ZooKeys 882: 1–24 (2019)
doi: 10.3897/zookeys.882.35229
http://zookeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

Placobdelloides sirikanchanae sp. nov., a new species of glossiphoniid leech and a parasite of turtles from lower southern Thailand (Hirudinea, Rhynchobdellida)

Poramad Trivalairat[1], Krittiya Chiangkul[1], Watchariya Purivirojkul[1]

1 *Animal Systematics and Ecology Speciality Research Unit, Department of Zoology, Faculty of Science, Kasetsart University, 50 Ngam Wong Wan Road, Chatuchak, Bangkok, 10900, Thailand*

Corresponding author: *Watchariya Purivirojkul* (fsciwyp@ku.ac.th)

Academic editor: *F. Govedich* | Received 6 April 2019 | Accepted 24 September 2019 | Published 23 October 2019

http://zoobank.org/FD9F8BCE-1DCD-48F6-9B6B-B48F90FEA0CF

Citation: Trivalairat P, Chiangkul K, Purivirojkul W (2019) *Placobdelloides sirikanchanae* sp. nov., a new species of glossiphoniid leech and a parasite of turtles from lower southern Thailand (Hirudinea, Rhynchobdellida). ZooKeys 882: 1–24. https://doi.org/10.3897/zookeys.882.35229

Abstract

Abstract A new species of glossiphoniid leech, *Placobdelloides sirikanchanae* **sp. nov.**, is reported in the Asian leaf turtle (*Cyclemys dentata*) and the dark-bellied leaf turtle (*C. enigmatica*) from Songkhla Province, southern Thailand. The examination of morphological characters revealed that this new species is similar to *P. siamensis* (Oka, 1917), a common turtle leech species found in Thailand. *Placobdelloides sirikanchanae* **sp. nov.** demonstrates distinct morphological characters, with an elongated, narrow body, 13–17 well-developed knob papillae on each annulus, dark brown to greenish dorsal color with a crimson median line, the absence of a scarlet dot, different male and female gonopore distributions, a rough posterior sucker with a random pit distribution, and 104–115 eggs per clutch. The phylogenetic relationships of COI-ND1 genes were clarified and shown to be distinct from those of *P. siamensis*. Additionally, habitat preferences tended toward low oxygen conditions such as puddles or water patches on rubber plantations.

Keywords

Clitellata, *Cyclemys*, Glossiphoniidae, Hirudinea, leaf turtle, Songkhla

Introduction

Glossiphoniid leeches are characterized as the only annelids that have parental care behavior by carrying cocoons and juveniles directly on the ventral surface for protection and feeding (Sawyer 1986; Siddall et al. 2005). *Placobdelloides* Sawyer, 1986 is a genus of jawless leech species in the most diverse family Glossiphoniidae, which are distributed in freshwater habitats on all continents except Antarctica (Grube 1866; Benham 1907; Johansson 1909; Harding 1920, 1924; Oka 1925; Ingram 1957; Baugh 1960; Cott 1961; Soós 1969; Mason 1974; Chandra 1977; Oosthuizen 1979; Govedich et al. 2002; Nesemann et al. 2004; McKenna et al. 2005). This genus has a protrusible proboscis for both blood-feeding and tissue meals on vertebrates (Soós 1969; Sawyer 1986; Govedich 2001; Govedich et al. 2002; Tucker et al. 2005). Glossiphoniid leeches can be used as alkalinity stress indicators of their ecosystems and they are also vectors of apicomplexan blood parasites of aquatic vertebrates and are therefore very important in both ecology and the environment (Grantham and Hann 1994; Siddall and Burreson 1994).

Placobdelloides siamensis (Oka, 1917) is the only leech species currently reported from several different turtles of the family Geoemydidae in Thailand, which commonly inhabit flowing-water ecosystems (Brophy 2004; Das 2010; Chiangkul et al. 2018): the Southeast Asian box turtle, *Cuora amboinensis* Daudin, 1802; yellow-headed temple turtle, *Heosemys annandalii* (Boulenger, 1903); Malayan snail-eating turtle, *Malayemys macrocephala* (Gray, 1859); Mekong snail-eating turtle, *M. subtrijuga* (Schlegel & Müller, 1845); Khorat snail-eating turtle, *M. khoratensis* Ihlow et al., 2016; and the black marsh turtle, *Siebenrockiella crassicollis* (Gray, 1831). In this study, *Placobdelloides sirikanchanae* sp. nov. is described as the second member of the genus found on the turtle species in the family Geoemydidae, from nonflowing water habitats in Songkhla Province, southern Thailand.

This study presents the first report of the use of a combination of morphological and molecular techniques to describe a new leech species that parasitizes Asian leaf turtles, *Cyclemys dentata* (Gray, 1831) and dark-bellied leaf turtles, *C. enigmatica* Fritz et al., 2008. This newly discovered turtle leech is here presented along with new information about its identification and geographic distribution in Thailand.

Materials and methods

Leech collection and preservation

Leech specimens were collected from two different turtle species at six different collecting sites. Seven leaf turtles (three individuals of *C. dentata* and four individuals of *C. enigmatica*) were collected from the bottom of small muddy puddles or patches of approximately 20–30 cm depth in rubber plantations in Sadao District, Songkhla Province (6°62'57.7"N, 100°41'12.7"E) on 21 October 2018. Leeches were removed from the body and shell of each turtle using forceps and then stored in sealed bottles with water from the capture sites to keep them alive. The carapace length was measured for all turtles, after which they were released back into their capture sites when finished.

Leeches were maintained in a glass container (10×12×8 cm^3) half full of puddle water and fitted with an oxygen-pumping machine for behavioral study in the laboratory. Afterward, some individuals were preserved in absolute ethanol in a relaxed stage for scanning electron microscopy (SEM) and molecular techniques, while still others were preserved in 70% ethanol in a relaxed stage for identification.

Morphological study

Each specimen was examined for eye number and placement, annulation, digestive system (including the number and structure of gastric ceca), and reproductive system, following Sawyer (1986) under an MVX10 Research Macro Zoom microscope (Olympus) at 250× magnification. For scanning electron microscopy (SEM), leeches were preserved in absolute alcohol, dried using the critical point drying technique (CPD), and coated in gold, and their morphology was studied using a Quanta 450 Scanning Electron Microscope equipped with an Oxford Instrument X-Max (Kruger and Du Preez 2015).

Molecular analysis

The leech specimens in absolute ethanol were sectioned into two equal pieces. The posterior part was used for DNA extraction with TIANamp Genomic DNA Kit (catalog number DP304-02; TIANGEN Biotech (Beijing) Co., Ltd., Beijing) while the anterior part was stored in absolute ethanol to be used later for a DNA sample stock. For the proteinase K treatment step, tissue samples were lysed for two hours at 58°C. The DNA was eluted from the spin column with 200 µl of buffer.

Polymerase chain reactions (PCR) were prepared using the EP0402 TAQ DNA POLYMERASE. Two mitochondrial gene fragments were amplified namely, cytochrome *c* oxidase subunit I (CO-I) and nicotinamide adenine dinucleotide dehydrogenase subunit I (ND-1) following Light and Siddall (1999). The CO-I universal primers used were: LCO1490 (5'-GGTCAACAAATCATAAAGATATTGG-3') and HCO2198 (5'-TAAACTTCAGGGTGACCAAAAAATCA-3') (Folmer et al. 1994). The ND-I primers used were LND300 (5'-TGGCAGAGTAGTGCATTAGG-3') and HND1932 (5'-CCTCAGCAAAATCAAATGG-3') (Light and Siddall 1999). Final volumes of PCR reactions were 30 µl with 3 µl of leech genomic DNA added per reaction. DNA was amplified under the following PCR conditions: 94 °C for 5 min; 35 cycles of 94 °C for 30 sec, 50 °C for 30 sec, and 72 °C for 45 sec; 72 °C for 7 min. PCR products were purified and sequenced by Macrogen Korea. The sequences obtained were than submitted to GenBank (Table 1).

Table 1. GenBank accession numbers for leech sequences used in the phylogenetic analysis of *Placobdelloides*.

Taxon	Locality	GenBank accession numbers	
		COI	ND1
Ingroup			
Placobdelloides sirikanchanae sp. nov.	Songkhla, Thailand	MK282428	MK282433
	Songkhla, Thailand	MK282429	MK282434
	Songkhla, Thailand	MK282430	MK282435
	Songkhla, Thailand	MK282431	MK282436
	Songkhla, Thailand	MK282432	MK282437
Placobdelloides jaegerskioeldi (Johansson, 1909)	Sudan, South Africa	AY962463	AY962450
Placobdelloides multistriatus (Johansson, 1909)	Louisiana, USA	DQ414338	DQ414383
Placobdelloides siamensis (Oka, 1917)	Bangkok, Thailand	AY962449	AY962462
	Bangkok, Thailand	MH777415	MH777409
	Bangkok, Thailand	MH777416	MH777410
	Bangkok, Thailand	MH777417	MH777411
	Bangkok, Thailand	MH777418	MH777412
	Bangkok, Thailand	MH777419	MH777413
	Bangkok, Thailand	MH777420	MH777414
	Udon Thani, Thailand	MN221458	MN242784
	Udon Thani, Thailand	MN221459	MN242785
	Udon Thani, Thailand	MN221460	MN242786
Outgroup			
Alboglossiphonia heteroclita (Linnaeus, 1761)	Michigan, USA	AF116016	AY047339
Alboglossiphonia quadrata (Moore, 1949) Sawyer, 1986	Namibia, South Africa	AY962455	AY962441
Alboglossiphonia weberi (Blanchard, 1897b)	Hawaii, USA	AY962453	AY962440
Batracobdelloides tricarinata (Blanchard, 1897a)	Hoedspruit, South Africa	AY962457	AY962445
Glossiphonia baicalensis (Stchegolew, 1922)	Lake Baikal, Russia	AY047329	AY047355
Glossiphonia complanata (Linnaeus, 1758)	United Kingdom	MF458715	AY047345
Glossiphonia concolor (Apathy, 1888)	Kila River, Sweden	AY962458	AY962446
Glossiphonia elegans (Verrill, 1872)	Connecticut, USA	AY047322	AY047335
Glossiphonia verrucata (Müller, 1844)	Rio s' Adde, Italy	AY962459	AY962447
Helobdella fusca (Castle, 1900)	Michigan, USA	AF329038	AF329061
Helobdella robusta (Shankland, Bissen & Weisblat, 1992)	Sacramento River, USA	MF067148	MF067201
Hemiclepsis marginata (Müller, 1774)	Étang de la Musse, France	AF003259	AY047336
Hirudo medicinalis (Linnaeus, 1758)	Gotland, Sweden	HQ333517	KU672396
Marsupiobdella africana Goddard & Malan, 1912	South Africa	AF116015	AY047347
Placobdella montifera (Moore, 1906)	Washington, USA	MF067129	MF067212
Placobdella pediculata (Hemingway, 1908)	Lake Pepin, USA	MF067121	MF067222
Theromyzon bifarium Oosthuizen & Davies, 1993	North USA	AY047330	AY047356
Theromyzon tessulatum (Müller, 1774)	Europe	AY047318	AY047338

Statistical analysis

The DNA sequences were aligned using ClustalW v. 1.83 (Thompson et al. 1994) and analyzed using MEGA6 v. 6 (Tamura et al. 2013) for maximum likelihood analysis and MrBayes v. 3.1.2 (Ronquist and Huelsenbeck 2003) for Bayesian analysis.

The maximum likelihood analysis consisted of 2000 tree search replicates, with 25 initial GAMMA rate categories and final optimization using four GAMMA shape categories. Bootstrap values were calculated using 2000 pseudoreplicates of the rapid bootstrap algorithm. Bayesian analysis was run for 20 million generations with trees sampled every 100 generations with a general time reversible (GTR) model and GAMMA distribution of nucleotide rates for all partitions. Burn-in was set to 10%. Bootstrap values ≥70% for maximum likelihood analysis and Bayesian posterior probabilities of ≥95% were considered a priori as being indicators of highly supported nodes (Felsenstein 2004).

Results

Turtle body size and prevalence

In total, six muddy puddles on rubber plantations (6°62'57.7"N, 100°41'12.7"E) were inhabited by two turtle species: *Cyclemys dentata* and *C. enigmatica* (Figure 1). Three individuals of *C. dentata* had a mean carapace length of 19.20 ± 2.36 cm (min-max: 17.50–21.90 cm), and four individuals of *C. enigmatica* had a mean carapace length of 24.02 ± 0.66 cm (min–max: 22.7–26.3 cm). Each leaf turtle had 2–3 individuals of *Placobdelloides sirikanchanae* sp. nov. attached to it. In total, twenty individuals of *P. sirikanchanae* were removed, mostly from the carapace or plastron surfaces. The turtles at the collecting sites were seen to be predating on small fishes and *Rhacophorus* tadpoles.

Species description

Placobdelloides Sawyer, 1986

Type species. *Placobdelloides multistriata* (Johansson, 1909) by original designation.

Genus diagnosis. eyes one pair, esophageal organ, crop caeca seven pairs, mouth pore terminal (Oosthuizen 1979).

Genus distribution. *Placobdelloides* species can be found in Africa (*P. fimbriata* (Johansson, 1909); *P. jaegerskioeldi* (Johansson, 1909); *P. multistriata* (Johansson, 1909)), Australia and United States, eastward to India (*P. fulva* (Harding, 1924); *P. emydae* (Harding, 1920); *P. undulata* (Harding, 1924); *P. horai* (Baugh, 1960); *P. indica* (Baugh, 1960)), Southeast Asia (*P. siamensis* in China and Thailand; *P. okadai* (Oka, 1925) in China; *P. okai* (Soós, 1969); *P. stellapapillosa* Govedich et al., 2002 in Malaysia and Singapore), and throughout Australia and New Zealand (*P. octostriata* (Grube, 1866); *P. maorica* (Benham, 1907); *P. bancrofti* (Best, 1931); *P. bdellae* (Ingram, 1957)).

Figure 1. Live *Placobdelloides sirikanchanae* sp. nov. (arrows) on the Asian leaf turtle (*Cyclemys dentata* (Gray, 1831)) (left) and the dark-bellied leaf turtle (*C. enigmatica* Fritz et al., 2008) (right): carapace (lower), plastron (upper).

