providing information of what species are present in sub-basins and understanding their ecological roles, to better manage and protect aquatic ecosystems for the future.

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Appendix I

Compiled dytiscid species list from own data and literature sources, and their distribution in sub-basins of Mongolia.

ID	Species name	DGLB	GRB	TRB	VLRB	KhGRB	KhRB	ORB	SRB	ShRB	BRB	Total occurrence in the basins	Total abundance of species
Agabinae													
1	*Agabus aequalis* Sharp, 1882	0	0	0	0	0	0	0	1	0	0	1	3
2	**Agabus amoenus* Solsky, 1874	0	1	0	0	0	0	0	0	0	0	1	5
3	**Agabus angusi* Harris, 1828.	0	0	0	0	0	0	1	0	0	0	1	1
4	*Agabus arcticus alpinus* Motschulsky, 1860	1	0	0	0	0	0	0	1	1	0	3	21
5	*Agabus congener* Thunberg, 1794	0	0	0	0	0	0	0	1	0	0	1	1
6	*Agabus costulatus* Motschulsky, 1859	1	0	0	0	0	0	0	1	0	0	2	24
7	*Agabus coxalis* Sharp, 1880	1	1	0	0	1	0	1	1	1	0	6	21
8	*Agabus infuscatus* Aubé, 1838	1	0	0	1	0	0	0	1	1	0	4	18
9	**Agabus japonicus continentalis* Guéorguiev, 1970	0	1	0	0	0	0	0	0	0	0	1	3
10	**Agabus kaszabi* Guéorguiev, 1972	0	0	0	0	0	0	1	0	0	0	1	1
11	*Agabus lapponicus* Thomson, 1867	0	0	0	0	0	0	0	1	0	0	1	6
12	**Agabus moestus* Curtis, 1835	0	0	0	0	0	0	0	1	0	0	1	1
13	**Agabus thomsoni* Sahlberg, 1871	0	0	0	0	0	0	0	1	0	0	1	2
14	*Agabus clavicornis* Sharp, 1882	1	0	0	0	0	0	0	1	0	0	2	9
15	*Agabus lineatus* Gebler, 1848	0	0	0	0	0	0	0	1	0	0	1	1
16	*Agabus pallens* Poppius, 1905	1	0	1	0	0	0	1	1	0	0	4	17
17	*Agabus adpressus* Aubé, 1837	1	1	1	1	0	1	0	1	1	0	7	58
18	**Agabus biguttulus* Thomson, 1867	0	0	0	0	0	0	1	0	0	0	1	1
19	**Agabus blatta* Jakovlev, 1897	1	0	1	0	0	0	0	0	0	0	2	2
20	*Agabus dichrous* Sharp, 1878	1	1	1	1	0	0	0	1	0	0	5	40
21	*Agabus kholini* Nilsson, 1994	0	0	0	0	0	1	0	0	0	0	1	1
22	*Agabus laferi* Nilsson, 1994	0	0	0	0	0	0	0	1	0	0	1	2
23	*Agabus nebulosus* Forster, 1771	0	1	1	0	0	0	0	0	0	0	2	2
24	**Agabus svenhedini* Falkenström, 1932	1	0	1	0	0	0	0	0	0	0	2	2
25	*Agabus udege* Nilsson, 1994	0	0	0	1	0	1	0	1	0	0	3	4
26	*Ilybius angustior* Gyllenhal, 1808	1	0	0	0	0	0	0	1	0	0	2	12
27	*Ilybius balkei* Fery&Nilsson, 1993	0	0	0	0	0	0	0	1	0	0	1	1
28	*Ilybius chishimanus* Kôno, 1944	0	0	0	0	0	0	0	1	0	0	1	9
29	*Ilybius cinctus* Sharp, 1878	0	1	0	0	1	1	1	0	0	0	4	8
30	*Ilybius erichsoni* Gemminger & Harold, 1868	0	0	0	0	0	0	0	1	0	0	1	4
31	*Ilybius lateralis* Gebler, 1832	1	0	0	0	0	0	1	1	1	0	4	8
32	*Ilybius obtusus* Sharp, 1882	0	0	0	1	0	0	0	1	1	0	3	10
33	*Ilybius opacus* Aubé, 1837	0	0	0	0	0	0	0	1	0	0	1	2
34	*Ilybius poppiusi* Zaitzev, 1907	1	1	0	0	1	0	1	1	0	0	5	26
35	*Ilybius subaeneus* Erichson, 1837	1	0	0	0	0	0	0	1	0	0	2	5
36	*Platambus maculatus* Linnaeus, 1753	0	0	1	0	0	0	0	0	0	0	1	1

ID	Species name	DGLB	GRB	TRB	VLRB	KhGRB	KhRB	ORB	SRB	ShRB	BRB	Total occurrence in the basins	Total abundance of species
Colymbetinae													
37	*Colymbetes dahuricus* Aubé, 1837	0	0	0	1	0	0	0	1	0	0	2	8
38	**Colymbetes dolabratus* Paykull, 1798	1	0	0	1	0	0	0	0	0	0	2	4
39	*Colymbetes pseudostriatus* * Nilsson, 2002	0	0	0	0	0	0	0	1	0	0	1	1
40	*Rhantus frontalis* Marsham, 1802	1	1	1	1	1	0	1	1	0	0	7	16
41	*Rhantus notaticollis* Aubé, 1837	1	0	1	0	0	1	1	1	1	0	6	62
42	**Rhantus rufus* Zimmermann, 1922	0	0	0	0	0	0	1	0	0	0	1	1
43	*Rhantus vermiculatus* Moschulsky, 1860	0	0	0	0	0	0	0	1	2	0	2	12
Dytiscinae													
44	*Acilius canaliculatus* Nicolai, 1822	0	0	0	0	0	0	0	1	1	0	2	2
45	**Acilius sulcatus* Linnaeus, 1758	0	0	0	0	0	0	0	1	0	0	1	1
46	*Graphoderus austriacus* Sturm, 1834	1	0	0	0	1	0	0	1	1	0	4	4
47	*Graphoderus cinereus* Linnaeus, 1758	1	1	0	0	0	0	0	1	0	0	3	3
48	*Graphoderus zonatus verrucifer* Sahlberg, 1824	0	0	0	0	0	0	0	1	0	0	1	1
49	*Graphoderus zonatus zonatus* Hoppe, 1795	1	0	0	0	0	0	0	1	1	0	3	3
50	**Dytiscus circumcinctus* Ahrens, 1811	1	1	0	0	0	0	0	1	0	0	3	3
51	*Dytiscus dauricus* Gebler,1832	1	1	0	1	0	1	1	1	0	0	6	6
52	*Dytiscus latro* Sharp, 1882	1	0	0	1	0	0	0	1	0	0	3	3
53	**Hydaticus aruspex* Clark, 1864	0	0	0	0	0	0	0	1	0	0	1	1
54	**Hydaticus continentalis* Balfour-Browne, 1944	0	0	0	0	0	0	0	1	0	0	1	1
Hydroporinae													
55	**Bidessus nasutus* Sharp, 1887	1	0	1	0	0	0	0	0	0	0	2	8
56	**Bidessus unistriatus* Goeze, 1777	0	0	0	1	0	0	0	0	0	0	1	1
57	*Hydroglyphus geminus* Fabricius, 1792	0	1	1	0	0	0	0	1	0	0	3	16
58	**Hydroglyphus hamulatus* Gyllenhal, 1813	1	0	0	0	0	0	0	0	0	0	1	1
59	*Hydroglyphus licenti* Feng, 1936	0	0	0	0	0	0	0	1	0	0	1	1
60	**Boreonectes aff. emmerichi* Falkenström, 1936	1	0	0	0	0	0	0	0	0	0	1	3
61	*Nebrioporus airumlus* Kolenati, 1845	1	1	1	1	0	0	0	1	1	0	6	32
62	**Nebrioporus assimilis* Paykull, 1798	1	0	0	0	0	0	0	0	0	0	1	1
63	*Nebrioporus depressus* Fabricius, 1775	1	0	1	0	0	0	0	1	0	0	3	4
64	**Nebrioporus hostilis* Sharp, 1884	1	0	0	0	0	0	0	1	0	0	2	3
65	*Oreodytes mongolicus* Brinck, 1943	1	1	1	1	0	1	0	1	1	1	7	40
66	*Oreodytes septentrionalis* Gyllenhal in C.R. Sahlberg, 1826	1	0	1	1	0	1	0	1	0	1	5	27
67	*Oreodytes shorti* Shaverdo & Fery, 2006	0	1	0	0	0	0	0	1	0	0	2	4
68	*Nectoporus sanmarkii* Sahlberg, 1826	1	1	1	1	0	0	0	1	0	0	5	45
69	*Zaitzevhydrus formaster* Zaitzev, 1908	1	0	0	0	0	0	0	1	1	0	3	20
70	*Hydroporus acutangulus* complex Thomson, 1856	1	0	1	0	0	1	1	1	1	0	6	36

ID	Species name	DGLB	GRB	TRB	VLRB	KhGRB	KhRB	ORB	SRB	ShRB	BRB	Total occurrence in the basins	Total abundance of species
71	*Hydroporus angusi* Nilsson, 1990	0	0	0	0	0	0	0	1	0	0	1	1
72	**Hydroporus crinitisternus* Shaverdo &	0	0	0	0	0	0	0	0	0	1	0	1
73	*Hydroporus elongatulus* Sturm, 1835	0	0	0	0	0	0	0	1	0	0	1	2
74	*Hydroporus fuscipennis* Schaum & Kiesenwetter, 1867	0	0	0	0	0	0	0	1	0	0	1	3
75	*Hydroporus geniculatus* Thomson, 1856	1	0	0	0	0	0	0	1	1	0	3	9
76	*Hydroporus kabakovi* Fery & Petrov, 2006	0	0	0	0	0	0	0	1	0	0	1	2
77	*Hydroporus morio* Aubé, 1838	0	0	0	0	0	0	0	1	0	0	1	5
78	*Hydroporus nigellus* Mannerheim, 1853	0	0	0	0	0	0	0	1	0	0	1	3
79	*Hydroporus notabilis* LeConte, 1850	0	0	0	0	0	0	0	1	0	0	1	6
80	*Hydroporus palustris* Linnaeus, 1760	0	0	0	0	0	0	0	1	0	0	1	1
81	*Hydroporus sibiricus* Sahlberg, 1880	0	0	0	0	0	1	0	1	0	0	2	5
82	*Hydroporus submuticus* Thomson, 1874	0	0	0	0	0	0	0	1	0	0	1	9
83	*Hydroporus uenoi* Nakane, 1963	0	0	0	0	0	0	0	1	0	0	1	13
84	*Hygrotus caspius* Wehncke, 1875	0	0	0	0	1	1	0	1	0	0	3	10
85	*Hygrotus confluens* Fabricius, 1787	0	1	0	0	0	0	0	0	0	0	1	1
86	*Hygrotus enneagrammus* Ahrens, 1833	1	1	1	0	0	0	0	1	0	0	4	9
87	*Hygrotus flaviventris* Motschulsky, 1860	1	1	1	1	1	1	0	1	0	1	7	24
88	*Hygrotus nigrolineatus* Steven in Schönherr, 1808	1	1	0	0	1	0	0	1	0	0	4	6
89	*Hygrotus pectoralis* Motschulsky, 1860	1	0	1	0	0	0	0	1	0	0	3	3
90	*Hygrotus inaequalis* Fabricius, 1777	0	0	1	0	0	0	0	1	1	0	3	8
91	*Hygrotus quinquelineatus* Zetterstedt, 1828	1	0	0	0	0	0	0	1	1	0	3	17
92	*Hygrotus chinensis* Sharp, 1882	0	1	0	0	0	1	0	1	0	0	3	4
93	*Hygrotus impressopunctatus* Schaller, 1783	1	1	1	1	0	1	0	1	1	0	7	72
94	*Hygrotus marklini* Gyllenhal, 1813	1	1	0	1	1	1	1	1	1	1	9	53
95	*Hygrotus parallellogrammus* Ahrens, 1812	0	0	0	1	0	0	0	1	0	0	2	3
96	*Hygrotus unguicularis* Crotch, 1874	1	1	1	0	0	1	0	1	0	0	5	31
97	*Hygrotus urgensis* Jakovlev, 1899	0	0	0	0	0	0	0	1	0	0	1	1
98	**Laccornis oblongus* Stephens, 1835	0	0	0	0	0	0	0	1	0	0	1	1
Laccophilinae													
99	*Laccophilus biguttatus* Kirby, 1837	1	1	0	1	0	1	1	1	1	0	7	44
	Overall species composition	**45**	**26**	**23**	**21**	**9**	**17**	**16**	**79**	**21**	**5**		

* Sampling points by others

DGLB- Depression of Great Lakes Basin; GRB-Gobi River Basin; TRB-Tes River Basin; VLRB-Valley of Lakes River Basin; KhGRB-Khalkh Gol River Basin; KhRB-Kherlen River Basin; ORB-Orkhon River Basin; SRB-Selenge River Basin; ShRB-Shishkhed River Basin; BRB-Bulgan River Basin.

Supplementary material 1

Species list of Dytiscid (Coleoptera, Dytiscidae) of Mongolia

Authors: Davaadorj Enkhnasan, Bazartseren Boldgiv

Data type: Table data

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RESEARCH ARTICLE

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The geographical distribution patterns of *Chrysoteuchia* Hübner in China and description of a new species (Lepidoptera, Crambidae)

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Abstract

The geographical distribution patterns of *Chrysoteuchia* Hübner in China are analysed with MaxEnt and ArcGIS based on known localities and nineteen environmental variables. The results suggest that south-eastern China is a highly suitable area, and Bio11 (mean temperature of the coldest quarter), Bio12 (annual precipitation) and Bio18 (precipitation of the warmest quarter) are revealed to be the main variables affecting the present distribution patterns. Among them, Bio18 is the strongest predictor with a 24.3% contribution. Furthermore, a new species from Tibet is added to the genus, *Chrysoteuchia landryi* **sp. nov.**, and the male of *C. curvicavus* is described for the first time. Images of adults and their genitalia are illustrated, and two maps showing the geographical distribution patterns of *Chrysoteuchia* in China are provided.

Keywords

ArcGIS, Crambinae, MaxEnt, Pyraloidea, taxonomy

Introduction

Chrysoteuchia was erected by Hübner (1825) with *Tinea hortuella* Hübner, 1796 as the type species. Morphologically, *Chrysoteuchia* species are variable in wing pattern, but can be recognised with characters of the genitalia: in males, the well-developed sacculus is adorned with a projection while in females the papillae anales have a concave

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posterior margin, the posterior apophyses are slender, and the anterior apophyses are absent (Li and Li 2010).

The genus has 35 species with Palearctic, Sino-Japanese, and Oriental distributions except for *C. topiaria* (Zeller, 1866), which is endemic to the Nearctic region (Bleszynski 1965; Chen et al. 2001, 2003; Inoue 1989; Landry 1995; Li and Li 2010; Li and Liu 2012). In China, the genus has an exceptional diversity with 33 species (Li and Li 2010; Li and Liu 2012). Prior to this study, most known localities of Chinese *Chrysoteuchia* were reported to occur in eastern China (Li and Li 2010), but this geographical pattern was never analysed. In the analysis of geographical patterns, MaxEnt (Phillips et al. 2006) has been used previously as an effective model for predicting the potential distribution of various taxa (Li 2017, 2018, 2019). In the present paper, we employ MaxEnt and ArcGIS to analyse the distribution of *Chrysoteuchia* in China. We also describe a new species from Galongla Snow Mountain, Tibet.

Materials and methods

All specimens were collected at night with a mercury-vapour lamp. The specimens were hand-collected alive and killed with vapours of ammonium hydroxide prior to mounting and spreading as shown in Landry and Landry (1994). The morphological terminology follows Landry (1995). Illustrations of adults and genitalia were prepared with a digital camera attached to a Zeiss SteREO Discovery V12 microscope and to an Optec BK-DM320 microscope, respectively.

The potential geographic distribution of *Chrysoteuchia* was predicted using MaxEnt (Phillips et al. 2006) based on known localities from the literature (Bleszynski 1965; Chen et al. 2001, 2003; Li and Li 2010; Li and Liu 2012) and the collection localities of the specimens examined in this study (see Suppl. material 1: Table S1); nineteen environmental variables (Table 1) were retrieved from the WorldClim database (http://www.worldclim.org) at a resolution of 2.5 arc-min (Hijmans et al. 2004). MaxEnt was set with 10,000 as the maximum number of background points and 75% training data. The relative importance of each variable was evaluated by contribution in percentage. The cartographic illustrations were created using ArcGIS 10.1. The logistic values of potential habitats were set to 0–1.

Results

Geographical patterns of distribution of *Chrysoteuchia*

The geographical patterns of distribution of Chinese *Chrysoteuchia* were analysed with MaxEnt based on all the known localities in China (Suppl. material 1: Table S1) and nineteen environmental variables (Table 1). Based on the results illustrated with ArcGIS (Fig. 1), we can recognise the mediocre and more suitable regions for *Chrysoteuchia* species, located in humid to semi-humid areas, generally called the monsoon regions

Table 1. Environmental variables used in the study and their contribution in percentage and permutation importance.