Placobdelloides sirikanchanae **sp. nov.**
http://zoobank.org/CE96B3D0-7E8F-47D5-8212-FCFFBFA907FF
Figures 2–9

Material examined. ***Holotype*** (ZMKU-ANN-0006), puddle on rubber plantation, Sadao District, Songkhla Province, Thailand (6°62'57.7"N, 100°41'12.7"E), 21 October 2018. ***Paratypes*** (nine individuals, ZMKU-ANN-0007 to 0015), same locality data as the holotype. All collected specimens were kept in 70% alcohol and deposited at the Zoological Museum of Kasetsart University (ZMKU), Department of Zoology, Faculty of Science, Kasetsart University (13°50'53.6"N, 100°33'47.3"E) on 23 November 2018.

Diagnosis. This species can be recognized from its elongated, narrow body, crimson median dorsal line, rich dark green pigmentation, 13–17 well-developed knob papillae on each annulus, symmetrical dorsal papillae between the left and right body sides, male gonopore on XIa1/a2, female gonopore on XIa3/XIIa1, amorphous salivary glands, smooth surface with random pits inside the anterior sucker, and rugged surface with randomly distributed pits inside the posterior sucker.

Description of holotype. ***External morphology.*** A mature *Placobdelloides sirikanchanae* sp. nov. (ZMKU-ANN-0006) has an elongated, dorso-ventrally flattened, tri-annulate body (Figure 2). The relaxed body length from the anterior tip to the posterior sucker is 20.83 mm. The widest point of the relaxed body (annuli 35; XV) is 4.21 mm. The cup-shaped anterior sucker diameter is 1.17 mm. The anterior sucker surface is smooth with numerous pits distributed inside (Figure 3; paratype ZMKU-ANN-0009). One pair of dark spherical eyes touch each other on somite III (Figure 4). The entire dorsal surface is quite rough, with 13–17 well-developed knob papillae present on each annulus (Figure 5; paratype ZMKU-ANN-0010). The dorsal papillae present a symmetrical pattern between the left and right sides of the crimson median line. The dorsal color is dark brown to greenish. The numerous respiratory pores are randomly distributed on the dorsal surface. The ventral surface is transparent and smooth. Two gonopores are located around the neck region and separated by two annuli. The male gonopore is situated in a furrow of XIa1/a2, between annuli 23 and 24 (Figure 6; paratype ZMKU-ANN-0009). The female pore lies in a furrow of XIa3/XIIa1, between annuli 25 and 26. The anus opening is on the dorsal furrow anterior to the last annulus (69; XXXIV). The posterior sucker diameter is 2.08 mm. The posterior sucker surface is rough with randomly distributed pits inside (Figure 7; paratype ZMKU-ANN-0009).

Annulation. Somites I-III are uni-annulate, IV and V are biannulate (annuli 4–7), VI-XIV are tri-annulate (annuli 8–34), XV-XVIII are uni-annulate (annuli 35–38), XIX-XXV are tri-annulate (annuli 39–59), XXVI is biannulate (annuli 60–61), and XXVII-XXXIV are uni-annulate (annuli 62–69).

Internal morphology. ***Digestive system*:** A cylindrical slender proboscis resides in a membranous sheath that protrudes through the lip of the posterior subterminal mouth (Figure 9). The proboscis sheath line is on VIa1-Xa2 (annuli 8–21). Amorphous

Figure 2. Dorsal surface (upper) and ventral surface (lower) of the live holotype of *Placobdelloides sirikanchanae* sp. nov.

salivary glands are packed on Xa2-XIa3 (annuli 21–25), followed by the esophageal glands on XIa1-XIIa1 (annuli 23–26). Each esophageal gland has a salivary duct that joins it to each side of the esophagus. Seven pairs of crop cecae are on XIIIa2-XXIIIa1 (annuli 30–51) with the last pair on XXIIIa1-XXXI (annuli 51–66) being diverted and extended posteriorly into four post cecae. Four pairs of diverticulated intestine are on XXIIIa1-XXXIII (annuli 51–68). A simple narrow rectum resides on XXVIa2-XXXIV (annuli 61–69) and opens dorsally at the anus in a furrow anterior of the last somite (XXXIV, annulus 69).

Reproductive system. The male gonopore rim is thick and curled. The ejaculatory bulb on XIa2-XIIa2 (annuli 24–27) is an apple-like sac opening into the vas deferens. Two vas deferens extend posteriorly and recurve in front of post ceca anteriorly to connect to the testisacs. Six pairs of ovoid testisacs are present, and each is located in the

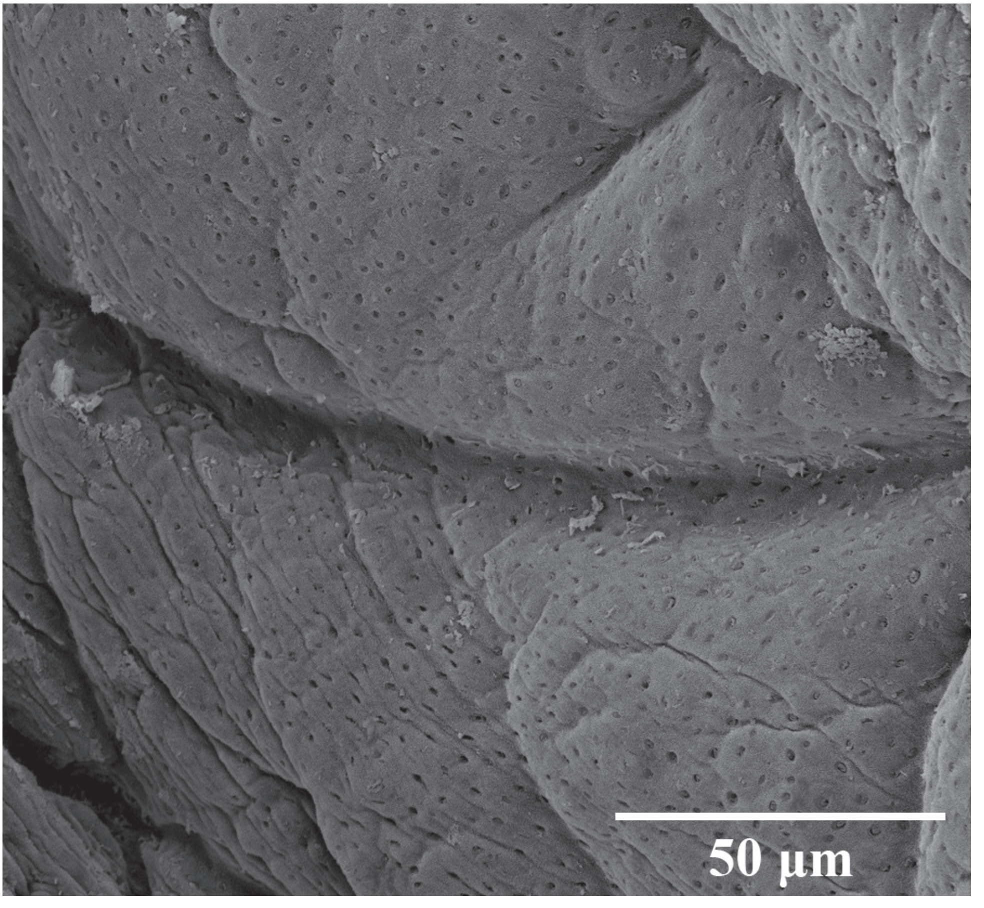


Figure 3. Scanning electron micrograph of anterior sucker of the paratype ZMKU-ANN-0009 of *Placobdelloides sirikanchanae* sp. nov. showing smooth surface with numerous pits.

space between a pair of crop cecae. The female gonopore rim is thinner and smoother than that of the male. The spermatheca is a rectangular sac on XIIa2-XIIIa3 (annuli 27–31), which opens into bifurcated ovisacs.

Variation. ***External morphology.*** The average relaxed body length is 10.77 mm long (range 7.62–40.39 mm, *N* = 20), and the average relaxed body width at the widest point (annuli 35, XV) is 3.96 mm (range 3.52–4.89 mm, *N* = 20). The average anterior sucker diameter is 1.08 mm (range 0.93–1.42 mm, *N* = 20). The average posterior sucker diameter is 1.94 mm (range 1.70–2.60 mm, *N* = 20), half the size of the maximum body width.

Color in life is uniformly dark brown to greenish, with randomly distributed dark brown, red, yellow, and especially rich dark green pigments. There is a crimson median line present dorsally from the neck region to the posterior sucker (Figure 8). On the margin of the body, brown, dark green and yellow spots are present along the posterior sucker. The ventral surface is transparent.

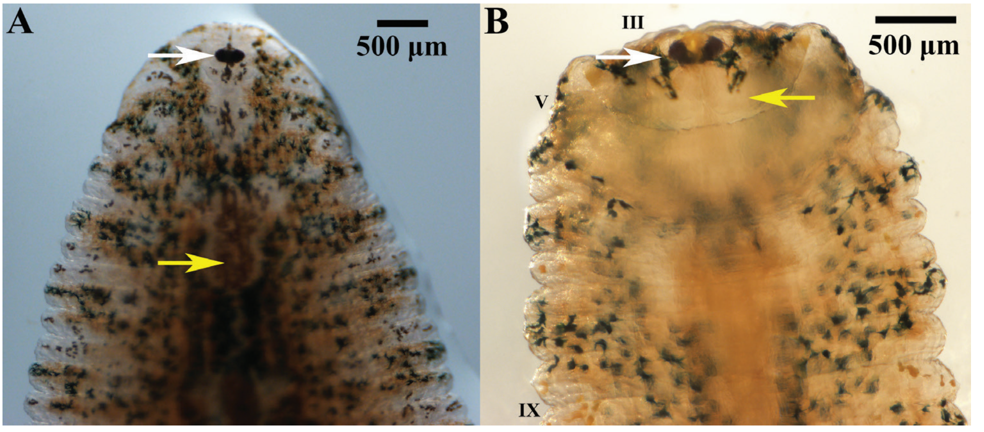


Figure 4. Anterior part of the live holotype of *Placobdelloides sirikanchanae* sp. nov. (**A**) Dorsal surface showing eyes touching on somite III (white arrow) and crimson red dorsal median line (yellow arrow), (**B**) Ventral surface showing rolled anterior lip (yellow arrow) and eyes (white arrow).

Reproductive system. The length of the ovisacs depends on the reproductive stage. During the normal, non-reproductive period, ovisacs are present on XIIIa1-XIVa1 (annuli 29–32), but they can extend from XIIIa1 to XXa1 (annuli 29 to 42 (4th pair of crop cecae)) during the gestational period.

Molecular description. Molecular comparisons based on *p*-distances among five specimens of *P. sirikanchanae* sp. nov. from a rubber plantation in the Sadao District, Songkhla Province, Thailand revealed a difference of 2.5–6.2% for 518 nucleotides of COI (GenBank MK282428–MK282432) and 1.3–3.3% for 555 nucleotides of ND1 (GenBank MK282433–MK282437) (see Tables 2, 3). The five specimens of *P. sirikanchanae* revealed differences based on *p*-distances of 10.4–27.7% for the COI gene and 5.4–6.9% for ND1 compared to ten specimens of *P. siamensis* (GenBank AY962449, MH777415–MH777420, MN221458–MN221460 for COI, and AY962462, MH777409–MH777414, XX123456–XX13456 for ND1) collected from Bangkok and Udon Thani Province, Thailand; differences of 19.3–21.7% for the COI gene and 15.1–15.8% for ND1 compared to a specimens of *P. multistriatus* (GenBank DQ414338 for the COI gene, and DQ414383 for the ND1 gene) collected from Louisiana, USA; and differences of 21.0–23.5% for the COI gene and 15.1–16.0% for ND1 compared to a specimen of *P. jaegerskioeldi* (GenBank AY692463 for COI, and AY962450 for ND1) collected from Sudan, South Africa. The Bayesian inference and maximum-likelihood trees of the COI and ND1 genes of the glossiphoniid leeches indicated high posterior probabilities and bootstrap support values for divergence between *P. sirikanchanae* and *P. siamensis* (Figure 10).

Type host. Dark-bellied leaf turtles (*Cyclemys enigmatica*).

Additional host. Asian leaf turtles (*C. dentata*).

Habitat. *Placobdelloides sirikanchanae* sp. nov. can be found attached on the shell surface, both the carapace and plastron, of *C. dentata* and *C. enigmatica*, which inhabit the bottom of enclosed shallow muddy puddles on rubber plantations. In the rainy

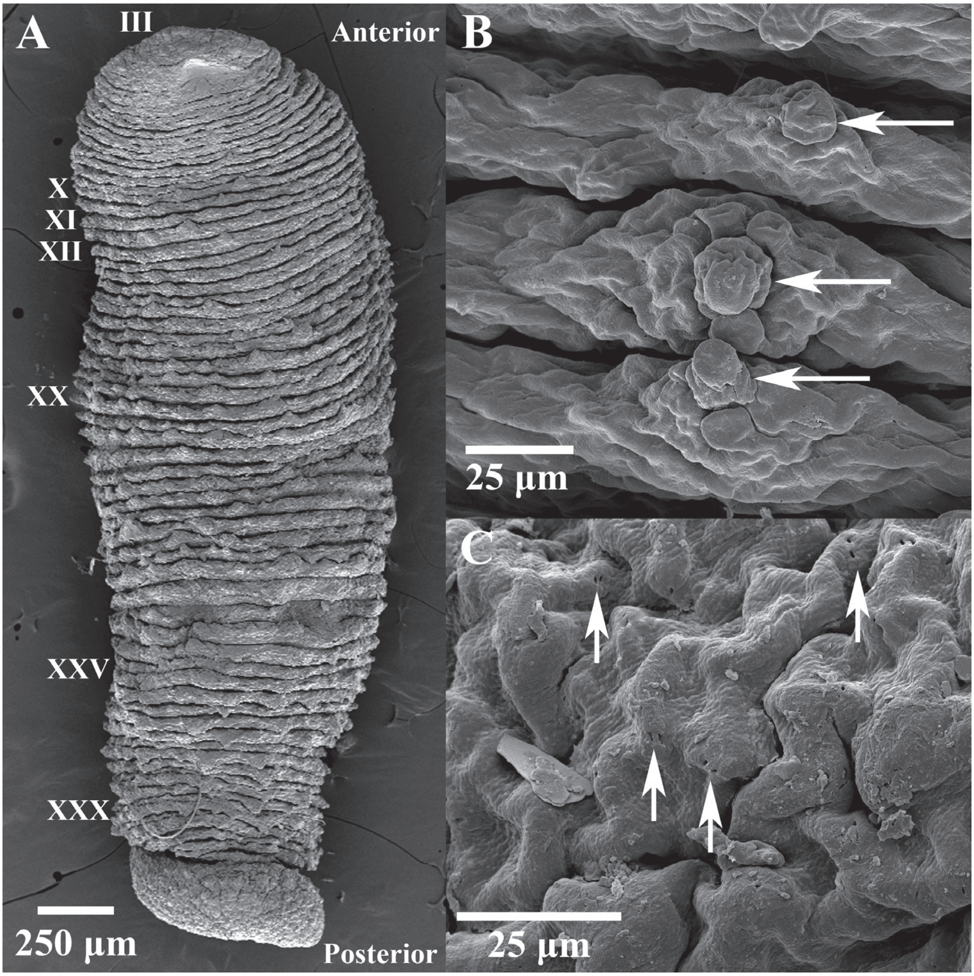


Figure 5. Scanning electron micrograph of dorsal surface of the paratype ZMKU-ANN-0010 of *Placobdelloides sirikanchanae* sp. nov. **A** Dorsal surface of the complete body **B** Dorsal papillae (arrows) **C** Respiratory pores on dorsal surface (arrows).

Table 2. *P*-distance values of COI genes within (diagonal) and among 4 species of *Placobdelloides* including *P. sirikanchanae* sp. nov. identified in this study.

Species	1	2	3	4
1 *Placobdelloides sirikanchanae* sp. nov.	2.5–6.2%			
2 *Placobdelloides siamensis*	10.4–27.7%	0.0–10.1%		
3 *Placobdelloides multistriatus*	19.3–21.7%	15.6–30.6%	–	
4 *Placobdelloides jaegerskioeldi*	21.0–23.5%	17.3–31.6%	12.6%	–

season, several puddles will be connected due to an increase in the water level. Numerous small vertebrates are present in these puddles, such as small fishes or tadpoles. In the dry season, the puddles will be disconnected as the shallower waters disappear from

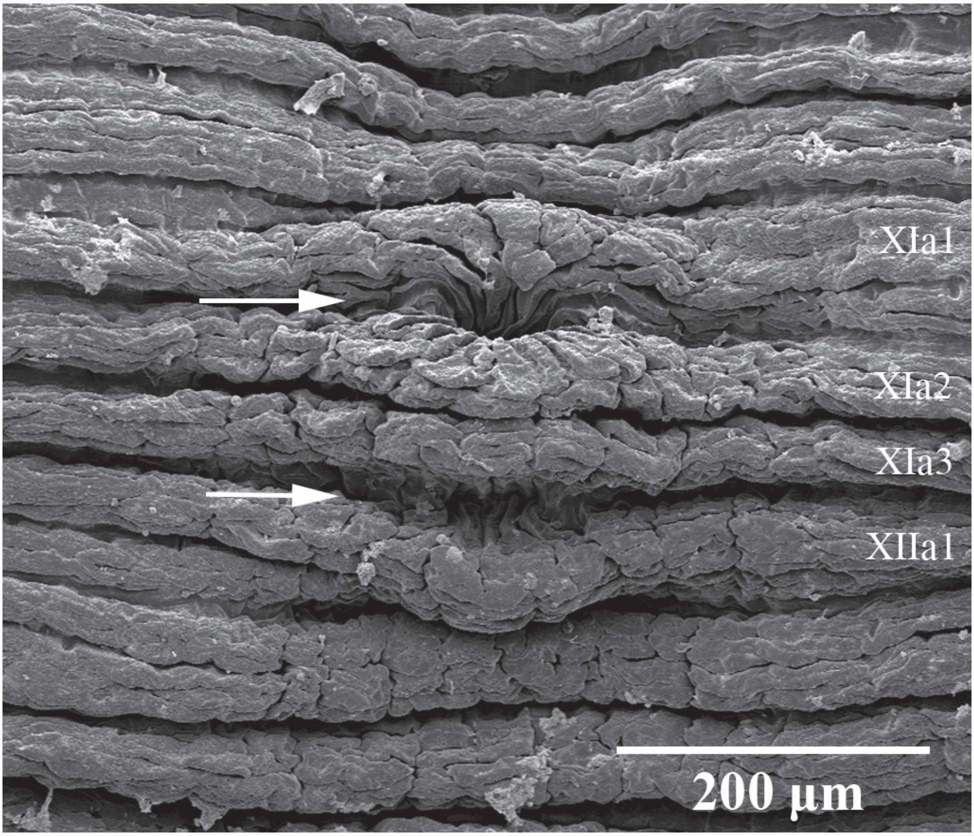


Figure 6. Scanning electron micrograph of ventral surface of the paratype ZMKU-ANN-0009 of *Placobdelloides sirikanchanae* sp. nov. showing gonopore arrangement. Upper arrow points to the male gonopore and lower arrow to the female gonopore.

Table 3. *P*-distance values of ND1 genes within (diagonal) and among 4 species of *Placobdelloides* including *P. sirikanchanae* sp. nov. identified in this study.

Species	1	2	3	4
1 *Placobdelloides sirikanchanae* sp. nov.	1.3–3.3%			
2 *Placobdelloides siamensis*	5.4–6.9%	0.0–1.7%		
3 *Placobdelloides multistriatus*	15.1–15.8%	15.1–15.4%	–	
4 *Placobdelloides jaegerskioeldi*	15.1–16.0%	13.4–13.6%	14.3%	–

evaporation. These aquatic ecosystems usually have low oxygen due to decomposition of leaf litter and nonflowing water.

Laboratory observations. Ten individuals of *P. sirikanchanae* sp. nov. were released into a tank with water from the type locality and equipped with an oxygen pump. All ten died almost immediately. The ten remaining specimens survived in a sealed bottle under low dissolved oxygen conditions. No ventilation (undulating movement display) was observed. After three days, they initiated copulation and deposited eggs in the sealed bottles.

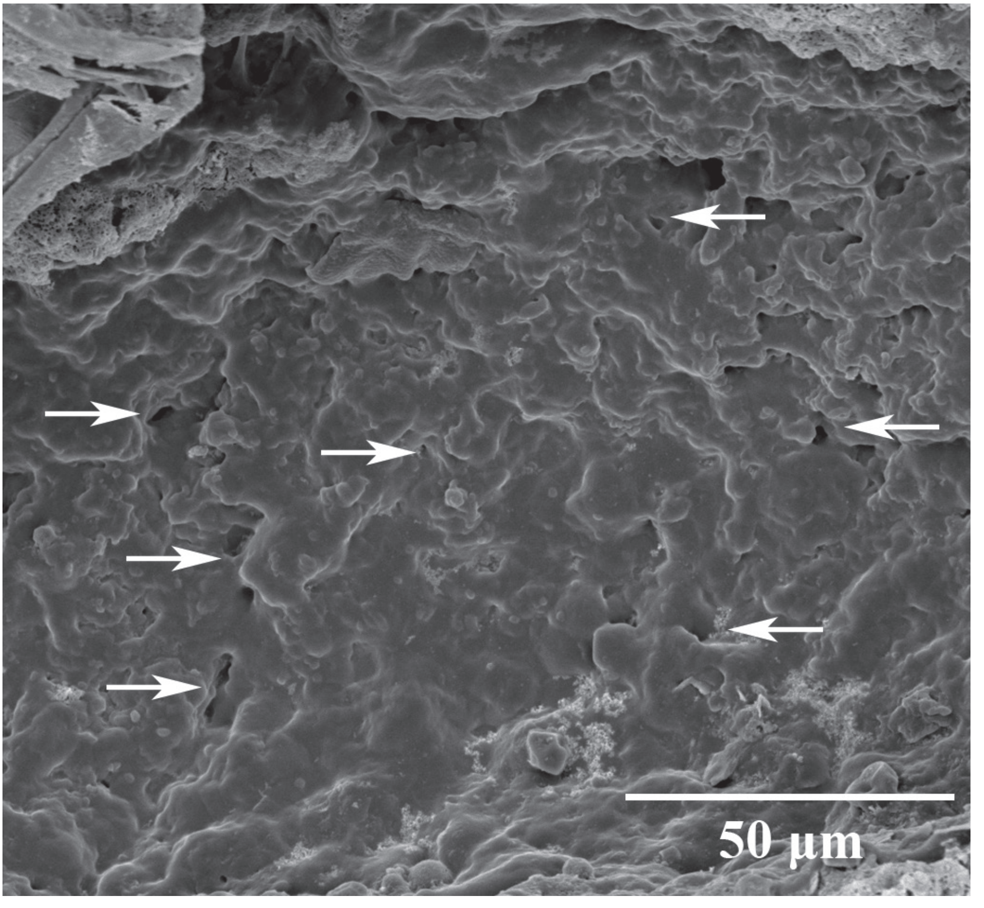


Figure 7. Scanning electron micrograph of posterior sucker of the paratype ZMUKU-ANN-0009 of *Placobdelloides sirikanchanae* sp. nov. showing rough surface with random pit distribution (white arrows).

Reproduction. Ten individuals of *P. sirikanchanae* sp. nov. displayed reproductive activity in a sealed bottle (low oxygen condition). One copulated with another individual for a few hours before they separated. The beginning of gestation was observed inside the ovisacs of both individuals (seen through the ventral surface) 2–3 days after copulation and gestation continued for approximately 3–4 days more before deposition of eggs. Round creamy-colored eggs, approximately 104–115 eggs per individual, were deposited and aggregated inside the transparent membrane beneath the venter groove of the parent (Figure 11). Eggs were incubated for 3–4 days before hatching. Juveniles remained beneath the ventral groove of the parent for 10–15 additional days before leaving the parent and living on their own.

Etymology. The species is named in honor of Associate Professor Prapaisiri Sirikanchana, the pioneer aquatic parasitologist of Thailand. The following common names, *Sirikanchana's leech* (English), *Pling Arjan Prapaisiri* (Thai), and *Sirikanchanas Plattegel* (German) are suggested.

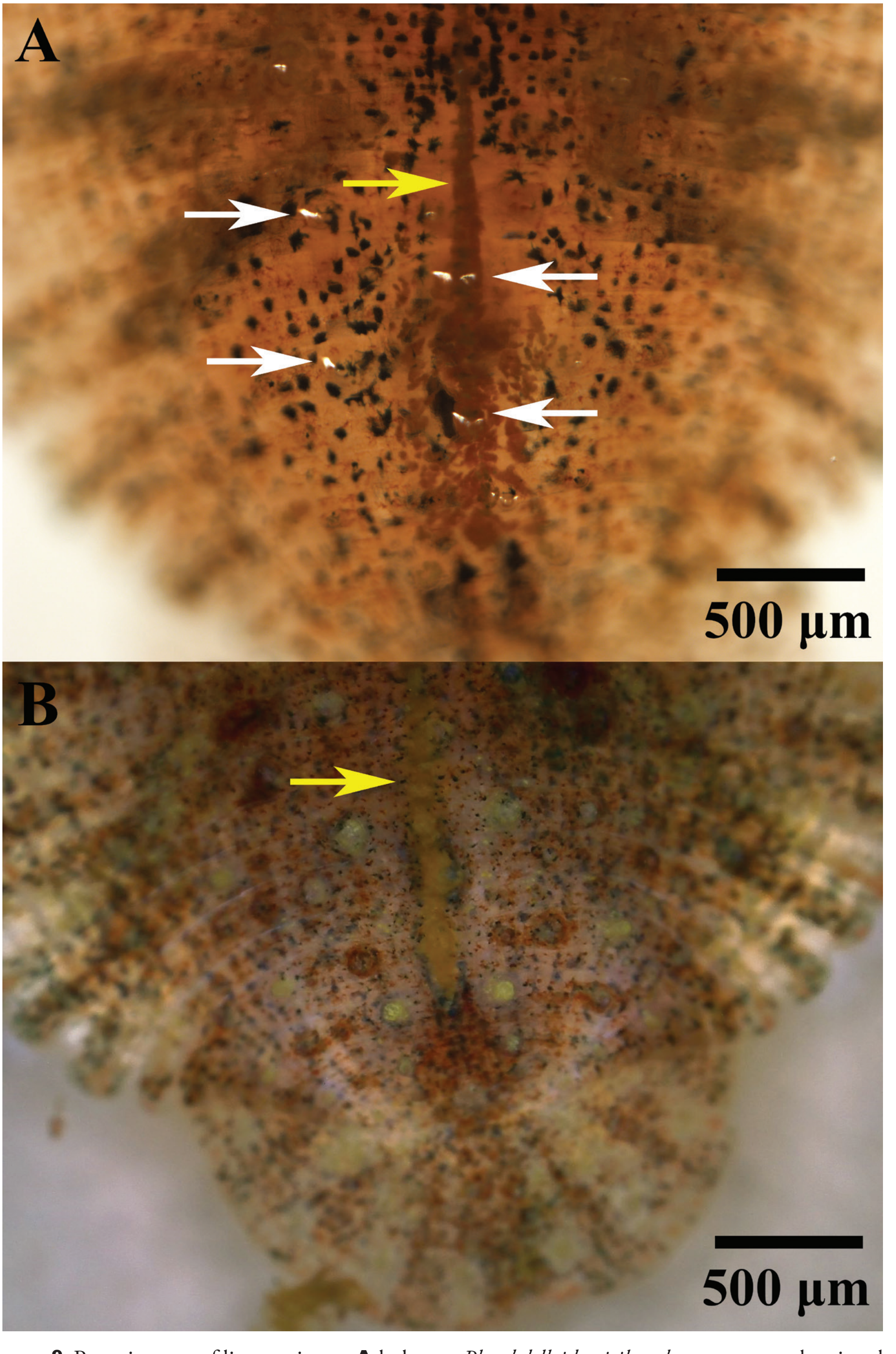


Figure 8. Posterior part of live specimens **A** holotype *Placobdelloides sirikanchanae* sp. nov. showing dorsal crimson median line (yellow arrow) with numerous scattered dark green pigments. Bubbles are emerging from the respiratory pores (white arrows) **B** *Placobdelloides siamensis* (Oka, 1917) from Bangkok, Thailand showing yellow median line (yellow arrow) with numerous scattered yellow pigments.