Code	Environmental variables	Unit	Contribution in percentage	Permutation importance
Bio1	Annual mean temperature	°C	0.1	0.1
Bio2	Mean diurnal range (mean of monthly max. and min. temperatures)	°C	9.9	0.2
Bio3	Isothermality ((Bio2/Bio7) × 100)	–	8.2	6.2
Bio4	Temperature seasonality (standard deviation ×100)	C of V	4.6	4.2
Bio5	Maximum temperature of the warmest month	°C	2	6.7
Bio6	Minimum temperature of the coldest month	°C	0.7	4.2
Bio7	Temperature annual range (Bio5–Bio6)	°C	0	0.5
Bio8	Mean temperature of the wettest quarter	°C	2.9	5
Bio9	Mean temperature of the driest quarter	°C	0.1	7
Bio10	Mean temperature of the warmest quarter	°C	0.8	0
Bio11	Mean temperature of the coldest quarter	°C	**16.5**	12.6
Bio12	Annual precipitation	mm	**21.3**	1.7
Bio13	Precipitation of the wettest period	mm	0	0.6
Bio14	Precipitation of the driest period	mm	0.3	3.6
Bio15	Precipitation seasonality (CV)	C of V	2.6	6.9
Bio16	Precipitation of the wettest quarter	mm	4	3.1
Bio17	Precipitation of the driest quarter	mm	1.5	5.8
Bio18	Precipitation of the warmest quarter	mm	**24.3**	**31.4**
Bio19	Precipitation of the coldest quarter	mm	0	0

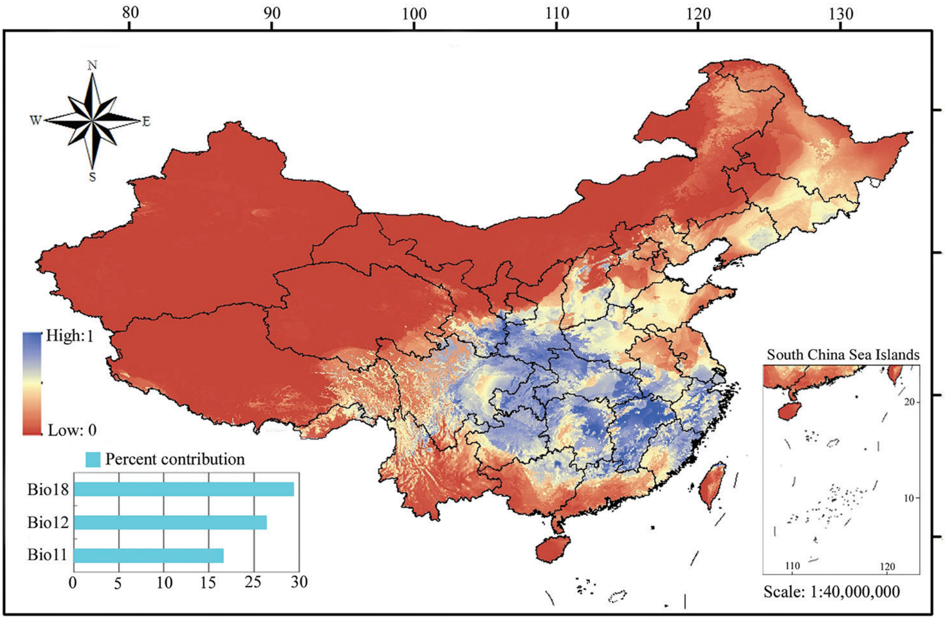


Figure 1. Potential distribution of *Chrysoteuchia* in China. Histograms show the contribution in percentage of the important variables affecting the distribution patterns. The rainbow bar indicates logistic values of potential habitats.

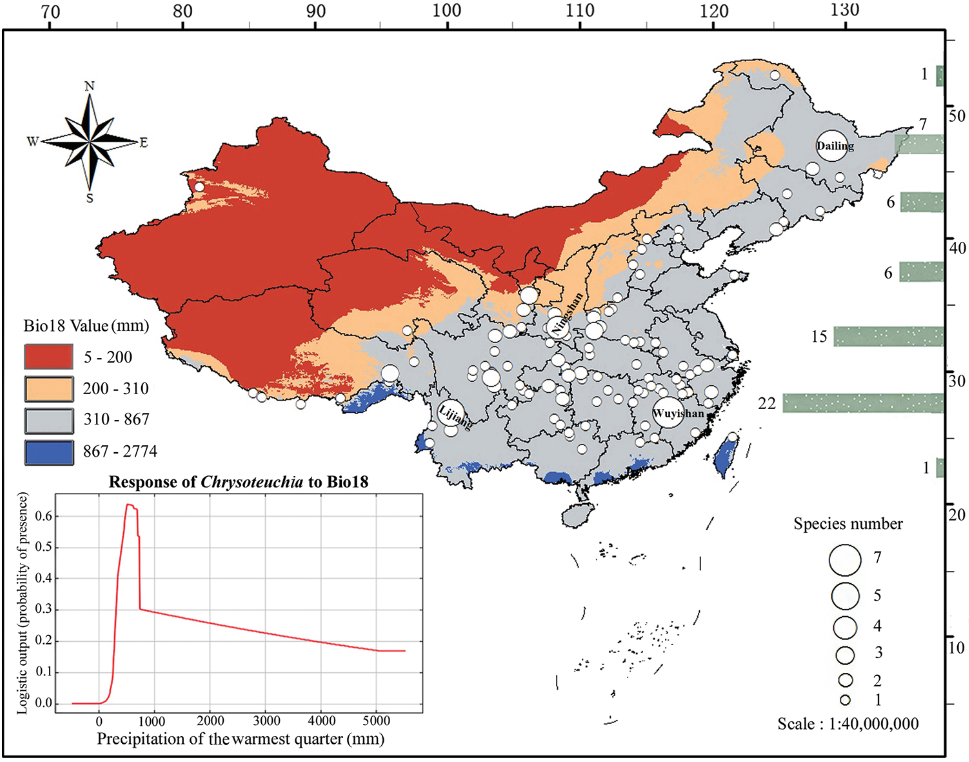


Figure 2. Geographical distribution of *Chrysoteuchia* in China and precipitation of the warmest quarter (Bio18). White circles indicate surveyed sites and number of species per site. Green bars show the known numbers of species at every 5° between 20°N and 55°N.

in eastern China. Among the environmental variables, our statistics show that Bio11 (mean temperature of the coldest quarter), Bio12 (annual precipitation), and Bio18 (precipitation of the warmest quarter) are the main variables affecting the geographical distribution of the genus (Fig. 1). Among them, Bio18 is revealed to be the strongest predictor with a 24.3% contribution (Table 1).

We illustrate all the known collecting localities of the genus in China by mapping the strongest predictor, i.e. Bio18 (Fig. 2). Dailing in Heilongjiang Province (129°02'E, 47°02'N) and Wuyishan in Fujian Province (116°42'E, 26°54'N) have the highest numbers of species (7 species) (Fig. 2). The second and third highest species diversity at a single locality were found at Lijiang in Yunnan Province (100°14'E, 26°52'N) and Ningshan in Shaanxi Province (108°20'E, 33°19'N), with 5 and 4 species respectively (Fig. 2). To further clarify the distribution patterns of the genus in China, we plotted the known numbers of species at every 5° between 20°N and 55°N (Fig. 2). The detailed results for each region are as follows: 20°N–25°N (1 species), 25°N–30°N (22 species), 30°N–35°N (15 species), 35°N–40°N and 40°N–45°N (6 species each), 45°N–50°N (7 species), and 50°N–55°N (1 species). In suitable areas, the general tendency in species richness of the genus decreases as the latitude increases. In addition, the suitable habitats and almost all known localities of the genus are located in the regions with 310–867 mm precipitation of the warmest quarter, which is supported by the response curve of *Chrysoteuchia* to Bio18 (Fig. 2). Thus, there is a high correlation between the distribution patterns of the genus and Bio18.

Taxonomic account

Chrysoteuchia landryi sp. nov.

http://zoobank.org/F7167000-855D-4BF2-8333-683B8123CC93
Figs 3–7

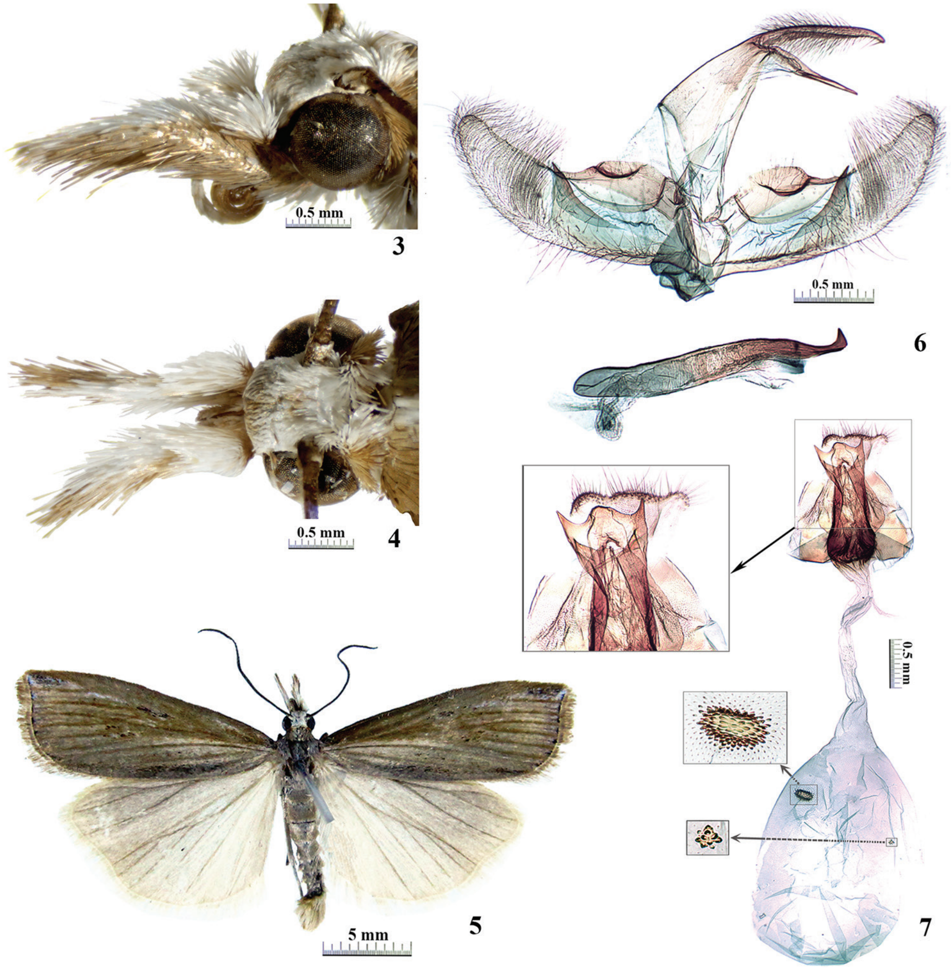
Type material. ***Holotype*** ♂: CHINA: the foot of Galongla Snow Mountain (29°44.29'N, 95°40.61'E), Mêdog, Tibet, 3415 m, 22.vii.2014, Wei-Chun Li leg., genital prep. no. LW15049 (JXAUM).

Paratypes: 2 ♂♂, 2 ♀♀, same data as the holotype, genital prep. nos. LW15007, LW15059 (JXAUM).

Differential diagnosis. This new species is similar to *Chrysoteuchia picturatella* (South, 1901), *C. gonoxes* (Bleszynski, 1962), and *C. dentatella* Song & Chen, 2001 in having an apical prong on the sacculus and a well-developed apical spine on the phallus in the male genitalia. In female genitalia, it also resembles the above three species in having two lateral spines on the posterior margins of the lamella postvaginalis, and double signa on the corpus bursae. However, the new species can be easily distinguished by lacking fasciae on the forewing (Fig. 5), the presence of a crescent-shaped protuberance on the costa of the valva in male genitalia (Fig. 6), and the female antrum ending with two small triangular projections on the lateral margins (Fig. 7). In the latter three species, the forewing fasciae are well developed, the costa of the valva is armed with spine-like projections, and the antrum is without distal spines (Bleszynski 1965; Song and Chen 2001).

Description. ***Adult*** (Figs 3–5): Forewing length 11.0–13.0 mm. Frons white mixed with pale brown. Vertex white. Labial palpus approximately twice as long as compound eye diameter, pale brown on outer side, white on dorsal and inner sides. Maxillary palpus white, basally pale brown. Antenna scapus white mixed with pale brown; flagellomere blackish brown. Patagium and tegula pale brown. Thorax blackish brown. Forewing densely covered with brown scales, apex suffused with black and white scales; termen of apex black, four terminal black dots running from middle of termen to tornus; cilia pale brown. Hindwing greyish white, suffused with pale brown scales around apex and along veins; cilia greyish white.

Male genitalia (Fig. 6): Uncus thin and long, tapering to blunt apex, tip slightly curved downward on lateral view. Gnathos straight, a bit shorter than uncus, tapering to point tip. Tegumen approximately twice as long as gnathos, with broad dorsal bridge. Valva broad at basal half, distal half narrowing towards apex, apex rounded. Costa with crescent-shaped protuberance near base, basal half strongly sclerotised and gently convex, concave near middle. Sacculus basally narrow, broadened towards distal prong; distal prong nearly triangular, tip pointed and reaching costa. Juxta ovate. Sac-



Figures 3–7. *Chrysoteuchia landryi* sp. nov. **3–6** holotype, male **7** paratype, female **3** head in lateral view **4** head in dorsal view **5** adult **6** male genitalia **7** female genitalia.

cus broad, concave at middle of distal margin. Phallus slightly shorter than valva, apical spine well-developed, ending with triangular prong; cornutus absent.

Female genitalia (Fig. 7): Papillae anales broad, concave on posterior margin. Tergite VIII coalescing with antrum. Lamella postvaginalis developed, slightly broader than antrum, medially convex, posterolaterally with long spine. Antrum strongly sclerotised, approximately three times as thick as median part of ductus bursae, ending with two small triangular projections at lateral sides. Ductus bursae long and thin, membranous; ductus seminalis arising from posterior one fourth of ductus bursae. Corpus bursae ovate; signa double, oblong and lotus flower-shaped, consisted of tiny spines with various sizes.

Distribution. Currently only found at Galongla Snow Mountain, in Mêdog County, Tibet of China.

Natural history. Unknown except that the moths are in flight in late July and come at light. The habitat of this species is identical to that of *Metaeuchromius glacialis* Li, 2015 and *Scoparia* spp., collected at the foot of Galongla Snow Mountain. Most parts of the mountain are covered with snow; the vegetation at the bottom is a blend of alpine meadows, shrubs, and conifers on the south slope (Li and Liu 2015; Li et al. 2016).

Etymology. In honour of Dr Bernard Landry, who contributed profoundly to systematic research on the subfamily Crambinae, and who substantially contributes to the catalogue of the world Crambinae species in GlobIZ (www.pyraloidea.org).

Chrysoteuchia curvicavus **Song & Chen, 2001**

Figs 8–10

Chrysoteuchia curvicavus Song & Chen in Chen et al. 2001: 186, figs 5, 11. Type locality: Wuyishan, Fujian Province, China. Type depository: Institute of Zoology, Chinese Academy of Sciences, Beijing.

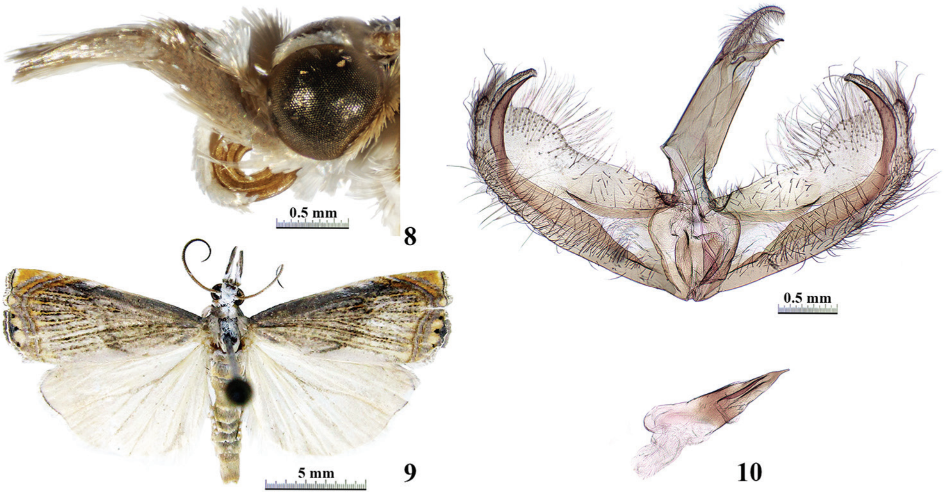
Specimens examined. 14 ♂♂, 25 ♀♀: CHINA: Dafengding Nature Reserves, Mabian (28°51'N, 103°31'E), Sichuan Province, 1100 m, 9–10.viii.2014, Wei-Chun Li leg., genital prep. no. WD17022 (JXAUM).

Description. ***Male adult*** (Figs 8, 9): Forewing length 9.5–11.0 mm. Frons and vertex white. Maxillary palpus pale brown, ending with white. Labial palpus pale brown. Antenna scapus white mixed with grey dorsally, pale brown ventrally; flagellomere pale brown and white alternately on dorsal surface, pale brown on ventral surface. Forewing ground colour white, costa densely covered with blackish brown scales between base and subterminal fasciae, the remaining suffused with sparse blackish brown scales along veins; median fascia blackish brown, angled outwards at anterior one fourth; two subterminal fasciae yellowish brown, out-curved at anterior one third; terminal area pale yellow; terminal fascia black, with three evenly spaced black spots; cilia shiny, pale brown, with greyish white basal line. Hindwing and cilia greyish white. Abdomen pale brown.

Male genitalia (Fig. 10): Uncus apically curved downwards in lateral view, tapering to blunt apex. Gnathos basally broad, tapering to point tip, a bit shorter than uncus. Tegumen nearly four times as long as gnathos, with narrow dorsal bridge. Valva with sclerotised basal line near middle, apical quarter nearly triangular. Costa concave at approximately basal three-fifths. Sacculus narrow and thin, distal prong well-developed and reaching beyond apex of valva. Juxta heart-shaped, basely narrow, broadened towards tip, distal margin slightly concave. Phallus approximately half as long as valva, basal half broad, distal half narrowing towards tip and armed with two sclerotised wrinkles, apex pointed; cornutus absent.

Distribution. China (Sichuan, Fujian).

Remarks. The male of *C. curvicavus* is described for the first time. This species is similar to *C. atrosignata* (Zeller, 1877) in having an apical prong on the sacculus and a pointed apex on the phallus in the male genitalia. However, it can be easily distinguished by the distal prong of the sacculus reaching beyond the apex of the valva, and



Figures 8–10. *Chrysoteuchia curvicavus* Song & Chen **8** head in lateral view, male **9** adult, male **10** male genitalia.

the phallus approximately half as long as the valva and armed with two sclerotised wrinkles (Fig. 10). In the latter species, the distal prong of the sacculus reaches beyond the costa at the basal three-fifths of the valva and the phallus is nearly as long as the valva and without sclerotised wrinkles (Bleszynski 1965). The female of this species was described and figured adequately by Chen et al. (2001).

Discussion

At present, the genus *Chrysoteuchia* includes 36 species worldwide, and all of them occur in China except for *C. topiaria* (Zeller, 1866) and *C. argentistriellus* (Leech, 1889), which are endemic to North America and Korea, respectively. Among them, 22 species were originally described from 1758 to 1965 (Bleszynski 1965). No species were described between 1965 and 2001, but a renewed interest in the genus added another eleven species in the early 2000's, all described from China (Chen et al. 2001, 2003; Li and Li 2010; Li and Liu 2012).

In this study, we show that Bio18 (precipitation of the warmest quarter) is the most important variable with respect to the distribution patterns of the genus (Table 1), with most known presence sites located within the regions with 310–867 mm precipitation of the warmest quarter (Fig. 2). However, the region to the south of 24°N, which has suitable precipitation has low logistic values of potential habitats and few recorded localities (Figs 1, 2). This can be explained by the aid of Bio11 (mean temperature of the coldest quarter), the strongest predictor of the temperature variables. According to the response curve of *Chrysoteuchia* to Bio11 (Suppl. material 2: Fig. S1), we can conclude that the suitable temperatures for the *Chrysoteuchia* occurrences are between -40 °C and 25 °C. These manifest that the species of this genus are humidity dependent and cold tolerant but find it difficult to colonise the relatively hot areas. The spectrum of tolerated temperatures in *Chrysoteuchia* suggests a dispersion to higher altitudes or latitudes in some species to avoid the hot weather in South China. Furthermore, some members of the genus may be considered as potential bioindicators with respect to global warming.

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Supplementary material 1

Table S1

Authors: Lu-Lan Jie, Jing-Bo Yang, Wei-Chun Li

Data type: species data

Explanation note: Overview of Chinese localities where *Chrysoteuchia* species have been collected (administrative divisions are given in bold) with geographical coordinates in the decimal system.

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Link: https://doi.org/10.3897/zookeys.853.34149.suppl1

Supplementary material 2

Figure S1

Authors: Lu-Lan Jie, Jing-Bo Yang, Wei-Chun Li

Data type: image

Explanation note: Response curve of *Chrysoteuchia* to Bio11 (mean temperature of the coldest quarter).

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Metapocyrtus kitangladensis sp. n., a new *Pachyrhynchus cumingii* GR Waterhouse, 1841 mimic from Mindanao Island, Philippines

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Abstract

A description of a new species from the genus *Metapocyrtus* Heller, 1912 (Coleoptera: Curculionidae: Pachyrhynchini) from Mt Kitanglad Range Natural Park, an ASEAN Heritage Site in northern Mindanao is presented and illustrated. The recent discovery is also the first mimic record of *Pachyrhynchus cumingii* GR Waterhouse, 1841 which are both found in the same locality. A *Coptorhynchus* sp. showing similar elytral patterns was also documented to be part of the mimicry complex. The new species differs from the other two species in having a distinct transverse groove between forehead and rostrum and the antennal scape reaching beyond the hind margin of the eye.

Keywords

Bukidnon, endemism, Mt Kitanglad Range Natural Park, weevil

Introduction

The province of Bukidnon is one of the most entomologically explored areas in Mindanao Island, Philippines, with dozens of species of Pachyrhynchini Schönherr, 1826 (Coleoptera: Curculionidae) discovered between 20th and 21st centuries (Schultze 1923, 1925; Bollino et al. 2017; Rukmane and Barševskis 2016; Cabras and Barševskis 2016).

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The province name means "highlander" or "mountain dweller" and its topography is rugged with numerous mountain ecosystems. One of the known mountain ecosystems in Bukidnon is Mt Kitanglad Range Natural Park (MKRNP), a 47,270-hectare ASEAN heritage park (DENR 2018) located in northern part of Bukidnon. It is one of the key biodiversity areas in the Philippines (Canoy and Suminguit 2001) and considered as an important bird area for it is the home of the Philippine Eagle (*Pithecophaga jefferyi* Ogilvie-Grant, 1897), the Philippine National Bird. Although several biodiversity expeditions have been conducted in MKRNP (Peterson et al. 2008; Tan et al. 2015; Rickart et al. 2003; James 2004; Naïve 2017; Cabactulan et al. 2017), no Coleoptera expedition was conducted until recently.

Part of the vision of the Coleoptera Research Center of the University of Mindanao Davao City is to document the coleopteran fauna of the different mountain ecosystems in Mindanao. In partnership with various stakeholders in Bukidnon, a Coleoptera expedition was conducted in Barangay Chinchona, Lantapan, which is one of the main trails of MKRNP. One of the interesting species belonging to the genus *Metapocyrtus* Heller, 1912 was discovered and further examination revealed it as a species new to science. The new species herein together with data on its ecology, distribution, and mimicry with *Pachyrhynchus cumingii* is described and illustrated. Mimicry among the tribe Pachyrhynchini has been widely recorded (Barševskis 2014, 2016, 2017; Cabigas 2010; Vives 2013) since the time of Wallace (1889) and Schultze (1923); however, we had barely scratched the surface of this topic considering so many mimics await discovery and description.

Materials and methods

The specimens deposited in the University of Mindanao Coleoptera Research Center (**UMCRC**) were collected through sheet beating and hand picking and killed in vials with ethyl acetate. Morphological characters were observed under Luxeo 4D and Nikon SMZ745T stereomicroscopes. Stacked digital habitus images were taken with Nikon D5300 digital camera and Sigma 18–250 macro lens, whereas digital images of genitalia were taken with Ricoh WG-50. All images were stacked and processed using a licensed version of the software Photoshop CS6 Portable. Endophallus eversion was done by Dr Bollino and images were taken with Nikon D90 digital camera, extension tubes, bellows, and Rodenstock Rodagon 60mm f/5.6 lens. Images were then stacked and processed using a licensed version of the software Helicon Focus 6.7.0. Measurements mentioned in this paper are abbreviated as follows:

LB	body length, from the apical margin of pronotum to the apex of elytra;
LE	elytral length, from the level of the basal margins to the apex of elytra;
WE	maximum width across the elytra;
LP	pronotal length, from the base to apex along the midline;
WP	maximum width across the pronotum;
LR	length of rostrum;
WR	maximum width across the rostrum.

All measurements are given in millimeters and follow the measurement methodology of Yoshitake (2013). The specimens are deposited in the following collections:

UMCRC	University of Mindanao Coleoptera Research Center, Mindanao, Philippines;
CMUUM	Central Mindanao University University Museum, Mindanao, Philippines;
MBLI	private collection of Dr. Maurizio Bollino, Lecce, Italy.

Results

Metapocyrtus kitangladensis **sp. n.**

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Figs 1–12, 14

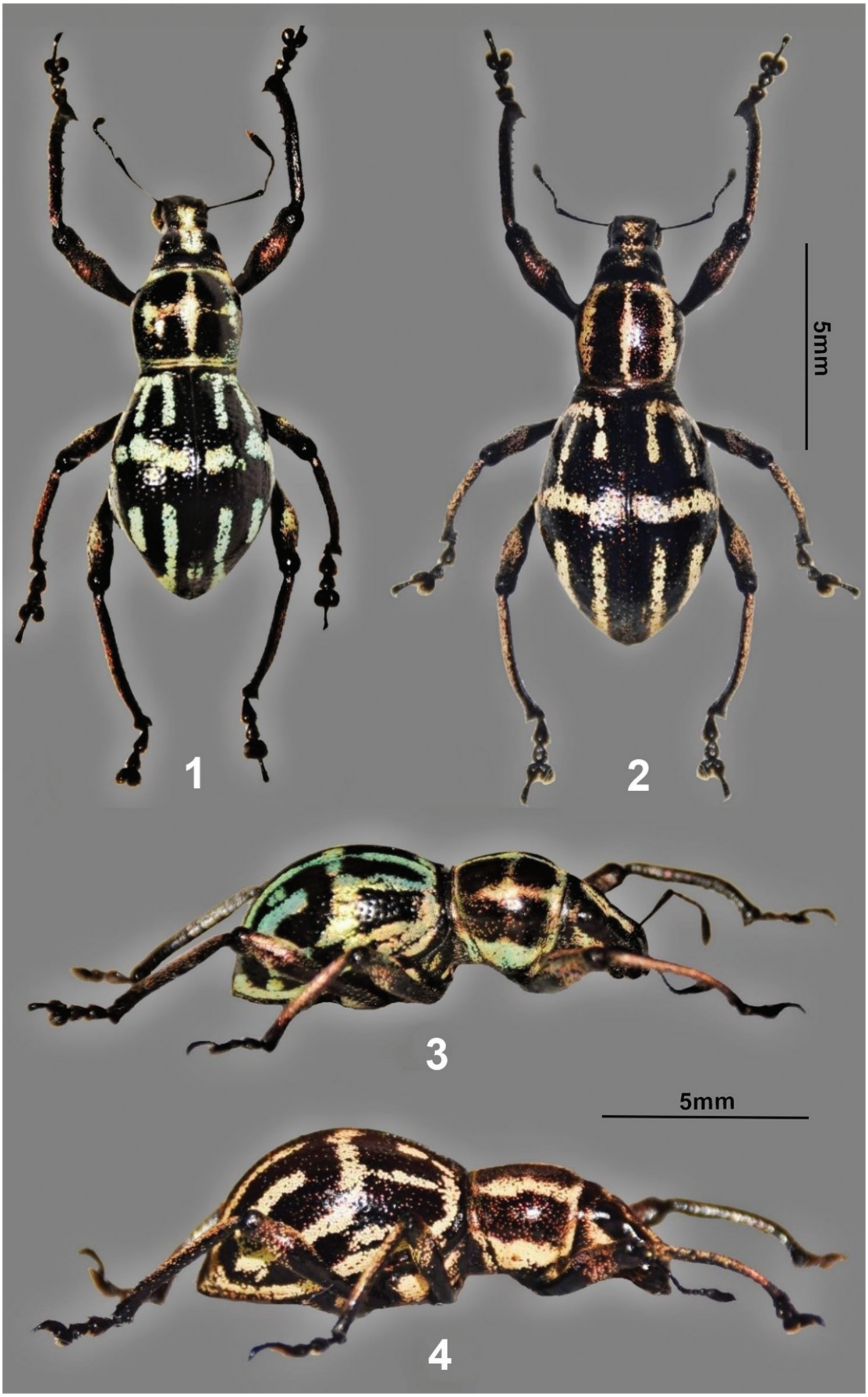
Material. ***Holotype*** (Fig. 1A, B), male: Philippines – Mindanao / Mt. Kitanglad Range Natural Park/ Bukidnon / July, 2018 / coll. Medina. Presently in UMCRC, it will be deposited in Philippine National Museum of Natural History (PNMNH) formerly Philippine National Museum (PNM). ***Paratypes.*** 3♂♂, 1 ♀: Philippines - Mindanao / Mt. Kitanglad Range Natural Park/ Bukidnon / V-VII.2018 / coll. Medina; 1 ♂: Philippines- Mindanao / Marilog District / Davao City / June, 2018 / coll. Van Dam; 1 ♀: Mindanao Marilog District / Davao City / June, 2018, presently deposited in UMCRC; 22 ♂♂, 16 ♀♀: Philippines – Mindanao / Mt. Katapagan / (Davao del Sur Province) / IX-X.2012 / coll. Bollino; 1 ♂: Philippines - Mindanao / Katapagan / (Davao del Sur Province) / IX-XI.2016 / coll. Bollino; 2 ♂♂, 1 ♀: Philippines - Mindanao / Buda Brgy. / (Davao City, Davao del Sur) / V.2017 / coll. Bollino; 4 ♂♂, 1 ♀: Philippines - Mindanao / Mt. Apo / XI 2010 / coll. Bollino, all in MBLI.

Diagnosis. *Metapocyrtus kitangladensis* sp. n. is similar in general appearance to *Metapocyrtus perpulcheroides* Schultze, 1923 which was described from Kalinga Province, Luzon Island. In addition to the unique scaly markings on the pronotum and elytra of *Metapocyrtus kitangladensis* sp. n., the new species differs from *Metapocyrtus perpulcheroides* for having a subglobular pronotum, a less prominent transverse groove on rostrum, and having unique male and female genital structures.

Description. Dimensions: LB: 10.5–11.5 (holotype 10.5 mm). LR: 1.5–2.0 (1.7 mm). WR: 1.4–1.7 (1.5 mm). LP: 3.5–3.8 (3.6 mm). WP: 3.9–4.0 (3.9 mm). LE: 7.5–8.1 (7.5 mm). WE: 5.2–5.6 (5.4 mm). N=5 for all measurements.

Body black; pronotum, head and legs coppery black, weakly lustrous with sparse pale yellow, green and violet scales; body surface weakly lustrous with golden yellow, orange, greenish, turquoise and bluish scales. Eyes, antennae, and tarsomeres black.

Head with the following markings: a) dense elongated pale orange and turquoise stripes under eye on each lateral side diminishing towards apex of rostrum, and b) elongated stripe of yellow, green, and orange scales from vertex to basal half of the rostrum at times confluent with lateral stripe. Rostrum rugose, longer than wide with



Figures 1–4. *Metapocyrtus kitangladensis* sp.n. **1** male holotype, dorsal view **2** female, dorsal view **3** ditto, lateral view **4** ditto, lateral view.

minute light yellow setae and long yellow hairs towards the apex; dorso-apically slightly convex; prominent transverse basal groove, and longitudinal median groove forming a cross shape. Front with deep depression covered with dense scales. Eyes small and weakly convex. Antennal scape as long as the funicle plus club, with flattened hairs and sparse scales. Funicular segments I and II almost of the same length, three times longer than wide; segments III–VII as long as wide; club subellipsoidal, nearly three times longer than wide.

Pronotum subglobular, widest at middle, weakly convex, glabrous, with very minute and sparse punctures; thin strips of golden yellow to turquoise scales at the anterior, posterior and latero-ventral margin; three thin longitudinal stripes dorsally at times with transverse stripe intersecting the median stripe forming a cross.

Elytra with regular weakly striate-punctate intervals with sparse scales, moderately convex, with few short hairs. Each elytron with the following golden yellow and turquoise to light blue markings: 1) three longitudinal stripes from behind base at interval II, IV and VI which may or may not be reach median transverse stripe; stripes confluent at base; 2) stripe on lateral margin extending from base towards the apex of the elytra; 3) thin transverse band in the middle part of elytra, medially; 4) thin longitudinal stripe between interval I and II extending from middle of the elytra to apex and confluent with lateral margin stripe, may or may not be connected with median transverse stripe; 5) apical triangular stripe extending from apex of each elytron to apical third, laterally connected with median marking. Underside weakly lustrous, pubescent with pale yellow and green scales on the basal margin of the pronotum and latero-ventral side of ventrites I and II and sometimes including ventrites III and IV.

Legs with strongly clavate femora. Femora covered with short hairs and sparse scales along posterior margins. Each tibia fringed with pubescence along internal margin, sparsely mixed with short hairs. Apical part of femora with dense orange and violet scales and short setae. Tibiae with sparse scales and short setae, with toothed projections along internal edge.

Tarsomeres covered by sparse pubescence.

Male genitalia as shown in Figures 5–7.

Everted endophallus as shown in Figures 11, 12.

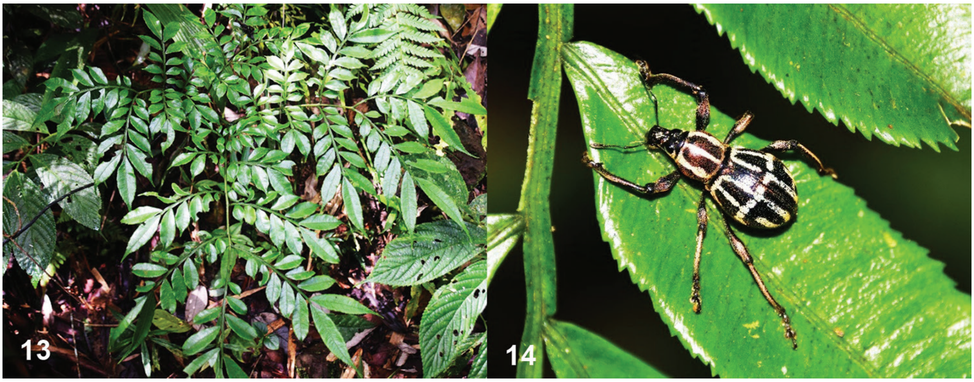
Etymology. The new species is named after Mt Kitanglad Range Natural Park (MKRNP), the park where the holotype was collected. It is a Latinized adjective.

Notes on the ecology and distribution

Metapocyrtus kitangladensis sp. n. was collected in the secondary forest of Barangay Cinchona, MKRNP as well as the degraded secondary forests of Marilog District, both at around 1200 m a.s.l. The new species was mostly collected on the leaves of *Angiopteris evecta* (G.Forst.) Hoffm. (Marattiaceae) in the sloppy trail towards the forest edge (Fig. 13). It was noted that the young leaves of this fern are the main food source of this species. In Marilog District, the specimens were collected in the vegetation along the trails of Epol Falls and forest edges of Mt Malambo. All specimens collected from Marilog and MKRNP were collected in open areas often in ridges and along the streams.