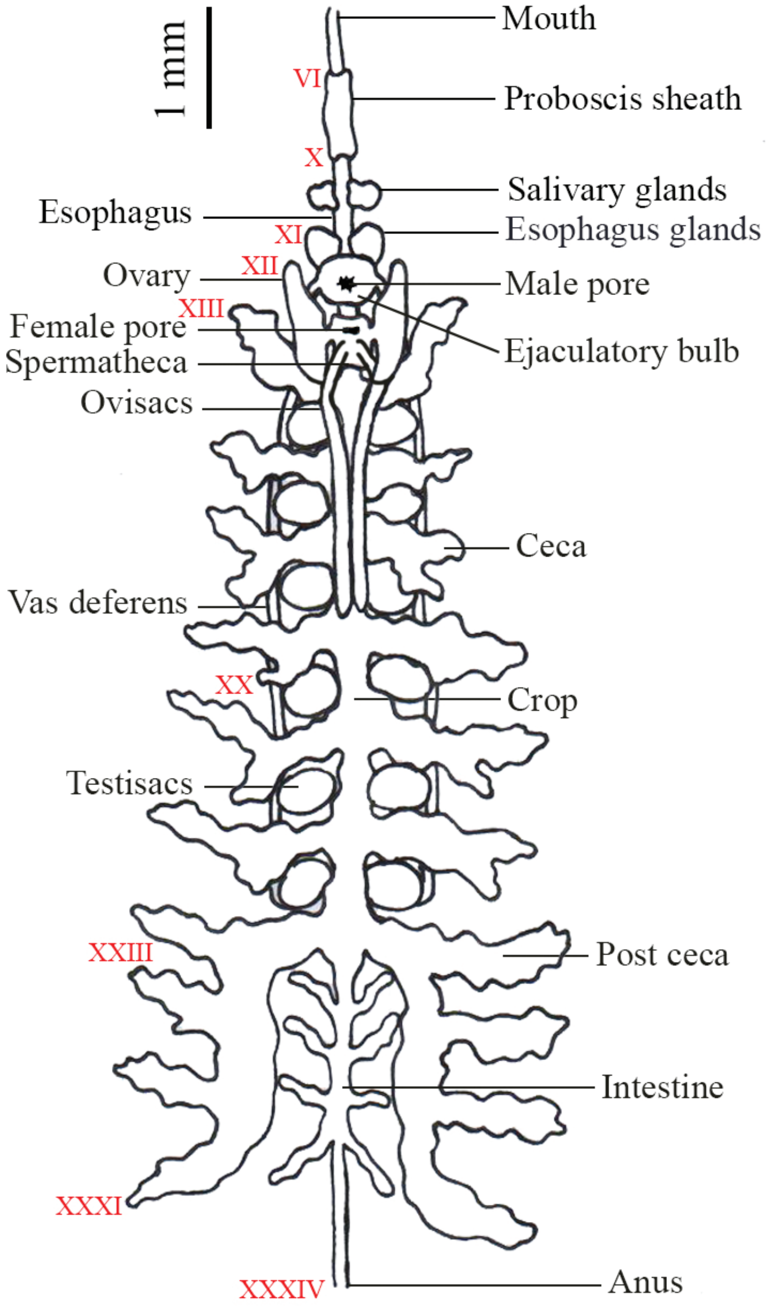


Figure 9. Internal anatomy of *Placobdelloides sirikanchanae* sp. nov.

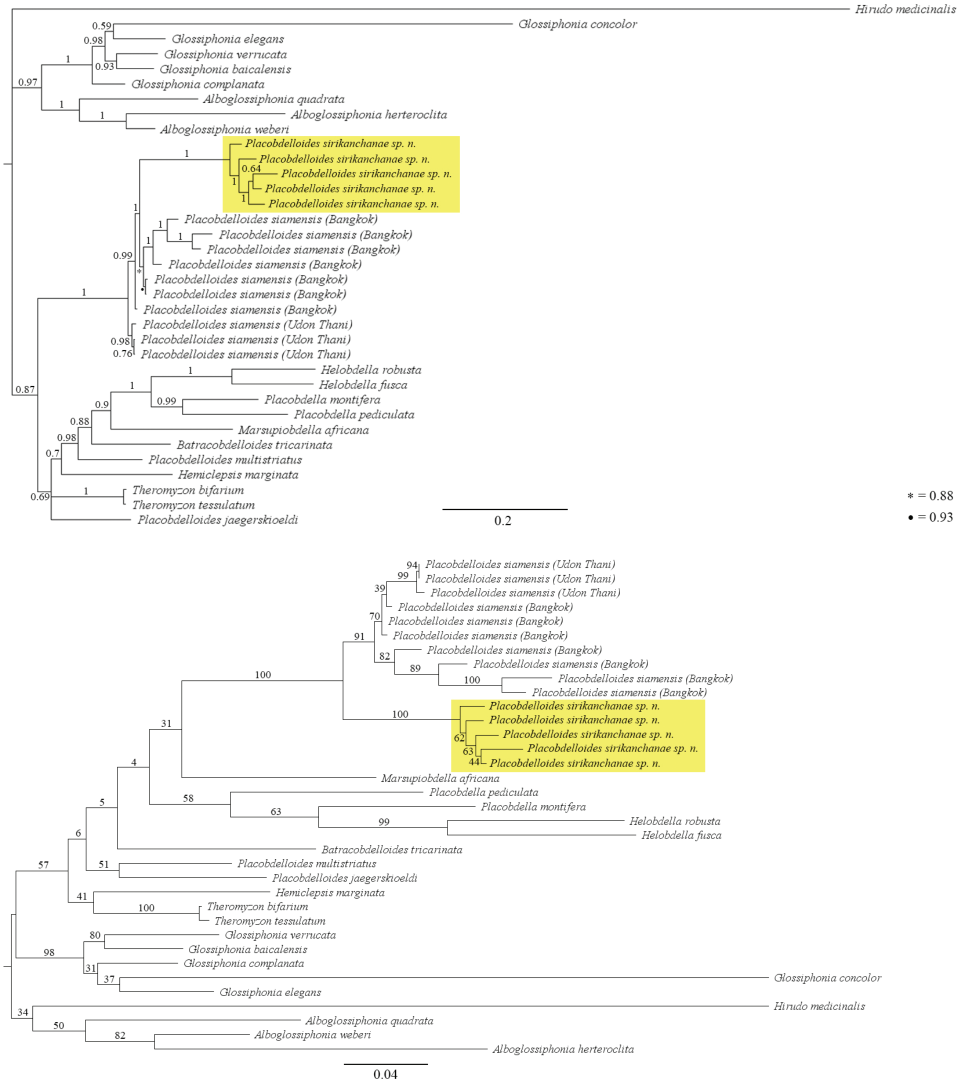


Figure 10. Phylogenetic analysis of the COI-ND1 genes of glossiphoniid leeches. The upper diagram is from the Bayesian analysis; the lower is from the maximum likelihood analysis.

Remarks. *Placobdelloides sirikanchanae* sp. nov. was distinguished from *P. siamensis* (based on the original description by Oka (1917) and the re-description by Chiangkul et al. (2018)) based on the following combination of characteristics (Table 4): elongated narrow body, smooth anterior sucker surface with numerous pits inside, 13–17 well-developed knob papillae on each annulus, 69 total annuli, dark brown to greenish color when live with a crimson median line, male gonopore between XIa1/a2 (annuli 23 and 24), female gonopore between XIa3/XIIa1 (annuli 25–26), anus opening between the last annulus and the posterior sucker, rough posterior sucker surface with random pits, and 104–115 eggs per clutch. In addition,

Figure 11. Two-day old creamy whitish coloured eggs of *Placobdelloides sirikanchanae* sp. nov. after deposition.

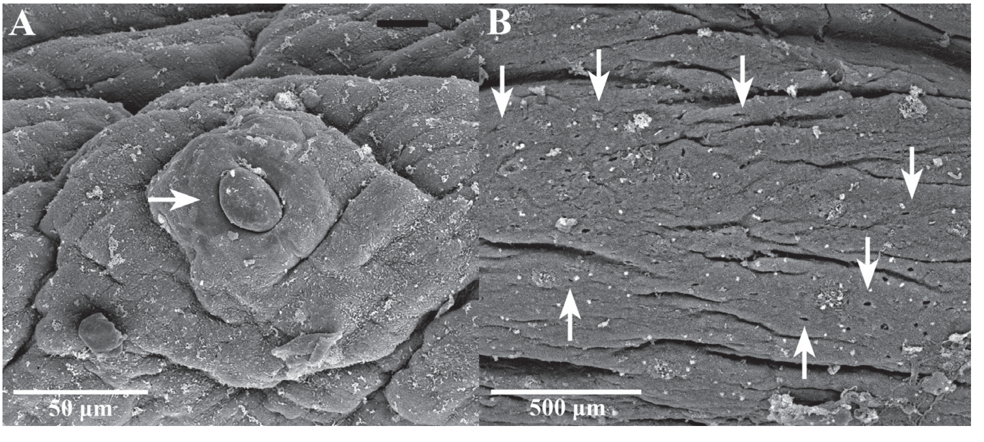


Figure 12. Scanning electron micrograph of *Placobdelloides siamensis* from previous study (Chiangkul et al. 2018) **A** dorsal papillae (arrow) **B** smooth surface with randomly scattered pits (arrows).

P. sirikanchanae was found on *C. dentata* and *C. enigmatica*, which inhabit the bottom of enclosed shallow muddy puddles on rubber plantations, differing from *P. siamensis*, in that it is found on *Cuora amboinensis*, *Heosemys annandalii*, *Malayemys macrocephala*, *M. subtrijuga*, *M. khoratensis*, and *Siebenrockiella crassicollis* inhabiting larger, more open ponds.

Table 4. Comparison of morphological characters, egg number per clutch, host, and distribution of *Placobdelloides sirikanchanae* sp. nov. and *P. siamensis* (Oka, 1917) in Thailand.

Characters	*P. sirikanchanae* sp. nov.	*P. siamensis* (Oka, 1917)	
		Oka 1917	Chiangkul et al. 2018
Host	*Cyclemys dentata* and *C. enigmatica*	*Siebenrockiella crassicollis*	*Cuora amboinensis*, *Heosemys annandalii*, *Malayemys macrocephala*, *M. subtrijuga*, *M. khoratensis*, and *S. crassicollis*
Distribution	Sadao, Songkhla	Lampam, Pattalung	Bangkok and Udon Thani
Maximum relaxed length (mm)	40.39	15.00	25.00
Maximum relaxed widest width (mm)	4.89	4.00	5.57
Body shape	Elongated narrow	Elongated oval	Elongated oval
Eye location	III	III	III
Anterior sucker diameter (mm)	1.08	2.50	1.86
Anterior sucker surface	Smooth with numerous pits	–	Smooth with numerous pit
Position of proboscis opening	Posterior subterminal	Posterior subterminal	Posterior subterminal
Number of dorsal papillae on each annulus	13–17	22–27	5–9
Shape of dorsal papillae	Well-developed knob shape	Cone shape	Well-developed longitudinal rod shape
Total annuli	69	67	69
Live dorsal color	Dark brown greenish with crimson median line	Uniform gray with faint brown median line (in alcohol)	Brownish gray with yellow median line and four pairs of scarlet dots
Male gonopore location	XIa1/a2 (annuli 23/24)	XIa3/XIIa1 (annuli 25/26)	Xa3/XIa1 (annuli 22/23)
Ejaculatory bulb	Apple-like sac	–	Glasses-like sac
Female gonopore location	XIa3/XIIa1 (annuli 25/26)	XIIa2/a3 (annuli 27/28)	XIa2/a3 (annuli 24/25)
Spermatheca	Rectangular sac	–	Slender sac
Anus location	Between last annuli and posterior sucker	Between last annuli and posterior sucker	Between last annuli and posterior sucker
Posterior sucker diameter (mm)	1.94	3.00	3.00
Posterior sucker surface	Rough with random scattered pits	–	Smooth with random scattered pits
Eggs per clutch	104–115	–	173–412

Discussion

Placobdelloides sirikanchanae sp. nov. was identified as a new leech species based on morphological and genetic characteristics and was shown to be distinct from other members of its genus. Comparison of *P. sirikanchanae* with other species of *Placobdelloides* that parasitize crocodiles and turtles revealed the following: *P. bancrofti* is distinguished from *P. sirikanchanae* by having one annulus separating the male and female gonopores and an absence of dorsal papillae; *P. emydae* has a slightly dilated head and three pairs of metameric papillae on the dorsum; *P. fimbriata* has a unique gill-like marginal fringe; *P. multistriata* has two pairs of salivary glands and the absence of dorsal papillae; the original description of *P. siamensis* from the description by Oka (1917) has an elongated oval shape, 22–27 cone papillae, and a different gonopore distribution; *P. siamensis* based on the description by Chiangkul et al. (2018), has an elongated oval shape, yellow median line, numerous scattered yellow pigments on dorsal, 5–9 well-developed rod papillae, a different gonopore distribution, and smooth posterior sucker with random pits (Figures 8, 12, clarified from previous study); and *P. stellapapillosa* Govedich et al. 2002 has a proboscis opening on the anterior subterminal mouth and unique star-shaped papillae (Oka 1917; Harding and Moore 1927; Best 1931; Sawyer 1986; Govedich et al. 2002; McKenna et al. 2005).

The phylogenies (Fig. 10) obtained in this study revealed the monophyletic relationship of *Placobdelloides* species that inhabit Thailand. The phylogenetic trees clearly indicated the divergence between *P. sirikanchanae* and *P. siamensis* (Bangkok and Udon Thani population) by having a high percentage of differences between the species for both the COI and ND1 gene. However, after several attempts, we were unable to retrieve the topotype of *P. siamensis* from Pattalung and could not conduct the sequence comparisons, but the morphological characters of *P. siamensis* from the other localities are clear and easily differentiate it from *P. sirikanchanae*. According to the phylogenetic analysis, *P. sirikanchanae* is the sister taxon of *P. siamensis* (Bangkok population).

This is the first report of the reproductive biology of *P. sirikanchanae*. This hermaphroditic leech displayed monandrous copulation and exchanged pseudospermatophores with other leeches a few hours before separation . The gestational period after copulation through egg deposition was approximately 5–7 days, which began in the ovisacs beginning 2–3 days after copulation. The family Glossiphoniidae is unique in that members of this family exhibit parental care of their eggs and juveniles (Sawyer 1971). Compared to other glossiphoniid leeches, *P. sirikanchanae* had more eggs per clutch (104–115 eggs per clutch) than *Glossiphonia complanata* (60 eggs per clutch) or *Helobdella stagnalis* (Linnaeus, 1758) (50 eggs per clutch) but fewer than *P. stellapapillosa* (100–200 eggs per clutch) and *P. siamensis* (173–412 eggs per clutch) (Kutschera and Wirtz 2001; Chiangkul et al. 2018). For the incubation period, *P. sirikanchanae* had a shorter period from egg deposition through juvenile hatching (3–4 days) compared to *H. robusta* (9 days and 13 hr) (Weisblat and Huang 2001). For the parental care period, it had a shorter period from egg deposition through separation of juveniles from the parent (13–19 days) than *G. complanata* (30 days) and *H. stagnalis* (45–50 days) (Sawyer 1986; Kutschera 1992). Therefore, *P. sirikanchanae* might currently have the smallest number of eggs per clutch in the genus *Placobdelloides* and the shortest periods of incubation and parental care in the family Glossiphoniidae.