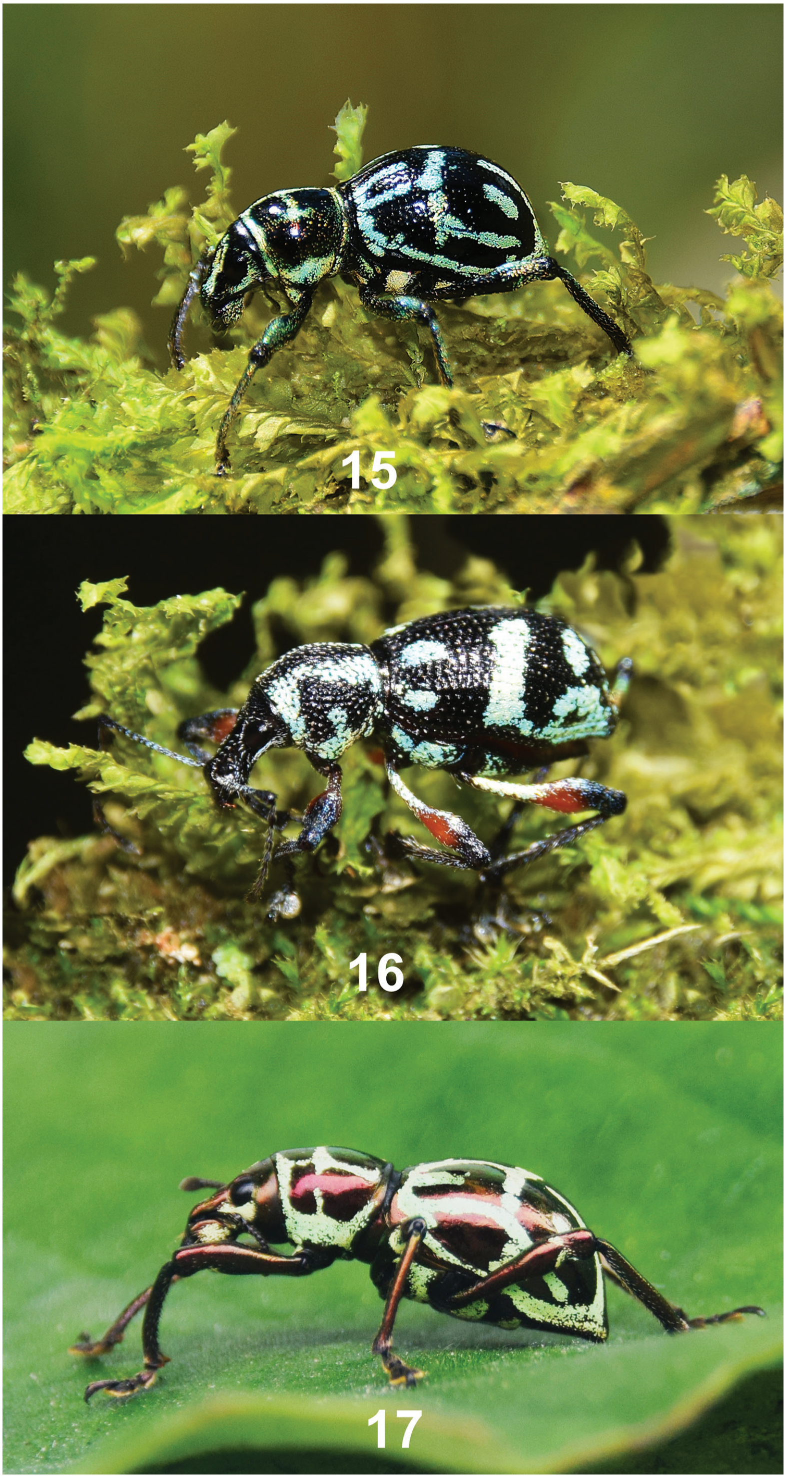
Figures 5–10. Male genitalia and female terminalia of *Metapocyrtus kitangladensis* sp. n. **5** aedeagus, ventral view **6** ditto, lateral view **7** sternite IX, dorsal view **8** sternite VIII, ventral view **9** ovipositor, dorsal view **10** spermatheca.

Figures 11, 12. *Metapocyrtus kitangladensis* sp.n. **11** everted endophallus, lateral view **12** everted endophallus, dorsal view (photographs by Dr Maurizio Bollino).



Figures 13, 14. 13 *Angiopteris evecta*, food plant of *M.kitangladensis* sp. n. **14** *M.kitangladensis* sp. n. in its natural habitat.

Metapocyrtus kitangladensis sp. n. has been recorded from MKRNP, Mt Dulangdulang, Mt Kiamo (Bukidnon), Marilog District, Barangay Buda, and Davao del Sur (Davao region) in Mindanao Island. These localities belong to Central Mindanao biogeographic region (Dickerson et al. 1928). Mindanao has five known biogeographic regions namely Eastern Mindanao, Central Mindanao, Western Mindanao, Southwestern and Northwestern Mindanao biogeographic regions (Dickerson et al. 1928). Based on collection and field observation, Bukidnon and Marilog's Pachyrhynchini fauna shows hefty similarities. Some of the notable species recently found in Marilog District which are also found abundantly in Bukidnon are *Pachyrhynchus sulphureomaculatus* Schultze, 1922, *Pachyrhynchus erichsoni* GR Waterhouse, 1841, *Pachyrhynchus speciosus* GR Waterhouse, 1841, *Metapocyrtus lanusinus* Schultze, 1922, and *Metapocyrtus insulanus* Schultze, 1919, among others. The trend of faunistic composition of Pachyrhynchini between Marilog and Bukidnon seem to follow



Figures 15–17. 15 *Metapocyrtus kitangladensis* sp. n. **16** *Coptorhynchus* sp. **17** *Pachyrhynchus cumingii* GR Waterhouse, 1841.

this biogeographical demarcation which can be attributed to the flightless nature of these weevils with very limited dispersal capabilities. However, more data are needed to confirm this hypothesis.

Notes on the mimicry with *Pachyrhynchus cumingii*

The new species *Metapocyrtus kitangladensis* sp. n. (Fig. 15) has very similar elytral markings with *Coptorhynchus* sp. (Fig. 16) and *Pachyrhynchus cumingii* (Fig. 17), which are found in the same locality. This is the first mimic recorded for *Pachyrhynchus cumingii*. The mimicry between the three species can be considered as Mullerian since all species share similar defense mechanism which is the hardness of their elytra. This is one among the many new mimic records for Mindanao Island. *Pachyrhynchus* Germar, 1823, *Metapocyrtus* and several other weevils has been known to exhibit such mimicry, but it has been barely studied and many new mimics awaits discovery.

Key to the *Pachyrhynchus cumingii* mimicry complex

1 Rostrum distinctly elongate, obviously longer than frons, antennal scrobes laterally oriented .... ***Coptorhynchus* sp.**

– Rostrum of medium length, antennal scrobes laterally curving downwards in front of eyes at sides of rostrum **2**

2 Head without a distinct transverse groove between frons and rostrum, apical half of rostrum dorsally swollen, and antennal scape not reaching hind margin of eye .... ***Pachyrhynchus cumingii***

– Head with a distinct transverse groove between forehead and rostrum, Apical half of rostrum not swollen dorsally, and antennal scape reaching beyond the hind margin of eye .... ***Metapocyrtus kitangladensis* sp. n.**

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RESEARCH ARTICLE

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Taxonomic review of the mantidfly genus *Nolima* Navás (Neuroptera, Mantispidae, Calomantispinae)

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Abstract

The mantidfly genus *Nolima* Navás, 1914 (Neuroptera, Mantispidae, Calomantispinae) is herein revised. *Nolima* is endemic to the New World, ranging from the southwestern United States south to Costa Rica. *Nolima infensa* Navás, *N. pinal* Rehn, and *N. victor* Navás are redescribed, while the new species *Nolima costaricensis* Reynoso & Contreras, **sp. nov.** is described from Costa Rica. The species *N. dine* Rehn and *N. kantsi* Rehn are synonymized with *N. pinal*. Additionally, the species *N. praeliator* Navás and *N. pugnax* Navás are synonymized with *N. victor*, for which a lectotype is designated. New distribution records are provided from Guatemala and Honduras for *Nolima infensa*, the state of Nevada in western United States for *N. pinal*, and the state of Puebla in central Mexico for *N. victor*. An illustrated key and a distribution map are presented.

Keywords

Lacewings, mantispids, New World, new species, taxonomy

Introduction

Mantidflies, mantid lacewings, or mantispids (Mantispidae) are distinctive within the Neuroptera because of their raptorial forelegs (Fig. 1), which are convergent in some Rhachiberothidae. The taxonomic knowledge of the New World mantispid fauna is still fragmentary (Ohl 2005). Noteworthy previous contributions are a genus-level revision by Penny (1982) and the works by Hoffman (1992, 2002) on the subfam-

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Figure 1. Habitus of a male of *Nolima victor* (abdomen removed).

ily Mantispinae. In the Nearctic, Rehn (1939) revised the genus *Plega* Navás. In the Neotropics, Penny (1982) and Penny and da Costa (1983) studied the fauna of Brazil. Most recently, Reynoso-Velasco and Contreras-Ramos (2008) studied the Mexican fauna of Mantispidae, Machado and Rafael (2010) treated the Brazilian species previously placed in *Mantispa* Illiger, and Ardila-Camacho and García (2015) and Ardila-Camacho et al. (2018) studied the Mantispidae from Colombia and Panama. Additionally, Hoffman et al. (2017) treated the Antillean fauna of Mantispidae.

Four subfamilies of mantidflies are currently recognized: Calomantispinae, Drepanicinae, Mantispinae, and Symphrasinae (Lambkin 1986a, b, Ohl 2004). *Calomantispa* Banks and *Nolima* Navás are generally taken to constitute the subfamily Calomantispinae. As originally proposed by Lambkin (1986a), the subfamily Symphrasinae was the sister group of the clade including Calomantispinae, Drepanicinae, and Mantispinae (Fig. 2). Willman (1990) found the same topology in his study on the phylogenetic relationships between Rhachiberothinae and Mantispidae. Lambkin (1986a) stated that Calomantispinae (*Calomantispa* + *Nolima*) was more closely related to Mantispinae than to Drepanicinae; this scheme was supported in the study by Liu et al. (2015), where the authors included information from DNA sequences and morphological characters. A recent study on the evolution of Neuropterida based on genomic data (Winterton et al. 2018) recovered a paraphyletic Mantispidae, where Calomantispinae was placed sister to Drepanicinae, together forming a clade sister to Mantispinae.

This study consists of the taxonomic revision of the New World genus *Nolima* Navás, which previously included seven nominal species and is the sole representative of the subfamily Calomantispinae in this part of the world. The distribution of the species in this genus ranges from southern United States south to Costa Rica in Central America. The original descriptions of the species in *Nolima* were mainly based on the pigmentation pattern on the head and prothorax. We noticed that those patterns were not consistent and of little help for species identification; for that reason, we decided to study the group and explore other characters (e.g., male genital structures) to better circumscribe the different species.

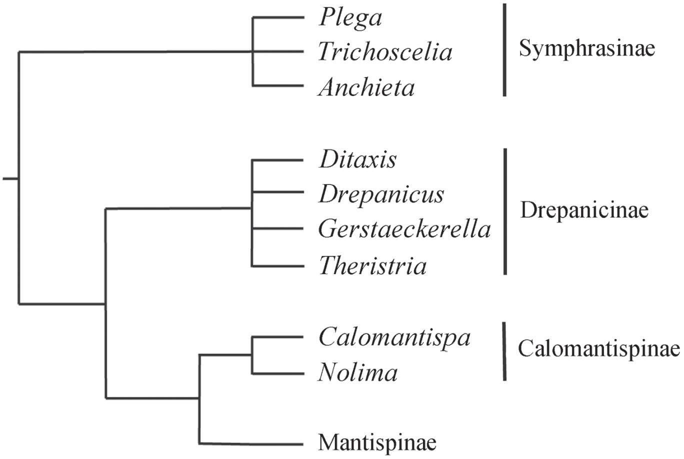

Figure 2. Phylogenetic relationships among subfamilies in Mantispidae (modified from Lambkin 1986a).

Materials and methods

Specimen sources

The specimens examined during this study, including species from other genera of Mantispidae (Table 1) that were used to establish the diagnostic features of the genus *Nolima*, were obtained through museum loans. The majority of type specimens were studied in situ at their depository collections. Status and validity of the species names were corroborated on the Neuropterida Species of the World Catalog (Oswald 2018). Information given in brackets [ ] did not appear on the specimen labels nor was no provided in publications, but was inferred from available data or represents corrections to misspellings on the labels. Specimens were obtained on loan from the following collections:

ANIC	Australian National Insect Collection (Canberra, Australia)
NHMUK	Natural History Museum (London, England)
CAS	California Academy of Sciences (San Francisco, United States)
CNIN	Colección Nacional de Insectos, Universidad Nacional Autónoma de México (Mexico City, Mexico)
EBCH	Estación de Biología Chamela, Universidad Nacional Autónoma de México, (San Patricio, Mexico)
ECOSUR	El Colegio de la Frontera Sur (San Cristóbal de las Casas, Mexico)
FSCA	Florida State Collection of Arthropods (Gainesville, United States)
INBIO	Instituto Nacional de Biodiversidad (Santo Domingo de Heredia, Costa Rica)
MCZ	Museum of Comparative Zoology, Harvard University (Cambridge, United States)
MNHN	Muséum national d'Histoire naturelle (Paris, France)

QDPI	Queensland Department of Primary Industries (Brisbane, Australia)
SDMC	San Diego Natural History Museum (San Diego, United States)
SRSU	Sul Ross State University (Alpine, United States)
TAMU	Texas A&M University (College Station, United States)
USNM	United States National Museum of Natural History (Washington DC, United States)
ZMB	Museum für Naturkunde, Humboldt-Universität (Berlin, Germany)

Dissecting techniques and illustration

Pinned specimens were placed in an airtight chamber with a solution of water and phenol for rehydration for approximately 24 hours. The abdomen of males was dissected and placed in 10% KOH for approximately 10 hours at room temperature, then rinsed in distilled water. The abdomen of each females was treated similarly, except that it was stained with Chlorazol Black E (in ethanol) to enhance contrast of the internal structures. The dye was injected with a syringe into the abdominal cavity for approximately 10 seconds, then the dissected abdomen was transferred to 70% ethanol and the dye was rinsed out. For observation, the abdomen was placed in a Petri dish with glycerin.

Table 1. Comparative taxa examined to establish diagnostic features of the genus *Nolima* Navás.

Taxon	Distribution	Sex / Repository
Calomantispinae		
Calomantispa picta Stitz	Australia: Australian Capital Territory: Canberra.	1♂, 1♀ / ANIC
Calomantispa spectabilis Banks	Australia: Queensland: Herberton.	1♂ / ANIC
Calomantispa venusta Lambkin	Australia: Australian Capital Territory: Mount Gingera.	1♀ / ANIC
	Australia: Australian Capital Territory: Lee's Spring.	1♂ / ANIC
	Australia: New South Wales: South Black Range.	1♀ / QDPI
Drepanicinae		
Drepanicus chrysopinus Brauer	Chile: Los Ríos: Valdivia.	1♂, 1♀ / CAS
Gerstaeckerella chilensis (Hagen)	Chile: Metropolitana de Santiago: Til-Til, Santa Maria.	1♂ / CAS
Theristria stigma (Esben-Petersen)	Australia: Queensland: West Claudie River.	1♀ / QDPI
Theristria storeyi Lambkin	Australia: Queensland: Kennedy River.	1♂ / QDPI
Mantispinae		
Climaciella brunnea (Say)	Mexico: Veracruz: San Andrés Tuxtla.	1♀ / CNIN
	Mexico: Veracruz: Santiago Tuxtla.	1♂ / CNIN
Dicromantispa interrupta (Say)	Mexico: Jalisco: Estación de Biología Chamela.	1♂ / CNIN
Dicromantispa sayi (Banks)	Mexico: Chihuahua: El Jaquex.	1♀ / CNIN
Zeugomantispa virescens (Rambur)	Mexico: San Luis Potosí: El Limoncito.	1♂ / CNIN
Symphrasinae		
Plega dactylota Rehn	México: Baja California Sur.	1♂ / CNIN
Trichoscelia sp. 1	Mexico: Sonora: Cerro Verde.	1♂ / CNIN

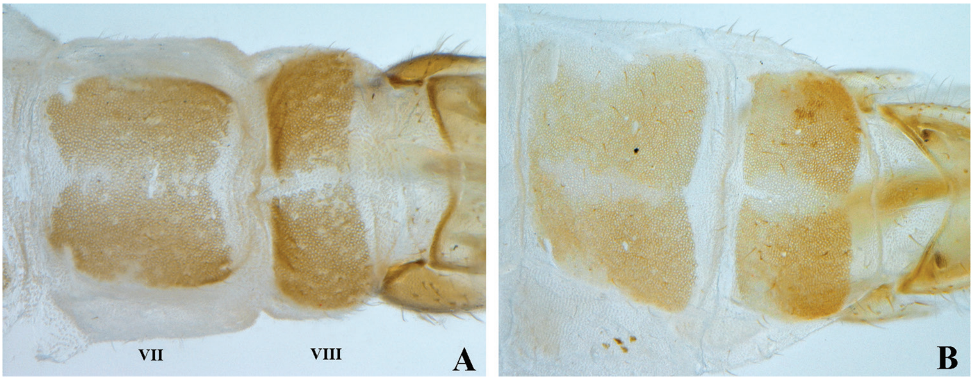

Figure 3. Abdominal terga VII–VIII of *Nolima* species. **A** *Nolima infensa* **B** *Nolima victor*.

A Zeiss Stemi SV11 stereomicroscope with 10× eyepieces and 1.0× and 2.5× main objectives (with a zoom magnifying range of 0.6–6.6×) was used for morphological examination. After examination, the dissected abdomens were stored in genitalia microvials with glycerin and pinned under the corresponding specimen. Pencil drawings were elaborated with a camera lucida attached to the stereomicroscope, which were later inked and scanned. Digital images were obtained by use of a Nikon SMZ25 stereomicroscope coupled with the Nikon NIS-Elements Imaging Software. Final figures were prepared with Photoshop CS5 (Adobe Systems Inc., San Jose, California).

Morphological terminology

This study mainly follows Lambkin (1986a, b). In males, the abdominal terga and sterna present sclerotized circular (Fig. 3A) or polygonal structures (Fig. 3B) that we consider are cuticular depressions, but lack a formal name. Such cuticular condition is a reliable diagnostic feature and in the text is simply referred to as circular or polygonal structures. We consider these structures not to be homologous to the abdominal pores of Mantispinae. The term gonarcal membrane is used for the membrane located between the base of the gonarcus, the ninth gonocoxite, and the pseudopenis of males. Females present a protuberant ovoid sclerotized structure associated to the spermatheca that may be a gland, so it is referred to as an accessory gland.

Diagnostic characters

External and internal structures of males and females where evaluated to serve as potential diagnostic features. The morphology of the female genitalia was found to be conserved and similar among the specimens examined. For that reason, only a generic description of the structures is provided. Attributes related to the presence and position of bristle-bearing chalazae and the pigmentation pattern on the forelegs of both sexes were found to be informative, although the most reliable diagnostic features were related to characteristics of the male abdominal cuticle and genital structures.