This is the first report of *P. sirikanchanae* parasitizing Asian leaf turtles (*C. dentata*) and dark-bellied leaf turtles (*C. enigmatica*). In the field surveys of this study, both the leech and the turtles inhabited the bottom of enclosed shallow muddy puddles or patches in rubber plantations. Small puddles and patches are a temporary aquatic system that usually occurs after rain and disappears within a few weeks or months from evaporation or seeping into the ground. In addition, this aquatic system usually has low dissolved oxygen conditions from leaf decomposition and the absence of flowing water, but despite this, there were numerous small vertebrates living there, such as fishes and *Rhacophorus* tadpoles (Shahriza et al. 2010).

For *P. sirikanchanae*, its small clutch size and faster development times might be an adaptation to living in these temporary ponds. Moreover, the observed behavior in the laboratory combined with water conditions in the field indicated that *P. sirikanchanae* is a leech that can tolerate low dissolved oxygen conditions.

Cyclemys dentata and *C. enigmatica* are members of the family Geoemydidae, the main freshwater turtle family found in Thailand, along with *Cuora amboinensis*, *Heosemys annandalii*, *Malayemys macrocephala*, *M. subtrijuga*, *M. khoratensis*, and *Siebenrockiella crassicollis*, all of which are the hosts of *P. siamensis* (Oka 1917; Chiangkul et al. 2018). However, most host turtles of *P. siamensis* usually inhabit ponds, lakes, or rivers that have flowing water and differ from the habitats of *C. dentata* and *C. enigmatica* (Das 2010; Fritz et al. 2008). Accordingly, the habitat preferences of host turtles also support the identification of *Placobdelloides* leech parasites in Thailand.

Acknowledgements

This work was supported by the Human Resource Development in Science Project (Science Achievement Scholarship of Thailand, SAST), Center of Excellence on Biodiversity (BDC), Office of Higher Education Commission (Project Code BDC-PG2-161004) and the Department of Zoology, Faculty of Science, Kasetsart University. The authors would like to thank Mrs. Pooncharat Trivalairat for field guidance and collecting some of the examined leech specimens. This research was approved by the Institutional Animal Care and Use Committee, Faculty of Science, Kasetsart University, Thailand under project number ACKU61-SCI-028.

References

Apathy StV (1888) Analyse der äusseren Körperform der Hirudineen. Mittheilungen aus der Zoologischen Station zu Neapal. 8: 153–232.

Best EW (1931) The anatomy of an Australian leech *Helobdella bancrofti.* Transactions and Proceedings of the Royal Society of South Australia 55: 23–31.

Baugh SC (1960) Studies on Indian Rhynchobdellid leeches-II. Zoologischer Anzeiger 165: 468–477.

Benham WB (1907) On the Oligochaeta from the Blue Lake, Mount Kosciusko. Records of the Australian Museum 6: 251–264. https://doi.org/10.3853/j.0067-1975.6.1907.1006

Blanchard R (1897a) Hirudineen Ost-Afrikas. Die thierwelt Ost-Africas 4, Lfg. 2. Dietr. Reimer, Berlin.

Blanchard R (1897b) Hirudinées des Indes néerlandaises. Weber's Zoologische Ergebnisse einer reise In Niederländisch Ost-Indian 4: 332–356.

Boulenger GA (1903) Report on the batrachians and reptiles. Fasciculi Malayensis Zoology 1: 130–176.

Brophy TR (2004) Geographic variation and systematics in the South-East Asian turtles of the genus *Malayemys* (Testudines: Bataguridae). Hamadryad 29(1): 63–79.

Castle WE (1900) Some North American fresh-water Rhynchobdellidae, and their parasites. Bulletin of the Museum of Comparative Zoology at Harvard 36: 17–64.

Chandra M (1977) A check-list of leeches of Himachal Pradesh, India. Records of the Zoological Survey of India 73: 189–195.

Chiangkul K, Trivalairat P, Purivirojkul W (2018) Redescription of the Siamese shield leech *Placobdelloides siamensis* with new host species and geographic range. Parasite 25: 56. https://doi.org/10.1051/parasite/2018056

Cott HB (1961) Scientific results of an inquiry into the ecology and economic status of the Nile crocodile (*Crocodylus niloticus*) in Uganda and northern Rhodesia. The Transactions of the Zoological Society of London 29: 211–337. https://doi.org/10.1111/j.1096-3642.1961.tb00220.x

Das I (2010) A field guide to the reptiles of Thailand & South-East Asia. New Holland, London.

Daudin EM (1802) Histoire naturelle des rainettes, des grenouilles et des crapauds. Paris, 108 p.

Felsenstein J (2004) Inferring Phylogenies. Sinauer Associates, Sunderland, 664 pp.

Fritz U, Guicking D, Auer M, Sommer RS, Wink M, Hundsdörfer AK (2008) Diversity of the Southeast Asian leaf turtle genus *Cyclemys*: how many leaves on its tree of life?. Zoologica Scripta. https://doi.org/10.1111/j.1463-6409.2008.00332

Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R (1994) DNA primers for amplification of mitochondrial cytochrome *c* oxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology 3: 294–299.

Goddard EJ, Malan DE (1912) The South African Hirudinea. Part I. Annals of the South African Museum 11: 307–319. https://doi.org/10.5962/bhl.part.5072

Govedich FR (2001) A reference guide to the ecology and taxonomy of freshwater and terrestrial leeches (Euhirudinea) of Australasia and Oceania. Cooperative research centre for freshwater ecology identification guide no. 35, Thurgoona, New South Wales.

Govedich FR, Bain BA, Davies RW (2002) *Placobdelloides stellapapillosa* sp. nov. (Glossiphoniidae) found feeding on crocodiles and turtles. Hydrobiologia 474: 253–256. https://doi.org/10.1023/A:1016591922650

Grantham BA, Hann BJ (1994) Leeches (Annelida: Hirudinea) in the experimental lakes area, northwestern Ontario, Canada: Patterns of species composition in relation to environment. Canadian Journal of Fisheries and Aquatic Sciences 5: 1600–1607.

Gray JE (1831) A synopsis of the species of class Reptilia. In: Griffith E, Pidgeon E (Eds) The animal kingdom arranged in conformity with its organisation by the Baron Cuvier with additional descriptions of all the species hitherto named, and of many not before noticed. Vol1. 9. Reptilia. Supplement. London: Whittaker, Treacher, Co., 1–110.

Gray JE (1859) Description of a new species of freshwater tortoise from Siam. The Annals and Magazine of Natural History 3(5): 501–502.

Grube AE (1866) Eine neue Annelida, zunäechst einer nordischen, in der Nähe der Ophelien und Scalibregmen zu stellenden Annelide. Euzonus arcticus. Jahres-Bericht der Schlesischen Gesellschaft für Vaterländische Culture, Breslau 43: 64–65.

Harding WA (1920) Fauna of the Chika Lake: Hirudinea. Memoirs of the Indian Museum 5(7): 509–518.

Harding WA (1924) Description of some new leeches from India, Burma and Ceylon. The Annals and Magazine of Natural History 14(9): 489. https://doi.org/10.1080/00222932408633143

Harding WA, Moore JP (1927) Hirudinea. In the fauna of British India, including Ceylon and Burma. London, 302 pp.

Hemingway EE (1908) *Placobdella pediculata* n. sp. The American Naturalist 42: 527–532. https://doi.org/10.1086/278964

Ihlow F, Vamberger M, Flecks M, Hartmann T, Cota M, Makchai S, Meewattana P, Dawson JE, Long Kheng L, Rödder D, Fritz U (2016) Integrative Taxonomy of Southeast Asian Snail-Eating Turtles (Geoemydidae: Malayemys) Reveals a New Species and Mitochondrial Introgression. PLoS ONE 11(4):e0153108. https://doi.org/10.1371/journal.pone.0153108

Ingram DM (1957) Some Tasmanian Hirudinea. Papers and Proceedings of the Royal Society of Tasmania 91: 191–232.

Johansson L (1909) Einige neue Arten Glossosiphoniden aus dem Sudan. Zoologischer Anzeiger 165: 468–477.

Kruger N, Du Preez LD (2015) Reproductive strategies of the kangaroo leech, *Marsupiobdella africana* (Glossiphoniidae). International Journal for Parasitology: Parasite and Wildlife 4(1): 142–147.

Kutschera U (1992) Reproductive behavior and parental care of the leech *Helobdella triserialis* (Hirudinea: Glossiphoniidae). Zoologischer Anzeiger 228: 74–81.

Kutschera U, Wirtz P (2001) The evolution of parental care in freshwater leeches. Theory in Biosciences 120: 115–137. https://doi.org/10.1007/s12064-001-0012-1

Light JE, Siddall ME (1999) Phylogeny of the leech family Glossiphoniidae based on mitochondrial gene sequences and morphological data. Parasitology 85: 815–823. https://doi.org/10.2307/3285816

Linnaeus C (1758) Systema naturae. Lipsiae (10th edn). Hirudinea. 648–651.

Linnaeus C (1761) Fauna Suecica sistens Animalia Sueciae Regni: Mammalia, Aves, Amphibia, Pisces, Insecta, Vermes. Distributa per Classes, Ordines, Genera, Species, cum Differentiis Specierum, Synonymis Auctorum, Nominibus Incolarum, Locis Natalium, Descriptionibus insectorum. Editio altera, auctior. L. Salvii, Stockholmiae. https://doi.org/10.5962/bhl.title.46380

McKenna SA, Betts DA, Pong WW, Govedich FR, Barton DP (2005) A redescription of the Australian Leech *Placobdelloides bancrofti* with new records of its distribution. The Journal of Parasitology 91(1): 117–121. https://doi.org/10.1645/GE-162R

Mason J (1974) Studies on the freshwater and terrestrial leeches of New Zealand – 1 Family Glossiphoniidae Vaillant. Journal of the Royal Society of New Zealand 4(3): 327–343. https://doi.org/10.1080/03036758.1974.10419401

Moore JP (1906) Hirudinea and Oligochaeta collected in the Great Lakes region. Bulletin of the Bureau Fisheries 25: 153–171.

Moore JP (1949) Hirudinea. In: Kenk R (Ed.) The Animal Life of Temporary and Permanent Ponds in Southern Michigan. Miscellaneous Publication of the Museum of Zoology, University of Michigan 71: 38–39.

Müller OF (1774) Vermium terrestrium et fluviatilium. Heineck & Faber 1: 1–214.

Müller F (1844) Hirudinibus circa Berolinum hucusque observatis. Universität Berlin, Dissertation, 36 pp.

Nesemann H, Sharma G, Sinha RK (2004) Aquatic Annelida (Polychaeta, Oligochaeta, Hirudinea) of the Ganga River and adjacent water bodies in Patna (India: Bihar), with description of a new leech species (Family Salifidae). Naturhistorisches Museum Wien 105: 139–187.

Oka A (1917) Zoological results of a tour in the Far East. Hirudinea. Memoirs of the Asiatic Society of Bengal 6: 157–176.

Oka A (1925) Notices sur les Hirudine Hirudinées d'Extrême Orient. Annotationes Zoologicae Japonenses 10: 311–335.

Oosthuizen JH (1979) Redescription of *Placobdella multistriata* (Johansson, 1909) (Hirudinea: Glossiphoniidae). Koedoe 22: 61–79. https://doi.org/10.4102/koedoe.v22i1.651

Oosthuizen JH, Davies RW (1993) A new species of *Theromyzon* (Rhynchobdellida: Glossiphoniidae), with a review of the genus in North America. Canadian Journal of Zoology 71(7): 1311–1318.

Ronquist F, Huelsenbeck JP (2003) MRBAYES 3: Bayesian phylogenetic inference under mixed model. Bioinformatics 19: 1572–1574. https://doi.org/10.1093/bioinformatics/btg180

Sawyer RT (1971) The phylogenetic development of brooding behavior in the Hirudinea. Hydrobiologia 37(2): 197–204. https://doi.org/10.1007/BF00015567

Sawyer RT (1986) Leech biology and behaviour. Vol. II: Feeding biology, ecology and systematics. Oxford University Press, Oxford, 741–749.

Schlegel H, Müller S (1845) Over de Schildpadden van den Indischen Archipel. In: Temminck, V. (1839–1847) Verhandelingen over de natuurlijke geschiedenis der Nederlandsche overzeesche bezittingen, door de leden der Natuurkundige Commisie in Oost-Indie en andere schrijvers. Leijden folio. Afd. 1 Zoologie in 12 afleveringen, met.

Shahriza S, Ibrahim H, Shahrul Anuar MS (2010) The correlation between total rainfall and breeding parameters of White-lipped frog, *Rana labialis* (Anura: Ranidae) in Kedah, Malaysia. Tropical Natural History 10(2): 131–139.

Shankand M, Bissen ST, Weisblat DA (1992) Description of the Californian leech *Helobdella robusta* sp. nov., and comparison with *Helobdella triserialis* on the basis of morphology, embryology, and experimental breeding. Canadian Journal of Zoology 70(6): 1258–1263. https://doi.org/10.1139/z92-174

Siddall ME, Burreson EM (1994) The development of a hemogregarine of *Lycodes raridens* from Alaska in its definitive leech host. Journal of Parasitology 80: 569–575. https://doi.org/10.2307/3283193

Siddall ME, Budinoff RB, Borda E (2005) Phylogenetic evaluation of systematics and biogeography of the leech family Glossiphoniidae. Invertebrate Systematics 19: 105–112. https://doi.org/10.1071/IS04034

Soós Ă (1969) Identification key to the leech (Hirudinoidea) genera of the world, with a catalogue of the species. VI Family: Glossiphoniidae. Acta Zoologica Academiae Scientiarum Hungaricae 15: 397–454.

Stchegolew GG (1922) A new species of leech from Baikal Russia. Hydrobiological Journal 1: 136–142.

Tamura K, Stecher G, Peterson D, Filipski A, Kumar S (2013) MEGA6: Molecular Evolutionary Genetics Analysis Version 6.0. Molecular Biology and Evolution 30: 2725–2729. https://doi.org/10.1093/molbev/mst197

Thompson JD, Higgins DG, Gibson TJ (1994) CLUSTAL W: Improving the sensitivity of progressive multiple sequence alignment through sequence weighting. position-specific gap penalties and weight matrix choice Nucleic Acids Research 22: 4673–4680. https://doi.org/10.1093/nar/22.22.4673

Tucker AD, Fitzsimmons NN, Govedich FR (2005) Euhirudinea from Australian turtles (*Chelodina burrungandjii* and *Emydura australis*) of the Kimberley Plateau, Western Australia, Australia. Comparative Parasitology 72(2): 241–244. https://doi.org/10.1654/4175

Verrill AE (1872) Descriptions of North American fresh water leeches. Report of United States Fish Commission 1872 (73): 666–689.

Weisblat DA, Huang FZ (2001) An overview of glossiphoniid leech development. Canadian Journal of Zoology 79: 218–232. https://doi.org/10.1139/z00-199

ZooKeys 882: 25–28 (2019)
doi: 10.3897/zookeys.882.38423
http://zookeys.pensoft.net

REVIEW ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

Clarification of the status of the type series and of the holotype of *Cyclophorus* (*Glossostylus*) *koboensis* Godwin-Austen, 1915 (Mollusca, Caenogastropoda, Cyclophoridae) in Nantarat et al. (2014)

Sheikh Sajan[1], Basudev Tripathy[1], Fred Naggs[2]

1 *Malacology Division, Zoological Survey of India, Prani Vigyan Bhawan, M-Block, New Alipore, Kolkata 700053, West Bengal, India* **2** *Department of Life Sciences, The Natural History Museum, Cromwell Road, London SW7 5BD, UK*

Corresponding author: *Sheikh Sajan* (sksajan.sajan@gmail.com)

Academic editor: *Eike Neubert* | Received 22 July 2019 | Accepted 11 September 2019 | Published 23 October 2019

http://zoobank.org/32728CC9-A2CD-4F4B-8BCF-EEBA216E61AD

Citation: Sajan S, Tripathy B, Naggs F (2019) Clarification of the status of the type series and of the holotype of *Cyclophorus* (*Glossostylus*) *koboensis* Godwin-Austen, 1915 (Mollusca, Caenogastropoda, Cyclophoridae) in Nantarat et al. (2014). ZooKeys 882: 25–28. https://doi.org/10.3897/zookeys.882.38423

Abstract
Here, the clarification of the “type” status for *Cyclophorus* (*Glossostylus*) *koboensis* Godwin-Austen, 1915 catalogued by Nantarat et al. (2014) is corrected and briefly discussed.

Keywords
Gastropoda, nomenclature, typification, NZSI, India

In describing *Cyclophorus* (*Glossostylus*) *koboensis* Godwin-Austen (1915) explicitly stated that his measured specimen from Kobo in the Abor Hills on the right bank of the Tsanspu or Brahmaputra, no. 6015, collected by Kemp, was the type and that it was deposited in the Indian Museum. Lot numbers 6019-20 from Rotung, collected by Kemp, were also deposited in the Indian Museum. All three lots are now held in the National Zoological Collection of Zoological Survey of India (NZSI). Three additional paratype lots, numbers 3579 from Rotung collected by Oakes (Godwin-Austen 1915: figs 4a–d), 3117 from Yamne Valley, and 3045 from Ponging, were deposited in the “BM”, more correctly the British Museum (Natural History), BM(NH), now the

Natural History Museum, London, NHM. Previously included within Assam, these localities now come within the East Siang district of Arunachal Pradesh, India (Table 1). The upper reaches of the Brahmaputra are currently named the Yarlung Tsangpo. During review of the type of *Cyclophorus* and comparing it with the original literature and that of Nantarat et al. (2014), we noticed that the *Cyclophorus* (*Glossostylus*) *koboensis* was erroneously designated as "lectotype" in a recent publication by Nantarat et al. (2014). In this paper, we correct and clarify the type status for *Cyclophorus* (*Glossostylus*) *koboensis* Godwin-Austen, 1915.

Godwin-Austen (1915: 495, fig. 4) described and illustrated the "type" specimen of *Cyclophorus koboensis* and clearly stated that "type" specimen was housed in the Indian Museum (= NZSI). However, Nantarat et al. (2014) catalogue of *Cyclophorus* types held in the Natural History Museum, London, failed to recognise the original holotype designation and designated a lectotype for *Cyclophorus* (*Glossostylus*) *koboensis* Godwin-Austen, 1915 (NHMUK 1903.7.1.3579/1). Their lectotype designation is therefore invalid. Nantarat et al. (2014) gave the type locality as Kobo whereas there can be little doubt that the locality for their invalidly designated lectotype was Rotung. This confusion can be attributed to the labelling that accompanies lot 3579 in the NHM collections, which states in Godwin-Austen's distinctive handwriting on the base of the box containing the four paratypes "*Cyclophorus koboensis*, G-A. Co Type. Kobo R.B. Brahmaputra. Assam. Capt. Oakes R.E.) Rec Ind Mus. Vol. VII. P. 495. Pl XXXVIII. figs 4–4d. 3579.03.VII.1". 'Type Indian Museum' has been subsequently added to the label in a different hand. However, the entry in the registration book gives the locality as 'Rotung, Abor Hills'; the original description states 'Rotung (Oakes)' and this is re-

Table 1. Detailed information on the type series of *Cyclophorus* (*Glossostylus*) *koboensis* Godwin-Austen, 1915 present in the National Zoological Collection of Zoological Survey of India, Kolkata, and Natural History Museum, London.

Type status and registration numbers	Localities in Abor Hills, Arunachal Pradesh	Collector	Latitude / Longitude	Altitude (m.)
Holotype NZSI M.6015/1	**Type Locality**: Kobo on right bank of Tsanspu or Brahmaputra River	SW Kemp	27.881588, 95.123787	375
2 Paratypes NZSI M.6019-20	Rotung, East Siang district	SW Kemp	28.133123, 95.14069	506
4 Paratypes NHMUK 1903.7.1.3579/1 is Godwin-Austen's figured specimen Plate XXXVIII, figures 4a-b, and the invalidly designated lectotype of Nantaret et al. 2014: figure 12A (1–3). Nanteret et al. (2014) invalidly attributed paralectotype NHMUK 1903.7.1.3579/2, their figure 12B (1–3) = (Godwin-Austen's figure 4c-d) NHMUK 1903.7.1.3579/3–4, unfigured	Rotung, East Siang district	Oakes	28.133123, 95.14069	506
2 Paratypes NHMUK 1903.7.1.3117/1–2 (register incorrectly states 1 specimen)	Yamne Valley, East Siang district	SW Kemp (from NHM register)	28.197478, 95.221596	442
3 Paratypes NHMUK 1903.7.1.3045/1–3	Ponging, East Siang district	Oakes (from NHM register)	28.18039, 95.202874	700

Figure 1. Shell of *Cyclophorus* (*Glossostylus*) *koboensis* Godwin-Austen, 1915 present in National Zoological Collection of ZSI. **A–G** "type" NZSI M.6015/1 (originally designated by author) **H** original handwritten label by Godwin-Austen, 1915 with "type" **I–J** registration number and label. Scale bars: 10 mm.

peated in the caption to the two paratypes, figures 4a, 4b and 4c, 4d. We conclude that the labelling with lot 3579 was a mistake on Godwin-Austen's part. The two figured specimens from this lot are shown from different views, two different views for each; these figured paratypes are not labelled separately in the NHM collections but their distinctive markings allow them to be recognised. Inexplicably, the holotype, figure 4, was shown by Godwin-Austen in apertural view only. Figures of standard views of the holotype are provided for the first time (Fig. 1) with detailed information on the type series and the location of collection sites (Table 1).

Acknowledgements

We are grateful the Director, Zoological Survey of India for providing the necessary facilities. We are thankful to the officer-in-charge and staff of Malacology Division of the Zoological Survey of India, Kolkata for their help during the examination of the material. This work was supported by the MoEF&CC through the NMHS vide Grant No. NMHS–LG-2016/0011/8509-8.

References

Godwin-Austen HH (1915) Zoological results of the Arbor expedition, XXXIX Mollusca III. Cyclophoridae. Records of the Indian Museum 8: 493–503. https://doi.org/10.5962/bhl.part.1195

Nantarat N, Sutcharit C, Tongkerd P, Ablett J, Naggs F, Panha S (2014) An annotated catalogue of type specimens of the land snail genus *Cyclophorus* Monfort, 1810 (Caenogastropoda, Cyclophoridae) in the Natural History Museum, London. ZooKeys 411: 1–56. https://doi.org/10.3897/zookeys.411.7258

ZooKeys 882: 29–39 (2019)
doi: 10.3897/zookeys.882.38811
http://zookeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

Two new species of the primitively segmented spider genus *Liphistius* Schiödte, 1849 (Mesothelae, Liphistiidae) from Myanmar

Khin Pyae Pyae Aung[1,2], Xin Xu[3,4], Wai Wai Lwin[1], Men Zing Sang[1], Long Yu[4], Hao Liu[4], Fengxiang Liu[4], Daiqin Li[5]

1 *Department of Zoology, University of Yangon, Kamayut Township, Pyay Road, Yangon, 11041, Myanmar* **2** *Department of Biology, Taungoo Education College, Taungoo, 08101, Myanmar* **3** *College of Life Sciences, Hunan Normal University, 36 Lushan Road, Changsha 410081, Hunan Province, China* **4** *State Key Laboratory of Biocatalysis and Enzyme Engineering, and Centre for Behavioural Ecology and Evolution (CBEE), School of Life Sciences, Hubei University, 368 Youyi Road, Wuhan 430062, Hubei Province, China* **5** *Department of Biological Sciences, National University of Singapore, 14 Science Drive 4, 117543, Singapore*

Corresponding author: *Xin Xu* (xuxin_09@163.com); *Daiqin Li* (dbslidq@nus.edu.sg)

Academic editor: *Jeremy Miller* | Received 5 August 2019 | Accepted 27 September 2019 | Published 23 October 2019

http://zoobank.org/70855376-BA7D-4E40-B8C6-6840A6461086

Citation: Aung KPP, Xu X, Lwin WW, Sang MZ, Yu L, Liu H, Liu F, Li D (2019) Two new species of the primitively segmented spider genus *Liphistius* Schiödte, 1849 (Mesothelae, Liphistiidae) from Myanmar. ZooKeys 882: 29–39. https://doi.org/10.3897/zookeys.882.38811

Abstract

Two *Liphistius* species of the primitively segmented spider family Liphistiidae, collected from Loikaw (Kayah State) and Pinlaung (Shan State), Myanmar, are diagnosed and described as new to science based on their genital morphology: *Liphistius hpruso* **sp. nov.** (♀), *Liphistius pinlaung* **sp. nov.** (♂♀).

Keywords

Liphistius, Myanmar, taxonomy, trapdoor spiders

Introduction

The segmented trapdoor spiders of the family Liphistiidae, the sister lineage to all other extant spiders, are at a pivotal position on the arachnid tree of life (Platnick and Gertsch 1976; Xu et al. 2015a). Liphistiids are often regarded as 'living fossils'

(Bristowe 1975) since they retain many plesiomorphic characters such as the presence of abdominal tergal plates and the position of the spinnerets on the median area of the opisthosoma (Pocock 1892; Platnick and Gertsch 1976; Haupt 1983, 2003; Coddington and Levi 1991). Two allopatric subfamilies, Liphistiinae Thorell, 1869 and Heptathelinae Kishida, 1923, are distributed in East (China, Japan and Vietnam) and South-east (Laos, Malaysia, Myanmar, Indonesia (Sumatra), and Thailand) Asia, respectively (Xu et al. 2015a, b; World Spider Catalog 2019). Liphistiinae contains 55 described species in the single genus, *Liphistius* Schiödte, 1849: 33 species from Thailand, 16 from peninsular Malaysia, one from both Thailand and peninsular Malaysia, two from Myanmar, one from Laos, one from Indonesia (Sumatra), and one from both Laos and Thailand (World Spider Catalog 2019). Surprisingly, only two species, *L. birmanicus* Thorell, 1897 and *L. lordae* Platnick & Sedgwick, 1984, have been reported from Myanmar since the first species was described in 1897 (Thorell 1897; Platnick and Sedgwick 1984; Schwendinger 1990; Xu et al. 2015b), given that its landmass is even larger than Thailand, its climate and geological topography are similar to those of Thailand, and it shares the mountain ranges with Thailand across a 10° latitude range (Fig. 1). Since at least six species in Thailand (*L. albipes* Schwendinger, 1995, *L. bristowei* Platnick & Sedgwick, 1984, *L. erawan* Schwendinger, 1996, *L. jarujini* Ono, 1988, *L. lahu* Schwendinger, 1998, and *L. maewongensis* Sivayyapram et al., 2017) occur very close to its border with Myanmar, one would expect a comparable species diversity also in Myanmar (Fig. 1).

To document species diversity of *Liphistius* in Myanmar, we carried out two expeditions in East Myanmar in 2018. In this study, we report two new species of *Liphistius* after having examined the specimens collected from our expeditions in 2018.

Materials and methods

Specimen acquisition

All specimens were collected from Loikaw (Kayah State) and Pinlaung (Shan State), Myanmar (Figs 1, 2). They were collected alive and fixed in absolute ethanol if they were adults, and then their right four legs were removed to be stored at −80 °C for molecular work. The rest of each specimen was preserved in 80% ethanol as the voucher for morphological examination.

Morphological examination

Specimens were examined using an Olympic SZX16 Leica stereomicroscope. Genitalia were cleared in boiling KOH for a few minutes to dissolve soft tissues, examined and photographed with an Olympic BX53 or SZX7 compound microscope and a Canon 7D camera. All voucher specimens are deposited at the Centre for Behavioural Ecol-

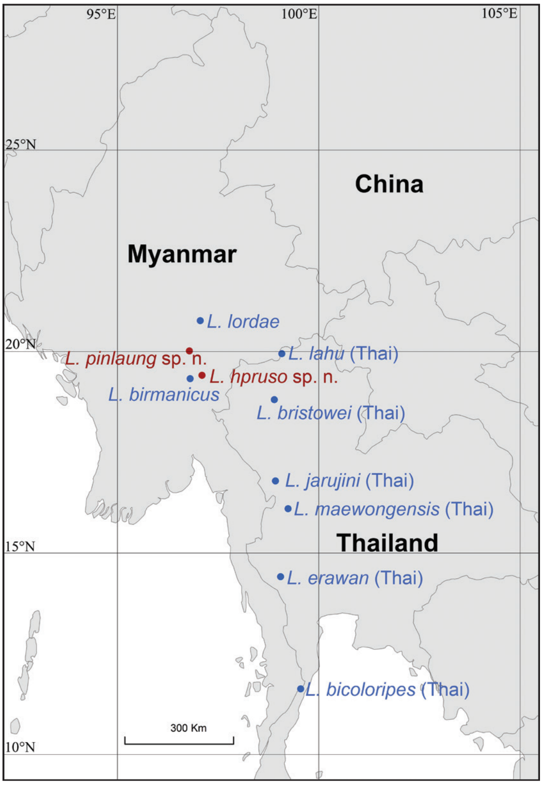


Figure 1. A map showing the type localities of ten *Liphistius* species in Myanmar and Thailand. Two new species are indicated in red solid circles, and two known species in Myanmar and six known species in Thailand are indicated in blue solid circles.

ogy and Evolution (**CBEE**), College of Life Sciences, Hubei University, Wuhan, Hubei Province, China. Genital anatomical terminology follows Schwendinger and Ono (2011) and Schwendinger (2017). All measurements were carried out under a Leica M205 digital microscope and are given in millimetres. Leg and palp measurements are given in the following order: total leg length (femur + patella + tibia + metatarsus + tarsus), total palp length (femur + patella + tibia + tarsus).