Systematics

The genus *Nolima* was erected (Navás 1914) for the species *Nolima victor* and *N. praeliator*, both from the Mexican state of Guerrero. In the same work, Navás (1914) created the tribe Nolimini to place the newly created genus. Later, *N. infensa* was described from Costa Rica (Navás 1924) and the species *N. dine* (Arizona), *N. kantsi* (Texas), and *N. pinal* (Arizona) were described from southwestern United States (Rehn 1939). Navás (1914) also created the genus *Bellarminus*, with the Central American (Guatemala) *Bellarminus pugnax* as the type species. Thereafter, Penny (1982) synonymized the genus *Bellarminus* under *Nolima*, so that *N. pugnax* (Navás) became the seventh nominal species in *Nolima*.

As proposed by Lambkin (1986a), the genera *Nolima* and *Calomantispa*, this latter endemic to Australia (Ohl 2004), are included in the subfamily Calomantispinae. This relationship was based on the unique shared characteristics of the bifid foretarsal claws, as well as the scoop-like ninth sternum of the male, which extends posteriorly beyond the ectoprocts. We consider *Nolima* to be monophyletic based on the forewing with a short subcostal space (long in *Calomantispa*), the female spermatheca with a distal accessory gland (proximal in *Calomantispa*), and the male mediuncus with the apex strongly produced posteriorly (not produced or only slightly produced in *Calomantispa*).

Genus *Nolima* Navás, 1914

Nolima Navás, 1914: 100–101 (original description, gender: feminine, etymology: anagram of Molina, type species by original designation: *Nolima victor*); Rehn 1939: 238, 256 (key, description); Acker 1960: 29, 92–93 (species list, illustrations); Penny 1977: 36 (species list); MacLeod and Redborg 1982: 39 (biology); Penny 1982: 212–213 (synonymy); Lambkin 1986a: 3, 9, 15–20, 28, 30, 84 (species list, systematics); Willman 1990: 261 (systematics); Oswald and Penny 1991: 45 (genera list); Henry et al. 1992: 439, 449 (key, species list); Hoffman 2002: 251–252 (key, species list); Ohl 2004: 157–158 (species list); Ohl 2005: 80 (distribution); Reynoso-Velasco and Contreras-Ramos 2008: 704–705, 708 (key, species list); Reynoso-Velasco and Contreras-Ramos 2009: 710 (species list); Reynoso-Velasco and Contreras-Ramos 2010: 270 (distribution); Cancino-López et al. 2015: 201–202, 205 (genera list, species list, systematics); Liu et al. 2015: 184, 194, 201, 204 (genera list, systematics, distribution).

Bellarminus Navás, 1914: 102–103 (original description, gender: masculine, etymology: after the Italian cardinal Roberto Bellarmino, type species by original designation: *Bellarminus pugnax*); Penny 1977: 34 (species list); Penny 1982: 212–213 (synonymy); Oswald and Penny 1991: 11, 45 (synonymy); Ohl 2004: 157 (synonymy).

Diagnosis. The genus *Nolima* can be distinguished by the following combination of characters (character states in parentheses are generally exhibited by other mantispid genera): a) Sc comes in contact with C near the middle of costal margin and distal to the base of pterostigma on the forewing (at apex of 2/3 of costal margin and proximal to pterostigma), b) M diverging from R distal to 1m-cu on the forewing (proximal to 1m-cu), c) abdominal terga and sterna or only terga of the male with circular or polygonal structures, respectively, d) male mediuncus apex strongly projecting posteriorly and deeply bifid (shallowly indented), and e) female spermatheca with accessory gland (generally without accessory gland, but if present then associated to copulatory bursa, e.g., species of *Calomantispa*).

Description. *General*. Coloration pale yellow, with dark brown pigmentation as stripes or marks in specific areas (detailed in the text below).

Head. Hypognathous. Vertex with a rhomboid protuberance covering nearly its entire area; vertex marking M-shaped, extending behind antennal sockets, where can be bifurcated, if bifurcated then one branch extends posteriorly, parallel to anterior ocular margin, additional branch generally extends anteriorly on frontogenal furrow, or extends on frontogenal and epistomal furrows; vertex with a pair of irregular marks originating posteromedially, extending anteriorly along the coronal suture, then angled at 45° toward anterior ocular margin, reaching the rhomboid protuberance, sometimes converging with upper part of M-shaped mark. Frons generally with pair of semicircular marks. Clypeus and labrum, each sometimes with a medial semicircular mark. Antennal flagellomeres dark brown, as long as wide in basal third of flagellum, twice as long as wide in distal two thirds in frontal view. Mandibles with pigmentation on inner and outer edges.

Thorax. Prothorax straight in lateral view, with pigmentation, bristle-bearing chalazae on pronotum and anterolateral and anteroventral areas, a pair of pale spots anterolaterally in dorsal view. Mesothorax with conspicuous mesoscutal and scutoscutellar sutures; scutum generally with two longitudinal stripes anterior to suture and four posterior to suture, two medial and two lateral; scutellum with color pattern variable; pleural area generally with pigmentation. Metathorax with mesoscutal suture obsolete, scutoscutellar suture conspicuous; scutum generally with an M-shaped mark medially, a longitudinal stripe on each side of medial mark. Forecoxa with bristle-bearing chalazae. Forefemur with dorsal margin slightly convex, midsection in dorsal view approximately twice as wide as apex; longitudinal row of spines on ventral side weakly compressed laterally; tibia arched, two thirds as long as femur, with ventral carina; first tarsomere more than twice as long as second. Middle and hindleg not modified, finely and evenly setose. Forewing (Fig. 4A) with costal margin convex above costal cells, almost straight to distal margin of pterostigma; Sc fusing with C distally, above Rs stem; pterostigma semicircular, reddish-brown, no hyaline space between pterostigma and R_1; M free basally, diverging from R distal to 1m-cu; 1m-cu slightly inclined; Cu branching reduced. Hindwing (Fig. 4B) with costal margin concave proximally and convex distally above costal cell, almost straight to distal margin of pterostigma; Sc fusing with C posterior to Rs stem; M not fused with R; CuP absent.

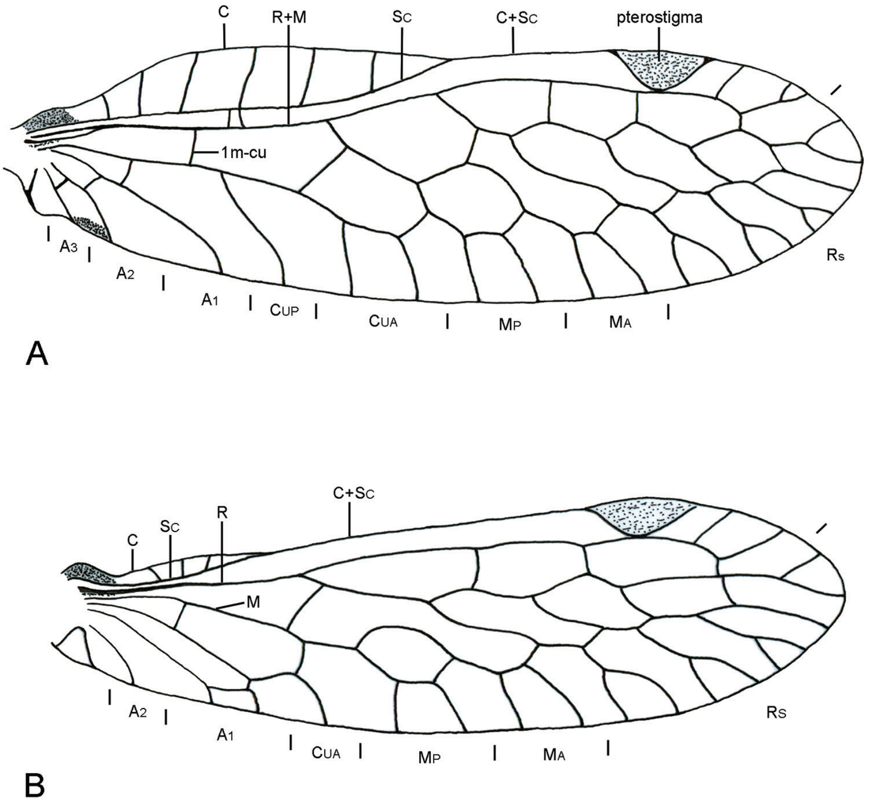

Figure 4. Wing venation of *Nolima pinal*. **A** forewing **B** hindwing.

Abdomen, *male* (Fig. 5A, B). Smaller than wing length at rest; terga and sterna I–VIII with circular structures barely touching each other (specially along midline) or terga I–VIII with polygonal structures in close contact to each other; terga and sterna I–VIII unfused laterally; tergum IX inconspicuous, narrow, almost reaching base of sternum IX; sternum IX elongate, posteriorly projected, scoop-like, with apodeme along basal margin. Ectoprocts with dorsal margin straight to strongly convex in lateral view, arched apodeme along basal margin, in dorsal view; ectoprocts fused dorsally, apex bilobed in dorsal view; apex of ectoprocts with microsetose membranous area between lobes, variably sclerotized; callus cerci not protuberant, obsolete. Gonarcus broadly or narrowly rounded in dorsal view, strongly sclerotized, apical process extending posterodorsally; gonarcal membrane with small tubercles dorsolaterally; gonarcus and gonocoxite IX associated basally, generally with laterally compressed apodemes extending anteriorly. Gonocoxite IX with posteroventrally inclined T-shape, small spines on apical and posteroapical surfaces. Mediuncus with obsolete to well-developed oval-shaped base, bifid apically; mediuncus apical processes strongly produced posteriorly, flanking pseudopenis. Pseudopenis sclerotized, lanceolate, produced further posteriorly than mediuncus processes. Hypandrium internum triangular in ventral view, longitudinal keel along midline.

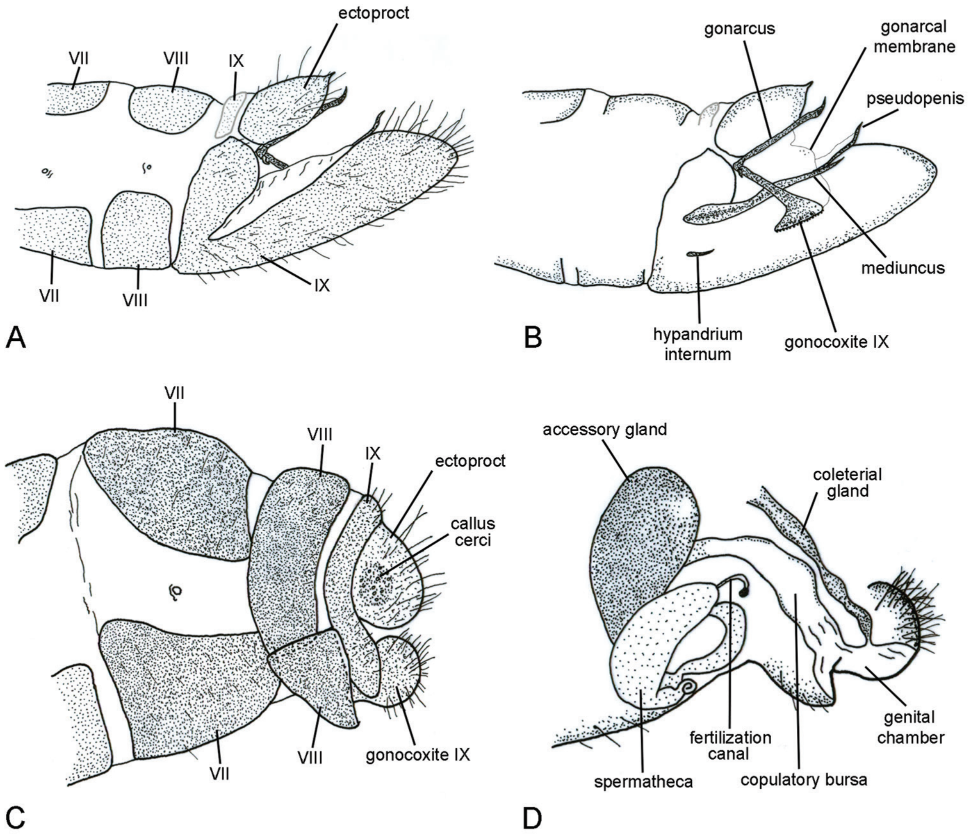

Figure 5. Last abdominal segments of *Nolima victor*, lateral. **A** male external morphology **B** male internal morphology **C** female external morphology **D** female internal morphology.

Abdomen, female (Fig. 5C, D). Size similar to male; terga and sterna I–VIII without circular or polygonal structures; terga and sterna I–VII unfused laterally; tergum VIII narrow, ventrally produced, in contact with sternum VIII forming a ring; sternum VIII posteriorly produced, covering gonapophyses IX; tergum IX narrow, ventrally produced, not fused ventrally; sternum IX absent. Ectoprocts with margin convex in lateral view, apodeme along basal margin; ectoprocts fused dorsally, apex bilobed in dorsal view; apex of ectoprocts with membranous area between lobes; callus cerci not protuberant, conspicuous. Gonapophyses IX sclerotized, concave. Gonocoxite IX ovoid in lateral view, smaller than ectoproct. Genital chamber a membranous sac with several folds, located from posterior edge of sternum VIII to medial part of gonocoxite IX. Colleterial gland emerging from dorsal part of genital chamber, extending anterodorsally. Copulatory bursa dorsoventrally flattened, strongly sclerotized, narrowing anteriorly. Spermatheca lightly sclerotized, diverticulum in first third, with ovoid accessory gland. Fertilization canal long, narrow, apex bulbous.

Distribution. This genus is endemic to the New World, ranging from southwestern United States to Costa Rica (Ohl 2004), including Guatemala, Honduras, and

Mexico. Based on material examined, the species *N. pinal* and *N. victor* inhabit mountainous regions above 1500 m, primarily in areas with oak (*Quercus*) and pine (*Pinus*) vegetation. *Nolima infensa* and *Nolima costaricensis* sp. nov. occur in more tropical latitudes, from lowlands to mid-elevations.

Biology and natural history. Little is known about this topic; the available information is related to the cytogenetics and larval diet of *Nolima pinal*.

Etymology. The word *Nolima* is an anagram of Molina, in honor of Luis de Molina (1535–1600), a Jesuit priest who was born in the city of Cuenca, Spain (Navás 1914). The gender of this genus is considered feminine (Ohl 2004, JD Oswald, Texas A&M University, pers. comm.).

Key to species of *Nolima* Navás

Most reliable diagnostic features are related to the external and internal genitalic morphology of males. Other traits (e.g., pigmentation, chalazae) are instructive for males and females but reliance on them alone may lead to misidentification.

1 Forecoxa with bristle-bearing chalazae on ventral, lateral (basally), and dorsal surfaces; chalazae bases generally surrounded with dark brown pigmentation (Figs 9C, 10C).. **2**

– Forecoxa with bristle-bearing chalazae only on ventral surface; chalazae bases not pigmented (Figs 6C, 8C).. **3**

2 Forefemur dorsal surface with conspicuous dark brown circular marks around bases of chalazae (Fig. 10C); prothorax ventral surface with dark brown longitudinal stripe; male abdominal terga I–VIII with polygonal structures (Fig. 10D); male ectoprocts with membrane between apices sclerotized (Fig. 10F, G); male ectoprocts with dorsal margin straight in lateral view (Fig. 10F).. ***Nolima victor* Navás**

– Forefemur dorsal surface without dark brown marks around bases of chalazae (Fig. 9C); prothorax ventral surface without longitudinal stripe; male abdominal terga and sterna I–VIII with circular structures (Fig. 9D); male ectoprocts with membrane between apices generally not sclerotized (Fig. 9F, G); male ectoprocts with dorsal margin slightly convex in lateral view (Fig. 9F).. ***Nolima pinal* Rehn**

3 Male ectoprocts with dorsal margin strongly convex in lateral view (Fig. 8F); male ectoprocts each with a cluster of long bristles anteromedially (Fig. 8F, G); pseudopenis conspicuously narrowing apically (Fig. 8I).. ***Nolima infensa* Navás**

– Male ectoprocts with dorsal margin slightly convex in lateral view (Fig. 6F); male ectoprocts with fine setae evenly arranged over entire surface (Fig. 6F, G); pseudopenis not narrowing apically (Fig. 6I)...... ***Nolima costaricensis* sp. nov.**

Nolima costaricensis **Reynoso & Contreras, sp. nov.**

http://zoobank.org/69F950F4-D1E8-472C-9ACC-C538FCDF0688
Figs 6, 7

Diagnosis. It differs from other species in the genus as follows: a) male sterna I–VIII with circular structures only laterally (Fig. 6E), b) male ectoprocts with membrane between apices not sclerotized, c) male ectoprocts with dorsal margin slightly convex (Fig. 6E, F), d) male ectoprocts with scattered long and short setae (Fig. 6E-G), e) gonarcus narrowly rounded (Fig. 6H), and f) pseudopenis not slender apically (Fig. 6I).

Note. This new species is described based on a single male specimen collected in southeastern Costa Rica, which unfortunately had lost pigmentation; therefore we were not able to specifically evaluate some of the characteristic markings.

Description. Male. *Head*. Vertex with M-shaped mark with lower arms getting wider towards anterior ocular margin (Fig 6A); vertex irregular marks that originate posteromedially converging with upper part of M-shaped mark (Fig. 6A). Frons with a pair of large irregular marks laterally (Fig. 6A). Antennae 34-segmented; scape with indistinct pigmentation on posterior surface; pedicel with pigmentation on posterior surface.

Thorax. Prothorax with pigmentation on entire surface of pronotum (Fig. 6B). Forecoxa with bristle-bearing chalazae only on ventral surface, fine dark setae on most of remaining surface (Fig. 6C). Forefemur with three marks on lateral surface (Fig. 6C), mesal and dorsal surfaces without marks. Foretibia with two small dorsolateral marks on basal half (Fig. 6C). Middle and hind leg with fine dark setae.

Abdomen. Terga and lateral surface of sterna I–VIII with circular structures, not in contact to each other (Fig. 6D), microsetae in space between circular structures. Sternum IX with setae on entire surface, apex narrowly rounded in lateral view (Fig. 6E). Ectoprocts with dorsal margin slightly convex in lateral view; long and short setae scattered (Fig. 6F, G); membrane between apexes of ectoprocts not sclerotized, posteriorly produced (Fig. 6F), broadly rounded in dorsal view (Fig. 6G); basal apodeme of ectoprocts narrow, slightly sclerotized (Fig. 6G). Callus cerci obsolete. Gonarcus frail, narrowly rounded (Fig. 6H). Gonocoxite IX with base almost straight (Fig. 6I). Pseudopenis not slender apically (Fig. 6I).