Abbreviations used in the text:

ALE anterior lateral eye;
AME anterior median eye;
CDO central dorsal opening;
CT contrategulum;
E embolus;
GA genital atrium;
PC paracymbium;
PeP paraembolic plate;
PLE posterior lateral eye;
PME posterior median eye;
PPl poreplate;
PS posterior stalk;
RC receptacular cluster;
ST subtegulum;
T tegulum;
TiA tibial apophysis.

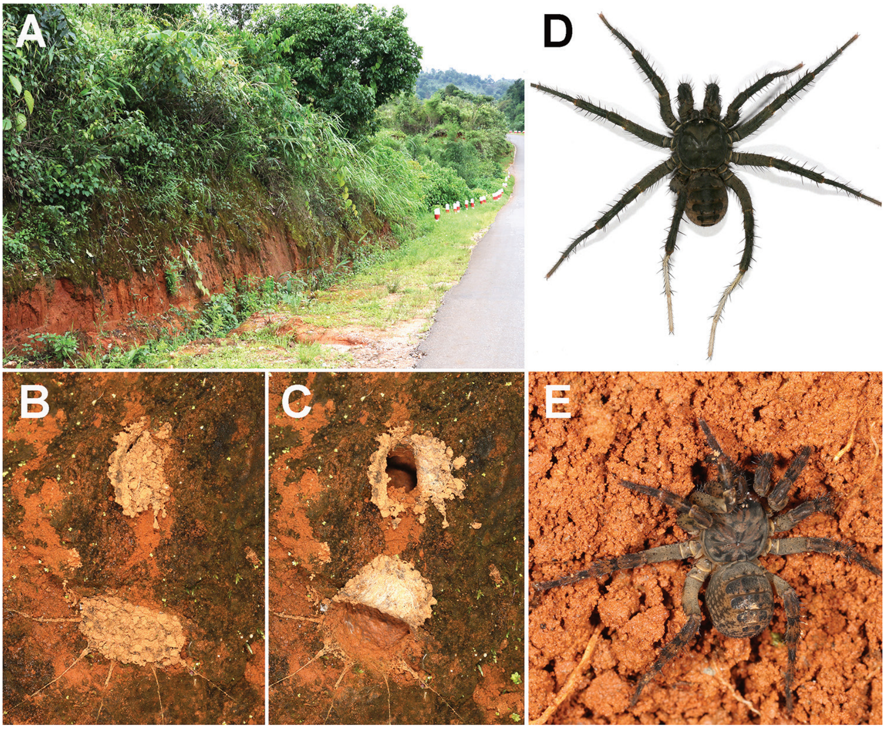


Figure 2. Macrohabitat, burrow with trapdoors, and general somatic morphology (taken in the field) of *Liphistius pinlaung* sp. nov. **A** macrohabitat **B** a burrow with two trapdoors closed **C** a burrow with two trapdoors opened **D** male (XUX-2018-164, holotype) **E** female (XUX-2018-162).

Taxonomy

Family Liphistiidae Thorell, 1869
Subfamily Liphistiinae Thorell, 1869
Genus *Liphistius* Schiödte, 1849

Type species. *Liphistius desultor* Schiödte, 1849

Diagnosis. *Liphistius* can be distinguished from all other liphistiid genera by the male palp that possesses a tibial apophysis (Fig. 4D, E), and by the presence of a pore-plate and a median receptacular cluster in female genitalia (Figs 3B–E, 5A–F).

Distribution. Laos, Malaysia, Myanmar, Indonesia (Sumatra) and Thailand.

***Liphistius hpruso* sp. nov.**
http://zoobank.org/DC7346A9-F429-4197-A207-7747C24EC9E7
Fig. 3

Type material. ***Holotype*:** MYNAMAR · ♀; Kayah State, Loi Kaw District, Hpruso, Dokhule, along a small road near Queen of Peace Church; 19.41N, 97.10E;

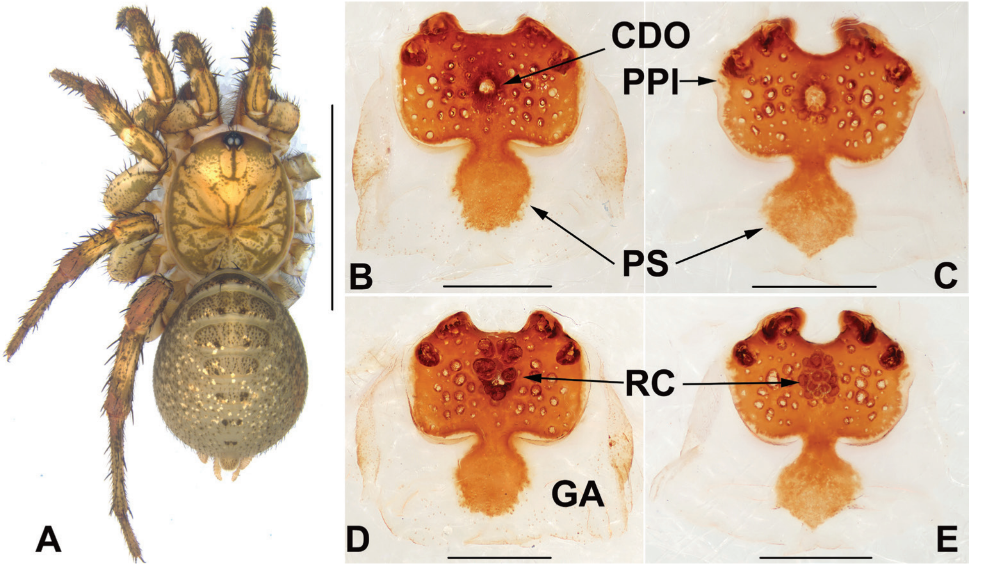


Figure 3. General somatic morphology (taken after fixed by ethanol) and female genitalia of *Liphistius hpruso* sp. nov. **A** female (XUX-2018-151, holotype) **B, D** XUX-2018-151 **C, E** XUX-2018-152 **B, C** vulvae, dorsal view **D, E** vulvae, ventral view. Scale bars: 10 mm (**A**); 0.5 mm (**B–E**).

alt. 1157 m; 17 July 2018; D. Li, F.X. Liu, X. Xu and L. Yu leg.; XUX-2018-151. Deposited in CBEE.

***Paratype*:** MYANMAR · 1 ♀; same data as for holotype; XUX-2018-152. Deposited in CBEE.

Diagnosis. Females of *Liphistius hpruso* sp. nov. resemble those of *L. birmanicus* and *L. pinlaung* sp. nov. by the poreplate with paired anterior lobes and anterolateral lobes, but can be distinguished from those of *L. birmanicus* and *L. pinlaung* sp. nov. by the globosely receptacular cluster (Fig. 3D, E), and the smaller anterolateral lobes of the pore plate (Fig. 3D, E); from *L. pinlaung* sp. nov. by the narrower posterior stalk; from the other *Liphistius* species by the pore plate with similarly sized anterior lobes and anterolateral lobes, and with the narrow posterior stalk (Fig. 3B–E).

Description. Female (holotype). Total length, excluding chelicerae, 16.85. Four thick setae on clypeus (Fig. 3A). Carapace 7.02 long, 6.16 wide, longer than wide, light brown, furnished with few short, scattered bristles. Eight eyes on darkened ocular tubercle, ALE > PLE > PME > AME. Eye sizes and interdistances: AME 0.05, ALE 0.57, PME 0.35, PLE 0.45; AME-AME 0.09, AME-ALE 0.17, PME-PME 0.08, PME-PLE 0.13, ALE-PLE 0.17, ALE-ALE 0.19, PLE-PLE 0.41, AME-PME 0.09. Chelicerae light and glabrous proximally, robust, dark brown; promargin of chelicerae groove with ten denticles of variable size. Labium 0.77 long, 1.47 wide. Sternum 3.61 long, 1.83 wide, brown with several setae. Opisthosoma 9.50 long, 7.53 wide, dark brown, with 12 tergites, and eight spinnerets. Legs brown with strong hairs and spines, long and short black sparse setae, with three tarsal claws. Measurements: palp 10.59 (3.18 + 2.20 + 2.69 + 2.52), leg I 11.77 (3.09 + 2.31 + 2.85 + 1.99 + 1.52), leg II 12.17

(2.72 + 2.21 + 2.92 + 2.49 + 1.83), leg III 12.45 (2.80 + 2.22 + 3.16 + 2.70 + 1.57), leg IV 20.99 (4.87 + 2.79 + 4.31 + 5.96 + 3.06).

Female genitalia: vulva with nearly rectangular pore plate; pore plate with similarly sized anterior lobes and anterolateral lobes; distinct transition between the pore plate and posterior stalk (Fig. 3B–E); posterior stalk narrow and long; receptacular cluster spherical and small; central dorsal opening small and circular (Fig. 3B–E).

Male. unknown.

Entomology. "hpruso" refers to the type locality of this species.

Distribution. Myanmar (Loi Kaw District, Kayah State).

Liphistius pinlaung **sp. nov.**

http://zoobank.org/1E893A2D-D43C-4B16-A19D-77352D7EE823

Figs 4, 5

Type material. ***Holotype*****:** MYNAMAR · ♂; Shan State, Pinlaung Township, ca.14 km to Pinlaung from Pekon; 20.02N, 96.79E; alt. 1410 m; 19 July 2018; D. Li, F.X. Liu, X. Xu and L. Yu leg.; XUX-2018-164. Deposited in CBEE.

Paratype**:** MYNAMAR · 1 ♂, 5 ♀♀; same data as for holotype; XUX-2018-162, 167, 169, 169A, 169B, 169J; 19 July 2018. All specimens deposited in CBEE.

Diagnosis. Males of *L. pinlaung* sp. nov. resemble those of *L. birmanicus*, *L. lordae* and *L. lahu* by the wide paraembolic plate, but can be distinguished from *L. birmanicus* by the lack of lateral process of paracymbium and by the cumulus with longer and stouter setae (Fig. 4C, D); from *L. lordae* by the wider tibial apophysis at base (Fig. 4D) and the tegulum with a dentated margin (Fig. 4C, F); from *L. lahu* by the narrower tegulum (Fig. 4C, F) and smaller paracybium (Fig. 4D, E). Females of *L. pinlaung* sp. nov. resemble those of *L. birmanicus* and *L. hpruso* sp. nov. by the poreplate with two pair of lobes, but can be distinguished from *L. birmanicus* by the wider posterior stalk, and sphere-shaped receptacular cluster (Fig. 5D–F); from *L. hpruso* sp. nov. by the wider posterior stalk and larger anterior lobes of the poreplate (Fig. 5A–F); from the other *Liphistius* by the poreplate with four anterior lobes (Fig. 5D–F).

Description. Male (holotype). Total length, excluding chelicerae, 12.71. Carapace 5.86 long and 5.47 wide, longer than wide, olive-green due to being fixed in ethanol immediately after molting, furnished with few short, scattered bristles (Fig. 4A). ALE>PLE>PME>AME, eye sizes and interdistances: AME 0.05, ALE 0.55, PME 0.31, PLE 0.48, AME-AME 0.10, AME-ALE 0.07, PME-PME 0.09, PME-PLE 0.09, ALE-PLE 0.09, ALE-ALE 0.11, PLE-PLE 0.38, AME-PME 0.09. Chelicerae robust, promargin of chelicerae groove with ten strong denticles of variable size. Labium 0.86 long and 0.89 wide, wider than long, fused with sternum and slightly pale olive-green (Fig. 4B). Sternum 2.94 long and 1.05 wide, longer than wide, and a few weakly spined setae on the anterior tip and many long spined setae on the posterior tip, elongated posterior tip (Fig. 4B). Opisthosoma 7.17 long and 4.92 wide, with 12 tergites, the fifth largest, eight spinnerets (Fig. 4B). Legs with strong hairs and spines. Measurements: leg I 16.99 (4.32 + 2.55 + 3.55 + 4.66 + 1.92), leg II 18.06 (4.32 + 2.41 + 3.74