Variation. It could not be assessed because only the holotype specimen is known.

Biology and natural history. Based on the collecting datum from the single specimen examined, adults of the species may be active during spring.

Etymology. The species name is dedicated to Costa Rica, the only country from which this species is currently known.

Repository. The holotype is housed at the INBIO.

Type locality. Costa Rica: Puntarenas, Parque Internacional La Amistad, Sector Altamira.

Distribution. This species is only known from its type locality, which is in the southeastern part of Costa Rica (Fig. 7), on the Talamanca range (1300–1400 meters).

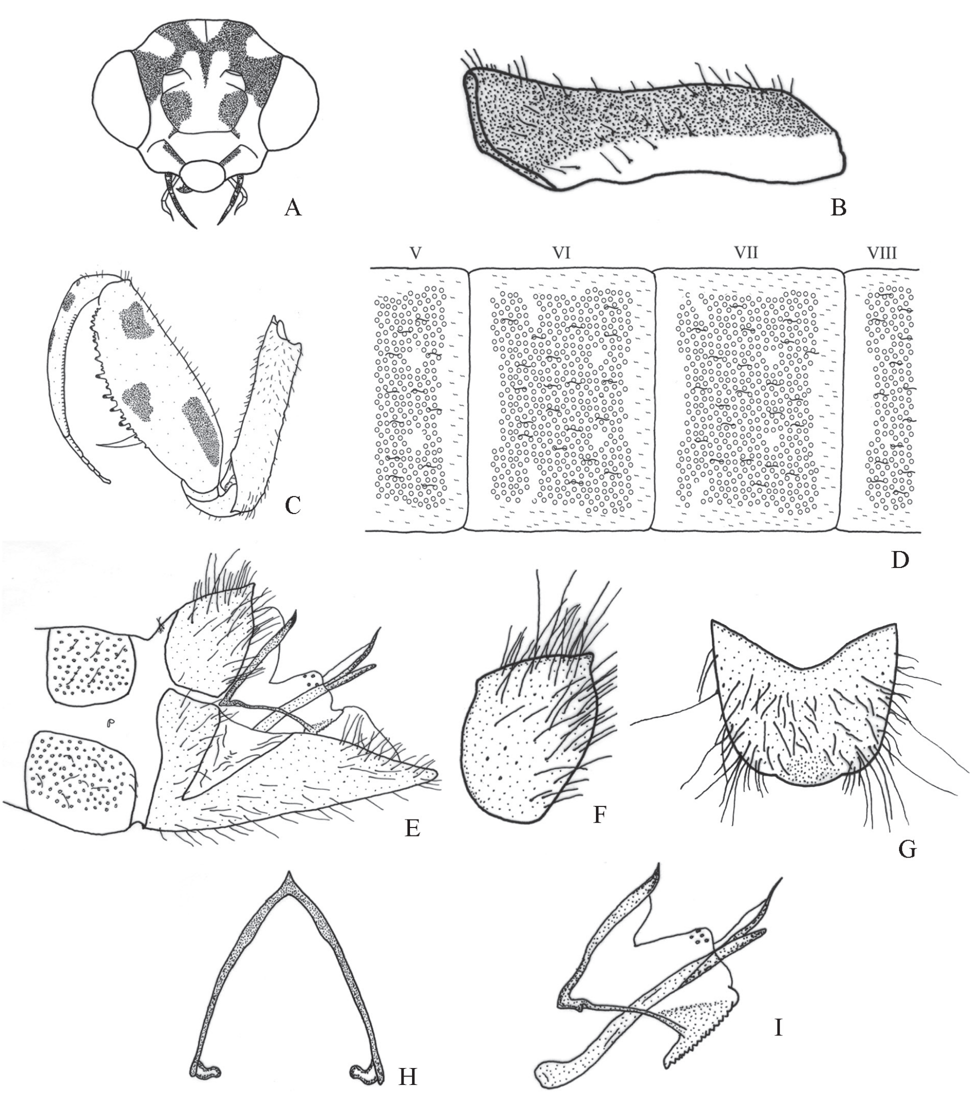

Figure 6. Structures of the male of *Nolima costaricensis* sp. nov. **A** head, frontal **B** prothorax, lateral **C** left foreleg, lateral **D** abdominal terga V–VIII, dorsal **E** external terminalia, lateral **F** left ectoproct, lateral **G** ectoprocts, dorsal **H** gonarcus, dorsal **I** internal terminalia, lateral.

Because of the extension of the Talamanca range, it is likely the species is also distributed in Panama.

Type material examined. HOLOTYPE ♂ (by present designation): **COSTA RICA**: **Puntarenas**: P[arque] I[nternacional] La Amistad, Sector Altamira, Send[ero] Gigantes del Bosque, 1300–1400 m, 13-IV–14-V-2005, R. González, T[ram]p[a] Malaise, LS331300 571500 #83526, INB0004129281, INBIOCRI, Costa Rica (INBIO).

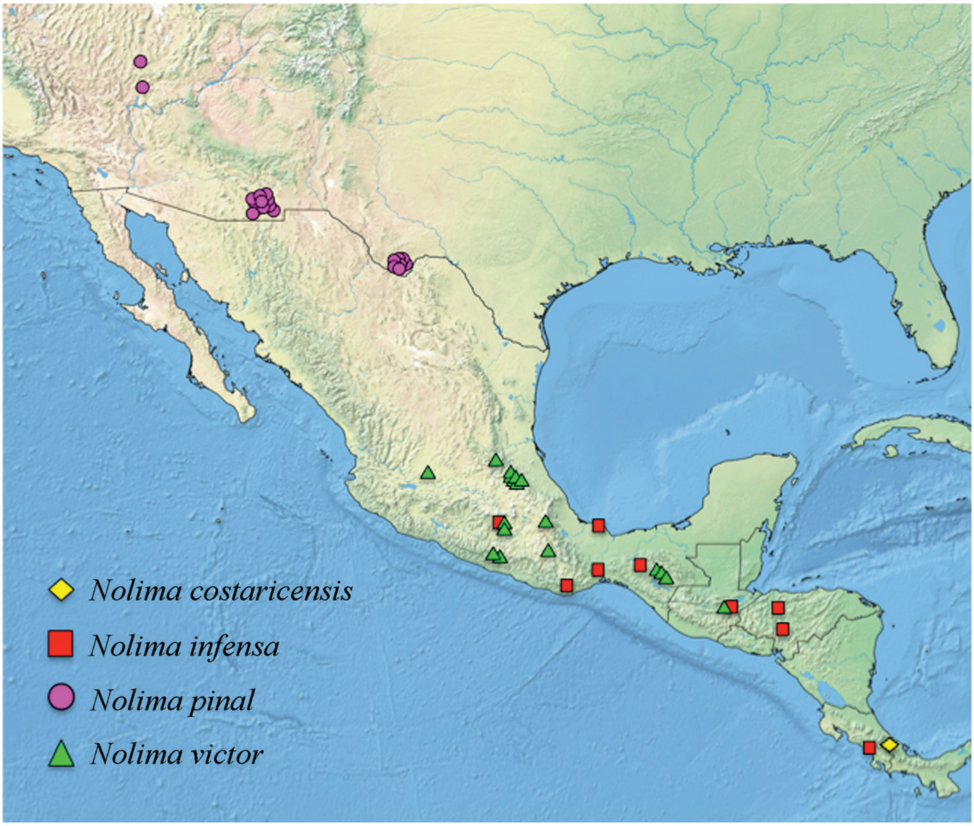

Figure 7. Distribution of the species in the genus *Nolima*.

Nolima infensa Navás, 1924

Figs 3A, 7, 8

Nolima infensus Navás, 1924: 61–62 (original description); Penny 1977: 36 (species list); Penny 1982: 213 (illustration); Henry et al. 1992: 449 (species list); Penny 1998: 212 (species list); Hoffman 2002: 252, 420–423 (species list, diagnosis, illustrations); Reynoso-Velasco and Contreras-Ramos 2010: 271–272 (species list, distribution).

Nolima infensa Navás: Ohl 2004: 158 (species list, correction of specific epithet original misspelling); Cancino-López et al. 2015: 202–203, 207–208 (species list, distribution, photo, systematics).

Diagnosis. It differs from other *Nolima* species as follows: a) male sterna I–VIII with circular structures only laterally (Fig. 8E), b) male ectoprocts with membrane between apices sclerotized, c) male ectoprocts with dorsal margin strongly convex (Fig. 8E, F), d) male ectoprocts each with cluster of long bristles anteromedially (Fig. 8E–G), e) gonarcus narrowly rounded (Fig. 8H), and f) pseudopenis slender apically (Fig. 8I).

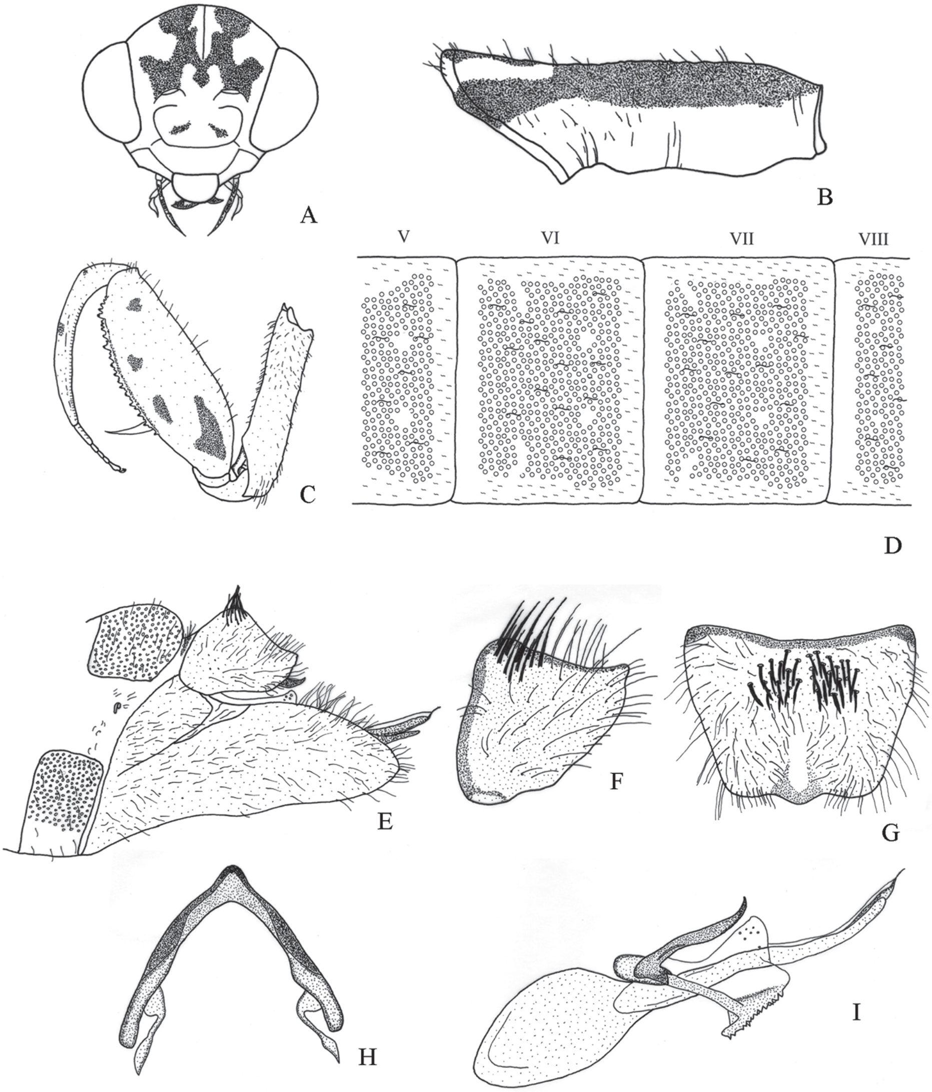

Figure 8. Structures of the male of *Nolima infensa*. **A** head, frontal **B** prothorax, lateral **C** left foreleg, lateral **D** abdominal terga V–VIII, dorsal **E** external terminalia, lateral **F** left ectoproct, lateral **G** ectoprocts, dorsal **H** gonarcus, dorsal **I** internal terminalia, lateral.

Note. This species was described based on a single female specimen collected in Costa Rica; Navás (1924) stated this species was similar to *N. victor*.

Description. Male. *Head*. Vertex with M-shaped mark not bifurcated behind antennal sockets (Fig. 8A); vertex irregular marks that originate posteromedially converging with upper part of M-shaped mark (Fig. 8A). Frons with a pair of small irregular marks (Fig. 8A). Antennae 39 to 46-segmented; scape with longitudinal ovoid mark on posterior surface, pigmentation on distal margin; pedicel with pigmentation on posterior surface.

Thorax. Prothorax with pigmentation on pronotum, except anterolateral pale yellow mark on each side of midline (Fig. 8B). Forecoxa with bristle-bearing chalazae only on ventral surface, fine pale yellow setae on most of remaining surface (Fig. 8C). Forefemur with four marks on lateral surface (Fig. 8C), mesal and dorsal surfaces without marks. Foretibia with small dorsolateral mark medially (Fig. 8C). Mesopleuron generally pale yellow. Metapleuron with pigmentation on anepimeron, katepimeron, and meron. Middle and hind legs with fine pale yellow setae.

Abdomen. Terga and lateral surface of sterna I–VIII with circular structures, not in contact to each other (Fig. 8D), microsetae in space between circular structures. Sternum IX with setae on entire surface, apex broadly rounded in lateral view (Fig. 8E). Ectoprocts with dorsal margin strongly convex in lateral view; long bristles arranged in two clusters anteromedially (Fig. 8F, G); membrane between apexes of ectoprocts sclerotized, posteriorly produced (Fig. 8F), narrowly rounded in dorsal view (Fig. 8G); basal apodeme of ectoprocts broad, strongly sclerotized (Fig. 8G). Callus cerci obsolete. Gonarcus robust, narrowly rounded (Fig. 8H). Gonocoxite IX with base almost straight (Fig. 8I). Pseudopenis conspicuously slender apically (Fig. 8I).

Female. Pigmentation and setation generally same as for male.

Variation. In both sexes, the pair of marks on the frons may be absent. An irregular mark may be present on the clypeus. The pigmentation on the forefemur may be absent. Specimens may also present pigmentation on the mesopleural katepisternum and anepimeron, on the metapleural anepisternum and katepisternum, or lack pigmentation on the pteropleural area. The dorsal margin of male ectoprocts may be only slightly convex in lateral view.

Biology and natural history. Based on collecting data, adults of this species may be found active from May through August.

Etymology. Navás (1924) did not specify the etymology of the species name. The specific epithet *infensus* is a Latin adjective meaning hostile or annoyed.

Repository. The holotype is housed at the MNHN.

Type locality. Costa Rica.

Distribution. This species is distributed from central Mexico (Chiapas, Morelos, Oaxaca, Veracruz) south to Costa Rica (Puntarenas), including Guatemala (Zacapa) and Honduras (Comayagua, Yoro) (Fig. 7). Based on the material examined, elevation records (n = 4) range from 396 to 1,500 meters. Reported here are the first records of the species from Guatemala and Honduras. A male specimen of *N. infensa* from FSCA indicates it was collected in Florida (United States). As *Nolima* is distributed in the southwestern United States and considering that *N. pinal* is the sole species present in that area, the record from Florida is considered erroneous. Also, a female specimen at the NHMUK indicates it was collected in Guyana, South America. The specimen exhibits similar features to those of *N. infensa*, yet male specimens are required to confirm the species identification. This record is considered dubious based on the fact that no other *Nolima* specimens have been reported from nearby countries such as Colombia, where the fauna of Mantispidae has been recently studied (Ardila-Camacho and García 2015, Ardila-Camacho et al. 2018).

Published records. Costa Rica; México: Morelos, Oaxaca (Navás 1924, Penny 1977, Henry et al. 1992, Ohl 2014, Reynoso-Velasco and Contreras-Ramos 2010, Cancino-López et al. 2015).

Type material examined. HOLOTYPE ♀ (by monotypy): **COSTA RICA:** *Nolima infensus* Nav. P. Navás S.J. det [1st label], TYPE [2nd label], Museum Paris, Costa Rica, Paul Serre 192 [3rd label]. Microvial with last abdominal segments of the holotype in glycerine, pinned next to specimen: HOLOTYPE *Nolima infensus* Navás ♀, Genitalia in Glycerin BEARD [single label] (MNHN).

Additional material examined. COSTA RICA: Puntarenas: Las Alturas, 1500 m, 22-V-1992, F. Andrews & A. Gilbert, *Nolima infensus* det. N. Penny (1♀, 1 adult without abdomen CAS). **GUATEMALA: Zacapa:** 12–14 km S San Lorenzo, 3-VI-1989, J. Wappes (1♂, 2♀ TAMU). **[GUYANA: East Berbice-Corentyne]:** British Guiana, New River, boundary mark 82, 1300 ft, 12-V-1938, C.[A.] Hudson (1♀ NHMUK). **HONDURAS: Comayagua:** Rancho Chiquito, Km 62, 2800 ft, 7-VI-1964, Blanton et al., blacklight trap (1♂ FSCA); **Yoro:** Pico Pijol, 22-VII-2001, R. Turnbow, mercury vapor light (1♂, 1♀ FSCA). **MEXICO: Chiapas:** [Ocozocoautla de Espinosa], Parque Laguna Bélgica, 2-VI-1991, B. Ratcliffe et al. (1♂ CASC); **Morelos:** [Mpio. Amacuzac], Huajintlán, carr. Amacuzac, 18°36'06"N, 99°25'19"W, 925 m, 4-VII-2005, H. Brailovsky & E. Barrera (1♀ CNIN); **Oaxaca:** [Mpio. Candelaria Loxicha], Portillo del Rayo, 3–4-VI-1987, L. Cervantes (1♂, 1♀ CNIN); [Mpio. Asunción Ixtaltepec], 12 mi S Chivela, 18-VIII-1959, L. Stange & A. Menke (1♀ FSCA); same but / ♂ genitalia close to my specimen ex [from] Oakland Park, Fla., leg. C.F. Dowling / not *Nolima pinal* E. MacLeod, 7-X-1979 (1♂ FSCA); **Veracruz:** [Mpio. Catemaco], Coyame, Lake Catemaco, 2-VII-1963, R.E. Woodruff, blacklight trap (1♀ FSCA). **UNITED STATES: Florida:** Broward Co., Oakland Park, [no day]-IV-1964, C.F. Dowling, at light (1♂ FSCA) [probably erroneous locality data].

Nolima pinal Rehn, 1939

Figs 4, 7, 9

Nolima pinal Rehn, 1939: 256–259, 263 (key, original description); Hughes-Schrader 1979: 10–11 (cytogenetics); MacLeod and Redborg 1982: 38–41 (biology, photos); Lambkin 1986a: 3, 21 (species list, systematics); Willman 1990: 263 (illustration); Penny et al. 1997: 73 (species list); Ohl 2004: 158 (species list); Liu et al. 2015: 185, 200, 204 (species list, illustration, systematics); Winterton et al. 2018: 342, 344 (systematics).

Nolima dine Rehn, 1939: 256–257, 261–263 (key, original description); Penny et al. 1997: 73 (species list); Ohl 2004: 157 (species list) (new synonym).

Nolima kantsi Rehn, 1939: 256–257, 260–262 (key, original description); Penny et al. 1997: 73 (species list); Ohl 2004: 158 (species list) (new synonym).

Diagnosis. It differs from other species in the genus as follows: a) male sterna I–VIII with circular structures on nearly the entire surface (Fig. 9E), b) male ectoprocts with membrane between apexes not sclerotized, c) male ectoprocts with dorsal margin slightly convex (Fig. 9E, F), d) male ectoprocts with scattered long setae (Fig. 9E–G), e) gonarcus broadly rounded (Fig. 9H), and f) pseudopenis not slender apically (Fig. 9I).

Notes. *Nolima pinal* was described based on a single female specimen collected in Arizona, United States. In the original description the holotype was erroneously reported as a male specimen. Rehn (1939) stated that this species was similar to *N. praeliator*. The distinction between *N. pinal* and the other two species in the United States, which were also described based on females but erroneously reported as males in the original descriptions, was based mainly on the pigmentation pattern of the head, pronotum, mesonotum, and metanotum, as well as width of the pronotum. After the examination of the type specimens of the three species from the southwestern United States and the additional material available for this study, we found that the pigmentation pattern used to distinguish among the species was not consistent, thus its aid in the species delimitation was questionable. In addition, after the examination of the male genital structures from specimens in the entire species distribution (southwestern United States), including specimens from the previously unknown range in Nevada, we found that the structures exhibited sufficient similarity to be considered a single species. Thus we propose *N. dine* and *N. kantsi* to be junior synonyms of *N. pinal*. Even when the name *N. pinal* has no position precedence because is not the type species of the genus (see *N. victor* section), we chose *N. pinal* as the valid name for this species only because it was the first to be described in the work by Rehn (1939, p. 257).

Description. Male. *Head*. Vertex with M-shaped mark bifurcated behind antennal sockets, one branch extending posteriorly parallel to anterior ocular margin, additional branch extending anteriorly on frontogenal furrow (Fig. 9A); vertex irregular marks that originate posteromedially converging basally with branch of bifurcation extending posteriorly (Fig. 9A). Frons with a pair of small irregular marks (Fig. 9A). Antennae 29 to 39-segmented; scape with narrow longitudinal mark on posterior surface; pedicel with pigmentation on posterior surface.

Thorax. Prothorax with pigmentation on pronotum, except narrow pale yellow longitudinal stripe along midline and anterolateral pale yellow mark on each side of midline (Fig. 9B). Forecoxa with bristle-bearing chalazae on ventral, lateral, and dorsal surfaces; pigmentation on chalazae bases (Fig. 9C). Forefemur with one large mark on lateral surface (Fig. 9C), mesal and dorsal surfaces without marks. Foretibia with long dorsal mark on basal 2/3. Meso- and Metapleuron with pigmentation on anepisternum, anepimeron, katepisternum, katepimeron, and meron. Middle and hind legs with dark setae.

Abdomen. Terga and sterna I–VIII with circular structures, not in contact to each other, microsetae in space between circular structures (Fig. 9D). Sternum IX with setae on entire surface, apex narrowly rounded in lateral view (Fig. 9E). Ectoprocts with dorsal margin slightly convex in lateral view; long setae scattered (Fig. 9F, G); membrane between apexes of ectoprocts not sclerotized, not posteriorly produced, concave

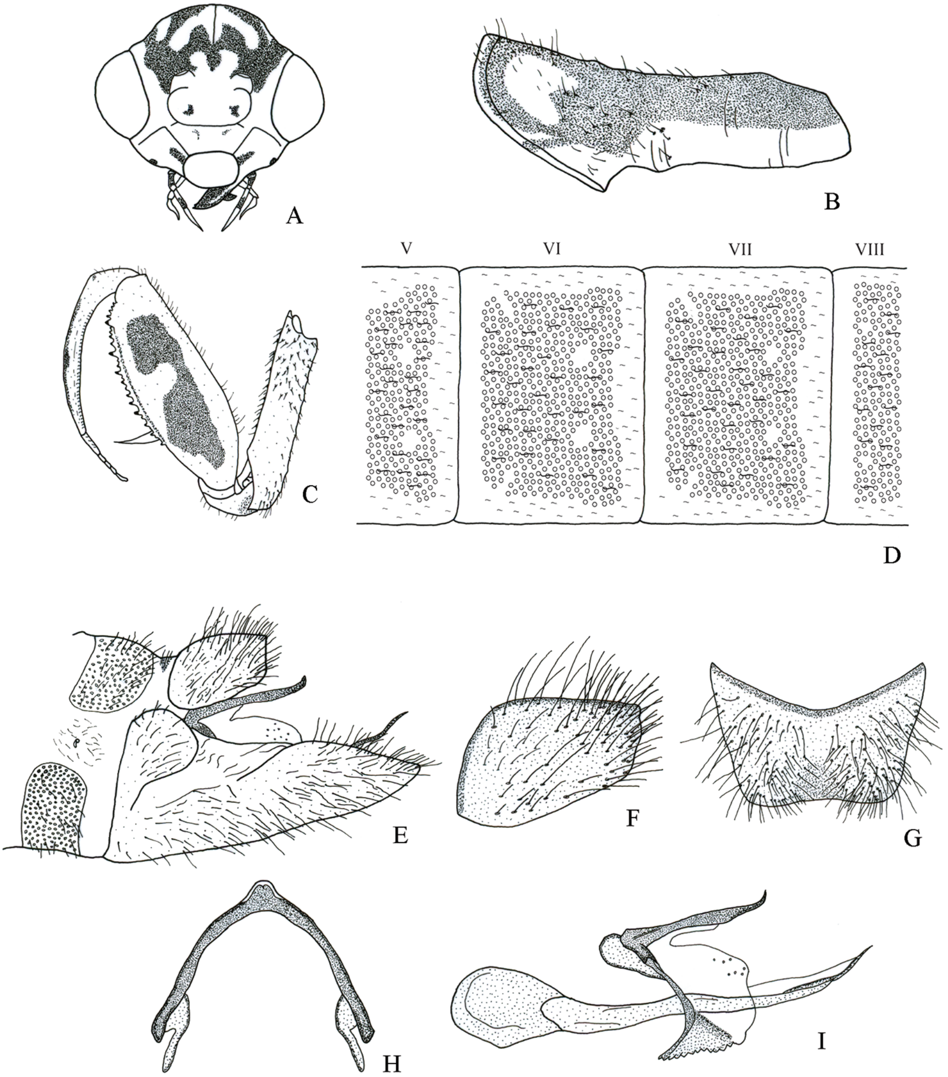

Figure 9. Structures of the male of *Nolima pinal*. **A** head, frontal **B** prothorax, lateral **C** left foreleg, lateral **D** abdominal terga V–VIII, dorsal **E** external terminalia, lateral **F** left ectoproct, lateral **G** ectoprocts, dorsal **H** gonarcus, dorsal **I** internal terminalia, lateral.

in dorsal view (Fig. 9G); basal apodeme of ectoprocts broad, strongly sclerotized (Fig. 9G). Callus cerci obsolete. Gonarcus robust, broadly rounded (Fig. 9H). Gonocoxite IX with base slightly curved (Fig. 9I). Pseudopenis not slender apically (Fig. 9I).

Female. Pigmentation and setation generally same as for male, except the antennal scape, which presents pigmentation on entire posterior surface.

Variation. The mark located on the frontogenal furrow sometimes extends ventrally onto the epistomal furrow, a feature more common in females. The clypeus may present a single irregular mark medially. The anterolateral pale yellow mark of the pronotum sometimes exhibits pigmentation medially, giving an appearance of two marks. The forefemur may present two marks on the lateral surface, a trait more common in females. Some females from Texas exhibited three marks on the lateral surface of the forefemur. Also, the forefemur may present an elongate mark on the first half of the mesal surface. Sometimes the foretibia presents three dorsal marks. The membrane between apexes of ectoprocts may be slightly sclerotized.

Biology and natural history. The cytogenetics of 15 species of mantispids from 11 genera and three subfamilies has been studied to date (Hughes-Schrader 1969, 1979); among these species, *N. pinal* has the lowest number of chromosomes. Its chromosomal complement consists of seven pairs of autosomes and one pair of sex chromosomes, XX (female) and XY (male). Under experimental conditions (Macleod and Redborg 1982), larvae of *N. pinal* were able to feed on a large variety of immature and adult insects and spiders, therefore it has been suggested the species is a generalist. In contrast, a certain degree of prey specialization has been documented for other mantispids (Parker and Stange 1965, Werner and Butler 1965, Redborg 1998). Mantispines are hypermetamorphic. The first instar is active and usually campodeiform, while later instars are vermiform or scarabaeiform and little active (Triplehorn and Johnson 2005). In contrast, larvae of *N. pinal* are ambulatory in all three larval instars, although they require prey to be sedentary because of low capacity of larval movement. In the laboratory (T = 25 °C, photoperiod L:D = 16:8) *N. pinal* took 15 days to go through three larval instars (from eclosion to just before construction of the cocoon) and 2–3 weeks in the pupal stage (MacLeod and Redborg 1982). Based on material examined, adults of *Nolima pinal* may be found active from April through September, being more common in August.

Etymology. Rehn (1939) named this species after the Pinal Coyotero Apache group, which inhabited the region around the Pinal Mountains in Arizona, United States.

Repository. The holotype is housed at the MCZ.

Type locality. United States: Arizona: Gila Co., Pinal Mountains.

Distribution. This species is distributed in the southwestern United States (Fig. 7). The species was reported from Arizona in the original description, also as *N. dine*. In addition, the species was reported from Texas as *N. kantsi*. Herein, *N. pinal* is reported from Nevada for the first time. Given this southern distribution in the United States, it may be expected the species is also distributed in the northern Mexican states of Chihuahua, Coahuila, and Sonora. Based on the material examined, this species may be found in areas with oaks at elevations (n = 9) ranging from 1,509 to 1,753 meters.

Published records. United States: Arizona, New Mexico, Texas (Rehn 1939, Penny et al. 1997, Ohl 2004).

Type material examined. HOLOTYPE ♀ (by original designation): **UNITED STATES: Arizona:** [Gila Co.], base of Pinal M[oun]t[ain]s, Ariz. [1st label, with antennal flagellum glued], Sep[tember], D.K. Duncan [2nd label], Oak [3rd label], M.C.Z. type 23645 [4th label], *Nolima pinal* Rehn TYPE [5th label], MCZ [6th label]. Microvial with last abdominal segments of the holotype in glycerine, pinned next to specimen:

Nolima pinal ♀, 28.I.1985, Genital prep. nr. Ragnar Hall 103 [single label] (MCZ). Extra label in Holotype's unit tray: The holotype of *Nolima pinal* Rehn is a ♀, not a male as described by Rehn, 21-X-1966, R. Beard. HOLOTYPE ♀.

Type material of synonyms examined. UNITED STATES: Arizona: [Pinal Co.], Peppersauce C[a]n[yon], Aug. 16, 1924 [1st label], Santa Catalina Mts. [2nd label], J.O. Martin Collector [3rd label], *Nolima dine* Rehn TYPE [4th label], California Academy of Sciences Type No. 4927 [5th label] (♀ CAS). PARATYPES: [Pinal Co.], Peppersauce C[a]n[yon], Aug. 16, 1924, Santa Catalina Mts., J.O. Martin Collector, *Nolima dine* Rehn Allotype (1♂ CAS); [Pinal Co.], Peppersauce Canyon, Aug. 17, 1924, E.P. Van Duzee, *Nolima dine* Rehn Paratype (1♀ CAS). HOLOTYPE ♀. **UNITED STATES: Texas:** Brewster Co., Chisos Mts., July 16 1921 [1st label], C.D. Duncan Collector [2nd label], *Nolima kantsi* Rehn TYPE [3rd label], California Academy of Sciences Type No. 4926 [4th label] (♀ CAS).

Additional material examined. UNITED STATES: Arizona: Cochise Co., Cave Creek Canyon, 3 mi W Portal, 31°53.023'N, 109°10.715'W, 5120 ft, 9-VIII-2000, A. Gilbert & N. Smith (1♀ ZMB); Cochise Co., Chiricahua M[oun]t[ain]s, Cave Creek Ranch, 4880 ft, 14-VIII-1966, D. Alsop et al., 15w UV light (1♂ NMNH); Cochise Co., Paradise Cemetery Area, 5700 ft, 17-VIII-1977, S. Schrader-K. & R. Cooper-E., UV light beneath *Quercus* (5♂ 4♀ TAMU); Cochise Co., Paradise Cemetery Area, 5700 ft, 17-VIII-1977, R. Cooper-E., swept from *Quercus* (1♂ SDMC; 2♀ TAMU); Cochise Co., Paradise Cemetery Area, 5700 ft, 19-VIII-1977, R. Cooper-E., swept from *Quercus* (1♀ SDMC; 4♂, 5♀, 1 adult without abdomen TAMU); Cochise Co., Pinery Canyon, 3 mi E of j[un]ct[ion] Ariz[ona] 181, 5440–5600 ft, 17-VIII-1966, R.G. Beard & C. Weidert, beating oaks (1♀ NHMUK; 1♀ TAMU); same but 25-VIII-1966 (1♀ ZMB); Cochise Co., Portal Cave-Creek Ranch, 4900 ft, 17-VIII-1977, K. Cooper, UV light in woods (1♂ TAMU); Cochise Co., Portal Ranger Station, 4950 ft, 5-VIII-1966, R.G. Beard & R.E. Dietz (1♂ CASC; 1♂ MCZ); same but *Nolima* ♀66-L, ♀ died 9-VIII, eggs laid 8-VIII hatched (1♀ MCZ); Cochise Co., Portal Ranger Station, 4950 ft, 5-VIII-1966, R.G. Beard & R.E. Dietz, *Nolima* ♀66-M, ♀ died 9-VIII, eggs laid 8-VIII hatched (1♀ MCZ); Cochise Co., Portal Ranger Station, 4950 ft, 5-VIII-1966, R.G. Beard & R.E. Dietz, *Nolima* ♀66-N, ♀ died 9-VIII, eggs laid 8-VIII hatched (1♀ MCZ); Cochise Co., Portal Ranger Station, 4950 ft, 7-VIII-1966, R.G. Beard, beaten from oak, *Nolima* ♀66-P, ♀ died 11-VIII, eggs laid 10-VIII hatched (1♀ MCZ); Cochise Co., Portal Ranger Station, 4950 ft, 9-VIII-1966, R.G. Beard, UV light (1♀ MCZ; 1♀ MNHN); Cochise Co., Portal Ranger Station, 4950 ft, 12-VIII-1966, R.G. Beard, UV light, *Nolima* ♀66-R, ♀ died 19-VIII, eggs laid 18-VIII hatched (1♀ TAMU); Cochise Co., Portal Ranger Station, 4950 ft, 12-VIII-1966, R.G. Beard, UV light, *Nolima* ♀66-S, ♀ died 19-VIII, eggs laid 18-VIII hatched (1♀ MCZ); Cochise Co., Portal Ranger Station, 4950 ft, 13-VIII-1966, R.G. Beard, beaten from oak (1♀ CASC); Cochise Co., Portal Ranger Station, 12-VIII-1999, at light, M. Ohl (2♀ ZMB); Cochise Co., Paradise, 20-VIII-1978, [no collector] (1♀ SDMC); Cochise Co., Douglas, 7-VIII-1980 (1♂ CASC); Cochise Co., 5 mi W Portal, S[outh] W[estern] R[esearch] S[tation], 5400 ft, 15-VIII-1969, [no collector] (1♀

CASC); Cochise Co., Lowell, 26-VIII-1964, G.H. Nelson, flying (1♂ FSCA); Cochise Co., Portal, 6 mi above S[outh] W[estern] Res[earch] Sta[tion], 24-VII-1969, G.H. Nelson, beating *Quercus hypoleuca* (1♂ FSCA); Cochise Co., Portal, 2-IX-1974, H. & M. Townes (1♀ FSCA); same but 6-IX-1974 (1♀ FSCA); same but 23-VIII-1987 (1♂ FSCA); same but 29-VIII-1987 (1♀ (FSCA); [Cochise Co.], 5 mi W Portal, Chiricahua M[oun]t[ain]s, 18-VIII-1958, D.D. Linsdale (1♀ FSCA); [Maricopa Co.], Seven Springs Ranger Sta[tion], 20-IV-1938, S.E. Crumb (1♀ TAMU); **Nevada:** Clark Co., Cabin C[an]y[o]n, 36.663062N, 114.070060W, 21-V-2008, C.W. Irwin, Lindgren trap PPQ07 (1♀ CASC); Lincoln Co., Spring Valley, 38.025963N, 114.208495W, 30-VIII-2008, R.J. Little, Lindgren trap BB60 (1♂, 3♀ CASC); **New Mexico:** Hidalgo Co., Animas M[oun]t[ain]s, Double Adobe Ranch, 5500 ft, 15-VIII-1952, H.B. Leech & J.W. Green (1♀ TAMU); **Texas:** [Brewster Co.], Big Bend State Park, 12-VII-1941, B.E. White (1♀ CASC); Brewster Co., B[ig] B[end] N[ational] P[ark], Laguna Medows Tr[ai]l, 29°15'17"N, 103°18'23"W, 5500–5750 ft, 20-VII-2002, E.G. & C.M. Riley, beating (1♀ TAMU); Brewster Co., B[ig] B[end] N[ational] P[ark], The Basin, 29°16'14"N, 103°17'54"W, 5600 ft, 21-VI-2004, E.G. Riley, UV light (1♀ TAMU); Brewster Co., B[ig] B[end] N[ational] P[ark], n[ea]r Lost Mine Trail, 29°16'03"N, 103°17'22"W, 5750 ft, 6-VI-2006, E.G. Riley, UV light (1♂ TAMU); Brewster Co., B[ig] B[end] N[ational] P[ark], The Basin ar[ea], 29°16'05'N, 103°18'09'W, 5600 ft, 5–8-VI-2006, E.G. Riley, UV [light] (1♂, 1♀ TAMU); Brewster Co., Chisos M[oun]t[ain]s, Panther Pass, 6000 ft, 2-VI-1973, D.C. Ferguson (1♂ USNM); [Brewster Co.], Chisos M[oun]t[ain]s, Big Bend Park, 3-VII-1946, E.C. Van Dyke (2♀ CASC; 1♀ ZMB); same but 6-VII-1946 (1♀ CASC); [Brewster Co.], Chisos Mountains, Big Bend Park, 16-VII-1956, H. & A. Howden (1♀ MCZ); [Brewster Co.], Chisos Mountains, Big Bend Park, 1-V-1959, Howden & Becker, at light (1♀ MCZ); [Brewster Co.], Chisos Mountains, Big Bend Park, 3-V-1959, Howden & Becker, beaten gray oak (*Quercus grisea*) (1♂ MCZ); [Brewster Co.], Chisos Mountains, Big Bend Park, 9-V-1959, Howden & Becker, beaten juniper (*Juniperus* sp.) (1♀ MCZ); [Brewster Co.], Chisos M[oun]t[ain]s, 26-VI-1961, D.J. & J.N. Knull (1♂, 2♀ MCZ); [Brewster Co.], Chisos M[oun]t[ain]s, 26-VI-1963 (1♀ SRSU); Davis M[oun]t[ain]s, 7-VII-1946, E.C. Van Dyke (1♂, 1♀ CAS; 2♂, 1♀ TAMU).

Nolima victor **Navás, 1914**

Figs 3B, 5, 7, 10

Nolima victor Navás, 1914: 101 (original description); Rehn 1939: 256–257 (systematics); Penny 1977: 36 (species list); Penny 1982: 213 (systematics); Oswald et al. 2002: 580 (species list, distribution); Ohl 2004: 158 (species list); Reynoso-Velasco and Contreras-Ramos 2008: 704–708 (species list, distribution, illustrations, as *Nolima* sp. 1); Reynoso-Velasco and Contreras-Ramos 2009: 710–711 (species list, distribution); Reynoso-Velasco and Contreras-Ramos 2010: 270–272 (species list, distribution); Cancino-López et al. 2015: 203, 205, 208 (species list, distribution, systematics).

Nolima praeliator Navás, 1914: 101–102 (original description); Rehn 1939: 256–257, 260–261 (systematics); Penny 1977: 36 (species list); Oswald et al. 2002: 580 (species list, distribution); Ohl 2004: 158 (species list); Reynoso-Velasco and Contreras-Ramos 2008: 708 (species list) Reynoso-Velasco and Contreras-Ramos 2010: 270 (distribution) (new synonym).

Nolima pugnax (Navás), 1914: 103 (original description); Henry et al. 1992: 449 (species list); Ohl 2004: 158 (species list) (new synonym).

Diagnosis. It differs from other *Nolima* species as follows: a) male terga I–VIII with polygonal structures (Fig. 10D, E), b) male ectoprocts with membrane between apexes sclerotized, c) male ectoprocts with dorsal margin straight (Fig. 10E, F), d) male ectoprocts with scattered setae (Fig. 10E–G), e) gonarcus narrowly rounded (Fig. 10H), and f) pseudopenis not slender apically (Fig. 10I).

Notes. The original description of *Nolima victor* apparently was based on at least two specimens because in that work, Navás (1914) provided measurement ranges of the body and wings. However, during the first author's visit to the NHMUK he only found one specimen, which is herein designated as the lectotype. In the same work, Navás (1914) described *N. praeliator* but reported only one measurement for the length of body and wings, suggesting the description was based on a single specimen, although Navás reported two specimens, one from Omiltemi and the other from Xucumanatlán. The latter was also reported as the type locality of *N. victor*. During the first author's visit to the NHMUK he found only the specimen of *N. praeliator* collected in Omiltemi, which was clearly identified as the type. The specimen from Xucumanatlán cited in the original description of *N. praeliator* may have been the specimen used to describe *N. victor*. It is possible that Navás examined the two specimens from Xucumanatlán for the description of *N. victor* and erroneously cited one of them in the description of *N. praeliator*. The three type specimens mentioned in this section are females and as we have previously mentioned, the female genital structures are conserved and do not provide sufficient information for species identification. After examination and mainly based on characteristics of the forelegs (e.g., position of chalazae, pigmentation), we concluded the specimens were conspecific. Thus, we propose *N. praeliator* and *N. pugnax* as junior synonyms of *N. victor*. Even when the three species were described in the same work, the author clearly stated (Navás 1914, p. 21) that *N. victor* was the type species of the genus. Thus, this name has precedence and is the valid name for the species.

Description. Male. *Head*. Vertex with M-shaped mark bifurcated behind antennal sockets, one branch extending posteriorly parallel to anterior ocular margin, additional branch not extending anteriorly (Fig. 10A); vertex irregular marks that originate posteromedially not converging with upper part of M-shaped mark (Fig. 10A). Frons with a pair of circular marks (Fig. 10A). Antennae 32 to 42-segmented; scape and pedicel without pigmentation on posterior surface.

Thorax. Prothorax with pigmentation on pronotum, except narrow pale yellow longitudinal stripe along midline and anterolateral pale yellow oval mark on each side of

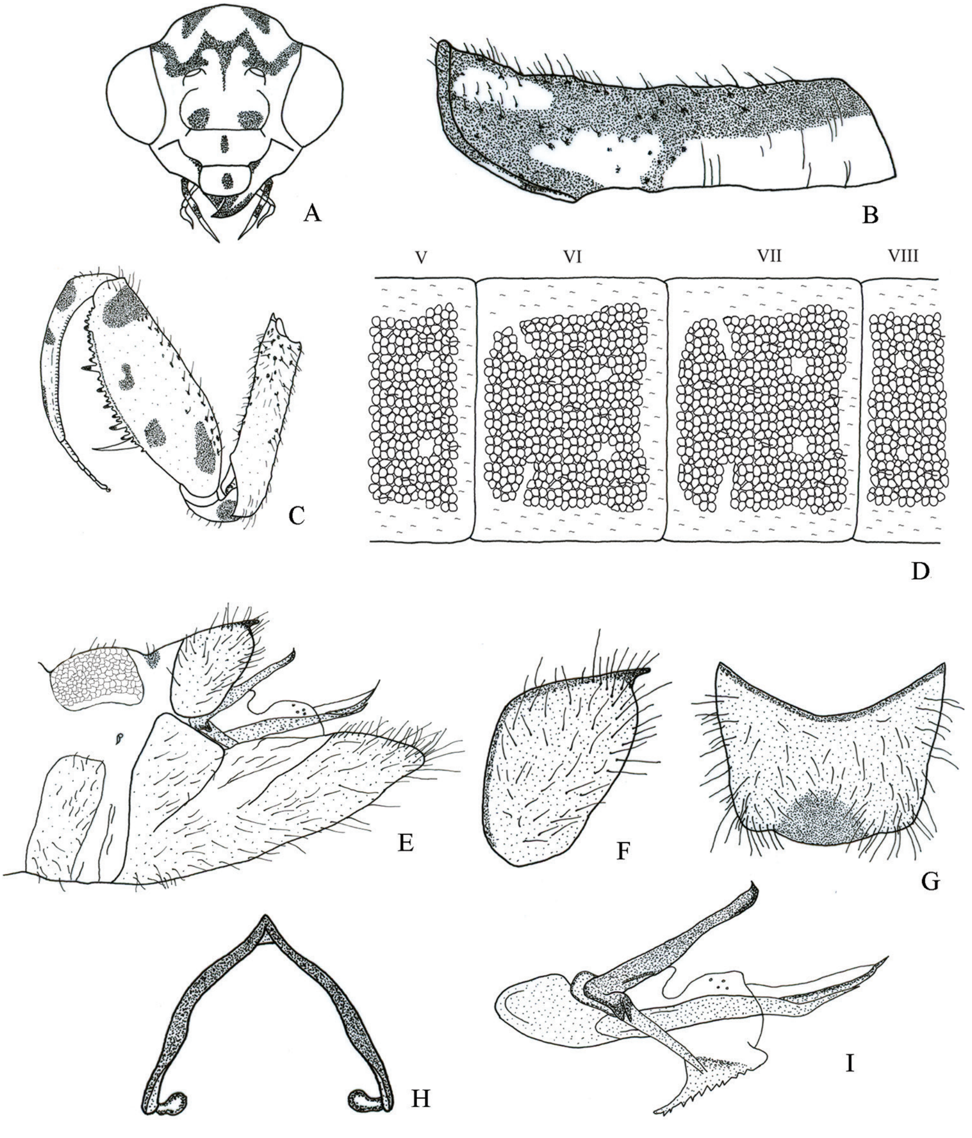

Figure 10. Structures of the male of *Nolima victor*. **A** head, frontal **B** prothorax, lateral **C** left foreleg, lateral **D** abdominal terga V–VIII, dorsal **E** external terminalia, lateral **F** left ectoproct, lateral **G** ectoprocts, dorsal **H** gonarcus, dorsal **I** internal terminalia, lateral.

midline (Fig. 10B). Forecoxa with bristle-bearing chalazae on ventral, lateral, and dorsal surfaces; chalazae bases colored (Fig. 10C). Forefemur with four marks on lateral surface (Fig. 10C), mesal surface with circular mark; dorsal surface with dark brown circular marks at setal bases (Fig. 10C). Foretibia with basal, medial, and apical dorsolateral marks (Fig. 10C). Meso- and metapleuron with pigmentation on anepimeron, anepisternum, katepimeron, katepisternum, and meron. Middle and hind leg with dark setae.

Abdomen. Terga I–VIII with polygonal structures, in close contact to each other (Fig. 10D), inconspicuous microsetae along margin of polygonal structures. Sternum IX with setae on entire surface, apex narrowly rounded in lateral view (Fig. 10E). Ectoprocts with dorsal margin straight in lateral view; setae scattered (Fig. 10F, G); membrane between apexes of ectoprocts sclerotized, posteriorly produced (Fig. 10F), broadly rounded in dorsal view (Fig. 10G); basal apodeme of ectoprocts broad, strongly sclerotized (Fig. 10G). Callus cerci obsolete. Gonarcus robust, narrowly rounded (Fig. 10H). Gonocoxite IX with base almost straight (Fig. 10I). Pseudopenis not slender apically (Fig. 10I).

Female. Pigmentation and setation generally same as for male.

Variation. Both sexes may exhibit a circular mark on clypeus and one on labrum. The pronotum may be yellowish, with pigmentation only on the chalazae. In females, the bifurcated M-shaped mark on the vertex may present the branch that extends anteriorly, on the frontogenal and epistomal furrows. The irregular marks that originate posteromedially on vertex may be fused to bifurcation of M-shaped mark that extends posteriorly. Also, the antennal scape may exhibit a small mark on the mesal surface and the pedicel may be pigmented on the posterior surface. Sometimes with small circular marks on entire surface of forefemur.

Biology and natural history. Based on collecting data from material examined, adults of this species are active from February through October.

Etymology. Navás did not specify the etymology of the species name. However, the specific epithet *victor* is a Latin adjective meaning victorious. According to this, the name could be read as “Molina victorious,” a phrase acclaimed by Father Molina’s adherents when in 1607 Pope Paul V decided not to condemn the ideas of Molinism.

Repository. The lectotype is housed at the NHMUK.

Type locality. México: Guerrero: Mpio. Chilpancingo de los Bravo, Xocomanatlán.

Distribution. This species is distributed in Mexico (Chiapas, Guerrero, Hidalgo, Jalisco, Morelos, Oaxaca, Puebla, Querétaro) and Guatemala (Baja Verapaz) (Fig. 7). Elevation records of this species are the highest known for the genus, ranging from 2,134 to 2,775 meters. This species was previously reported from the Mexican state of Guerrero as *N. praeliator*. In addition, it was reported as *N. pugnax* from San Jerónimo, in the Guatemalan department of Baja Verapaz. Herein, the species is reported for the first time from the state of Puebla in central Mexico.

Published records. Guatemala: Baja Verapaz; México: Chiapas, Guerrero, Hidalgo, Jalisco, Morelos, Oaxaca, Querétaro (Navás 1914, Penny 1977, Henry et al. 1992, Oswald et al. 2002, Ohl 2004, Reynoso-Velasco and Contreras-Ramos 2008, 2009, 2010, Cancino-López et al. 2015).

Type material examined. LECTOTYPE ♀ (by present designation): **MEXICO: Guerrero:** [Mpio Chilpancingo de los Bravo], Xucumanatlan [Xocomanatlán], 7000 ft, July [no year], H.H. Smith [1st label, with antennal flagellum glued], Godman-Salvin Collection 1913-214 [2nd label], Typus [3rd label], *Nolima victor* ♀ Nav. Navás S.J. det. [4th label], Genitalia prep. in vial on other pin made 20-V-1969, R.G. Beard # 1008 [5th label], Type H.T. [6th label]. Microvial with last abdominal segments of the holotype in glycerine, pinned next to specimen: HOLOTYPE ♀ *Nolima victor* Navás

1909, ♀ Genitalia in glycerine [1st label], R.G. Beard # 1008 Genitalia prep. of *Nolima victor* Navás 1909 ♀ Holotype in glycerine [2nd label] (NHMUK).

Type material of synonyms examined. [**MEXICO]: Guerrero:** [Mpio Chilpancingo de los Bravo], Omilteme [Omiltemi], 8000 ft, Aug., H.H. Smith [1st label], Godman-Salvin Collection 1913–214 [2nd label], *Nolima praeliator* Nav. Navás S.J. det. [3rd label], Typus [4th label], *Nolima victor* Navás ♀ D. Reynoso-Velasco det. 2008 [5th label], NHMUK 012502477 [6th label] (NHMUK) [SYNTYPE ♀ of *N. victor*]. **GUATEMALA: [Baja Verapaz]:** San Geronimo [Jerónimo]. Champion [1st label], Godman-Salvin Collection 1913–214 [2nd label], *Bellarminus pugnax* Nav. Navás S.J. det. [3rd label], Typus [4th label], *Bellarminus pugnax* Nav., ♀ type, H.T. genital prep. made by Ragnar Hall 10.XI.1982 [5th label], *Nolima victor* Navás ♀ D. Reynoso-Velasco det. 2008 [6th label], NHMUK 012502476 [7th label].

Additional material examined. MÉXICO: Chiapas: Hwy 199, 11 km NE San Cristóbal, 8000 ft, 25-V-1987, D.A. Rider et al. (1♀ TAMU); Mpio. Huixtlán [Huixtán], 2.4 km NE Chilil, camino a F[ray] Bartolomé, 23-V-1995, M. Girón (1♀ ECOSUR); 10 mi SE Teopisca, 20-VI-1965, Burke et al. (1♀ TAMU); **Hidalgo:** [Mpio.] Huasca [de Ocampo], R[an]cho Santa Elena, Manantial de Las Vigas, 2300 m, 21-V–3-VI-2003, Contreras-Ramos & Menchaca-Armenta, Malaise 2 (1♂ CNIN); same but 3-VI–19-VI-2003 (1♂ CNIN); [Mpio.] Huasca [de Ocampo], R[an]cho Santa Elena, Manantial de Las Vigas, 17-VI–3-VII-2003, Contreras-Ramos & Meléndez-Ordóñez, Malaise 1 (1♀ CNIN); [Mpio.] Huasca [de Ocampo], R[an]cho Santa Elena, Manantial de Las Vigas, 16-VII–19-VIII-2003, Contreras-Ramos, Malaise 1 (1♀ CNIN); [Mpio.] Huasca [de Ocampo], R[an]cho Santa Elena, Manantial de Las Vigas, 20°07'53.4"N, 98°31'38.5"W, 19-VIII–19-IX-2003, Contreras-Ramos & Menchaca-Armenta, Malaise 1 (1♀ CNIN); [Mpio.] Huasca [de Ocampo], R[an]cho Santa Elena, Manantial de Las Vigas, 20°07'53.4"N, 98°31'38.5"W, 2300 m, 5-IX–3-X-2005, Meléndez-Ordóñez & Reynoso-Velasco, Malaise 1 (2♀ CNIN); [Mpio.] Huasca [de Ocampo], R[an]cho Santa Elena, Manantial de Las Vigas, 20°07'52.2"N, 98°31'39"W, 2480 m, 3–31-X-2005, Contreras-Ramos et al., Malaise (1♂ CNIN); same but 23-II–23-III-2006 (1♀ CNIN); [Mpio. Mineral del Chico], P[arque] N[acional] El Chico, 20°11'18.7"N, 98°44'33.3"W, 2775 m, pine forest, 1-X–12-X-2002, J. Asiain & J. Márquez, pitfall trap (squid) (1♀ CNIN); **Jalisco:** Mpio. Degollado, La Sanguijuela, 14-VII-1995, R. Ayala (1♀ EBCH); **Morelos:** 8 km N Cuernavaca, Hwy 95, 5-IX-1982, C. O'Briend et al. (1 adult without abdomen CAS); **Oaxaca:** 8 mi SE Nochixtlán, 7500 ft, 13-VIII-1974, W. O'Brien et al. (2♀ CAS); **Puebla:** [Mpio. Nicolás Bravo], 4 miles east of Azumbilla, 22-VII-1984, Carroll et al. (1♀ TAMU); **Querétaro:** 4.5 km Carr[etera] La Lagunita-Tilaco, N 21 12 75, O 99 14 18, 27-II-1998, E. Barrera & G. Ortega (1♀ CNIN).

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