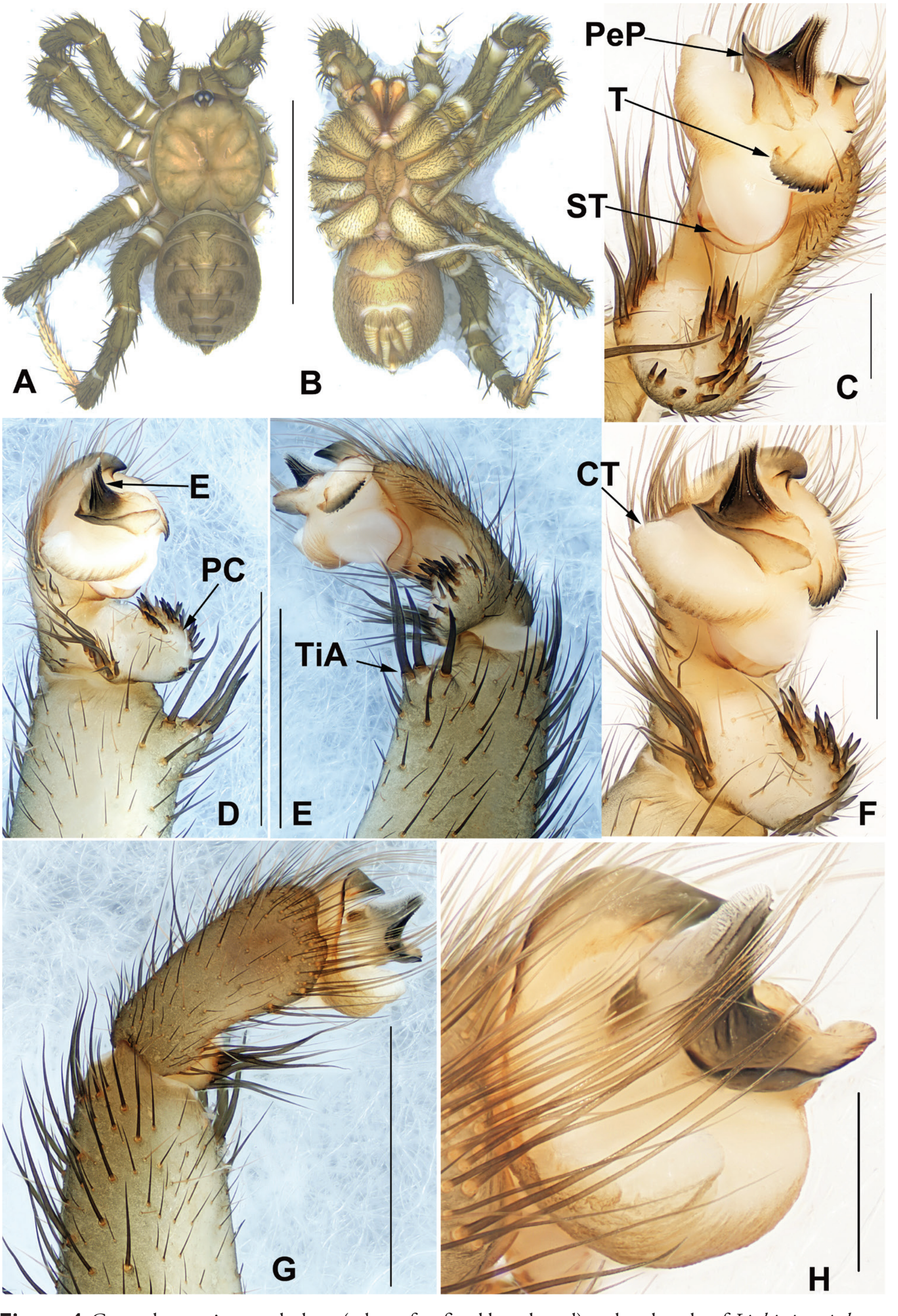


Figure 4. General somatic morphology (taken after fixed by ethanol) and male palp of *Liphistius pinlaung* sp. nov. (XUX-2018-164, holotype) **A, B** male: **A** dorsal view **B** ventral view **C, F, H** palp distal view **D** palp ventral view **E** palp retrolateral view **G** palp prolateral view. Scale bars: 10 mm (**A, B**); 2 mm (**D, E, G**); 0.5 mm (**C, F, H**).

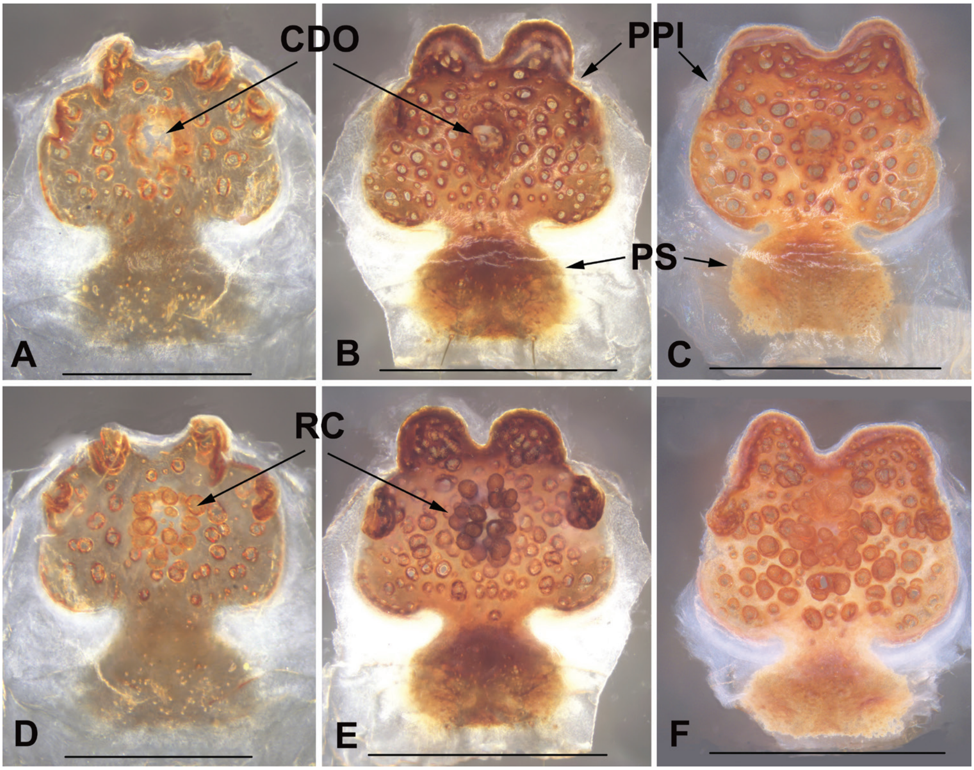


Figure 5. Female genitalia of *Liphistius pinlaung* sp. nov. **A, D** XUX-2018-167 **B, E** XUX-2018-169A **C, F** XUX-2018-169J **A–C** vulvae, dorsal view **D–F** vulvae, ventral view. Scale bars: 0.5 mm (**A, D**); 1 mm (**B, C, E, F**).

+ 5.18 + 2.41), leg III 18.46 (4.44 + 1.85 + 2.83 + 6.68 + 2.66), leg IV 20.40 (3.56 + 1.52 + 4.25 + 8.46 + 2.63).

Palp: Tibial apophysis with four long spines of different lengths (Fig. 4D, E), paracymbium large and wide, many setae situated at the tip and a row of several tapering spines one the indistinct cumulus (Fig. 4C, D, F); subtegular apophysis weakly developed (Fig. 4C); contrategulum with conical, tip blunt with a short process (Fig. 4C, F), distal edge widely arched, with a smooth and sharp edge (Fig. 4F–H); tegulum small and the terminal apophysis with finely dentated margin (Fig. 4C, E, F); paraembolic plate short, widely rounded, embolic parts adjacent (Fig. 4D, F, H); embolus long and conical, basally sclerotized, with 3–4 longitudinal ridges that reach to tip (Fig. 4C, D, F).

Female. Total length, excluding chelicerae, 14.46. Carapace 6.70 long, 6.07 wide, light brown, furnished with few short, scattered bristles. Four thick setae on clypeus. Eight eyes on darkened ocular tubercle, ALE > PLE > PME > AME, eye size and interdistances: AME 0.09, ALE 0.61, PME 0.33, PLE 0.47, AME-AME 0.11, AME-ALE 0.16, PME-PME 0.13, PME-PLE 0.13, ALE-PLE 0.14, ALE-ALE 0.14, PLE-PLE 0.43, AME-PME 0.14. Chelicerae proximally glabrous, robust, dark brown; promargin of chelicerae groove with 14 strong denticles of variable size. Labium 0.75 long, 1.19 wide, slightly pale brown. Sternum 3.25 long, 1.59 wide, brown and weakly

Table 1. Body measurements (mm) of one male (♂) and five females (♀) of *Liphistius pinlaung* sp. nov.

Sample number	Carapace		Opisthosoma		Sternum		labium		Body
	length	width	length	width	length	width	length	width	length
XUX-2018-162 (♀)	6.70	6.08	8.20	5.73	3.25	1.57	0.75	1.19	14.46
XUX-2018-167 (♀)	5.23	4.86	4.96	3.36	2.60	1.28	0.61	0.95	10.27
XUX-2018-169 (♂)	6.54	6.34	7.06	5.34	2.84	1.08	0.59	0.94	13.58
XUX-2018-169A (♀)	7.05	5.99	7.43	5.53	3.29	1.57	0.91	1.38	14.47
XUX-2018-169B (♀)	7.62	6.55	7.50	5.24	3.10	1.48	0.89	1.37	14.49
XUX-2018-169J (♀)	7.47	6.66	7.05	4.96	3.75	1.65	0.72	1.59	14.09

spined, a few setae on the outside of this area, elongated posterior tip. Opisthosoma 8.20 long, 5.73 wide, dark brown, with 12 tergites, the fifth largest, and eight spinnerets. Legs brown with strong hairs and spines, long and short black sparse setae, legs each with three tarsal claws. Measurements: palp 8.59 (2.01 + 1.67 + 2.65 + 2.27), leg I 11.75 (3.39 + 1.99 + 3.03 + 2.01 + 1.33), leg II 12.02 (2.69 + 2.05 + 3.14 + 2.45 + 1.68), leg III 13.47 (4.19 + 1.22 + 3.51 + 2.49 + 2.05), leg IV 22.4 (6.47 + 2.58 + 4.38 + 5.82 + 3.15).

***Female genitalia*:** pore plate with a pair of large anterior lobes and a pair of small, strongly elevated anterolateral lobes, and anterior lobes larger than anterolateral lobes (Fig. 5D–F); distinct transition between the pore plate and posterior stalk (Fig. 5A–F); posterior stalk wide; receptacular cluster spherical and small; central dorsal opening small and circular (Fig. 5A–C).

Entomology. "pinlaung" refers to the type locality of this species.

Distribution. Myanmar (Pinlaung Township, Shan State).

Variation. Body measurements, see Table 1. The examined female genitalia differ from each other; for the specimen of XUX-2018-169A, the central part of anterior and anterolateral lobes of the pore plate are depressed in the dorsal view (Fig. 5B), whereas the depression is absent in the other two specimens (XUX-2018-167 and 169J); the shape and size of anterior and anterolateral lobes of the pore plate, as well as the shape of anterior margin of the pore plate are rather variable (Fig. 5A–F). The size of the receptacular cluster is also slightly different (Fig. 5D–F).

Relationships. *Liphistius hpruso* sp. nov. and *L. pinlaung* sp. nov. belong to the *birmanicus*-group that currently contains *L. birmanicus*, *L. lordae* and *L. lahu* based on morphological characters (Schwendinger, 1998). The two new species are closer to *L. birmanicus* than to *L. lordae* and *L. lahu* since their female poreplates possess four anterior lobes (Figs 3B–E; 5D–F).

Acknowledgements

This study was supported by the grants from the National Natural Sciences Foundation of China (NSFC) (31272324; 31601850), the Hunan Provincial Natural Science Foundation of China (2017JJ3202), the Singapore Ministry of Education AcRF Tier 1 grant (R-154-000-A52-114), ASEAN University Network funding, and Special PhD Program on Zoology from Hubei University. We would like to thank Prof. Thida Lay

Thwe for her advice and support, and Prof. U Moe Moe Dwe for his help in the field. We are also grateful to Dr Ko Myint for his help for the applications of research permits and spider export permits. In particularly, we would also thank Myanmar Department of Forestry for research permit (NGA/CITES/9/6825/2018) and spider export permit (NWCD/CITES/9/8038/2018) as well as Agri-Food & Veterinary Authority (AVA) of Singapore for spider import permit. We thank Hirotsugu Ono, Matjaž Kuntner and Rebecca Godwin for their constructive and insightful comments on the manuscript and Shakira Quinones for helping edit the language. We also thank the staff of the Centre for Behavioural Ecology and Evolution (CBEE), Hubei University, College of Life Sciences, Hunan Normal University, and Department of Zoology, University of Yangon for all their help and support throughout this study.

References

Bristowe WS (1975) A family of living fossil spiders. Endeavour 34: 115–117. https://doi.org/10.1016/0160-9327(75)90130-1

Coddington JA, Levi HW (1991) Systematics and evolution of spiders (Araneae). Annual Review of Ecology and Systematics 22: 565–592. https://doi.org/10.1146/annurev.es.22.110191.003025

Haupt J (1983) Vergleichende Morphologie der Genitalorgane und Phylogenie der liphistiomorphen Webspinnen (Araneae: Mesothelae). I. Revision der bisher bekannten Arten. Zeitschrift für Zoologische Systematik und Evolutionsforschung 21: 275–293. https://doi.org/10.1111/j.1439-0469.1983.tb00296.x

Haupt J (2003) The Mesothelae – monograph of an exceptional group of spiders (Araneae: Mesothelae) (Morphology, behaviour, ecology, taxonomy, distribution and phylogeny). Zoologica 154: 1–102.

Ono H (1988) Liphistiid spiders (Araneae, Mesothelae) of northwest Thailand. Bulletin of the National Museum of Nature and Science Tokyo (A) 14: 35–41.

Platnick NI, Gertsch WJ (1976) The suborders of spiders: a cladistic analysis (Arachnida, Araneae). American Museum Novitates 2607: 1–15.

Platnick NI, Sedgwick WC (1984) A revision of the spider genus *Liphistius* (Araneae, Mesothelae). American Museum Novitates 2781: 1–31.

Pocock RI (1892) XXXVIII. – *Liphistius* and its bearing upon the classification of spiders. Journal of Natural History Series 6(10): 306–314. https://doi.org/10.1080/00222939208677416

Schwendinger PJ (1990) On the spider genus *Liphistius* (Araneae: Mesothelae) in Thailand and Burma. Zoologica Scripta 19: 331– 351. https://doi.org/10.1111/j.1463-6409.1990.tb00262.x

Schwendinger PJ (1995) New *Liphistius* species (Araneae, Mesothelae) from southern Thailand and northern Malaysia. Zoologica Scripta 24(2): 143–156. https://doi.org/10.1111/j.1463-6409.1995.tb00396.x

Schwendinger PJ (1996) New *Liphistius* species (Araneae, Mesothelae) from western and eastern Thailand. Zoologica Scripta 25(2): 123–141. https://doi.org/10.1111/j.1463-6409.1996.tb00155.x

Schwendinger PJ (1998) Five new *Liphistius* species (Araneae, Mesothelae) from Thailand. Zoologica Scripta 27: 17–30. https://doi.org/10.1111/j.1463-6409.1998.tb00426.x

Schwendinger PJ (2017) A revision of the trapdoor spider genus *Liphistius* (Mesothelae: Liphistiidae) in peninsular Malaysia; part 1. Revue Suisse de Zoologie 124: 391–445. https://doi.org/10.5281/zenodo.893555

Schwendinger PJ, Ono H (2011) On two *Heptathela* species from southern Vietnam, with a discussion of copulatory organs and systematics of the Liphistiidae (Araneae: Mesothelae). Revue Suisse de Zoologie 118: 599–637. https://doi.org/10.5962/bhl.part.117818

Sivayyapram V, Smith DR, Weingdow S, Warrit N (2017) A new *Liphistius* species (Mesothelae: Liphistiidae: Liphistiinae) from Thailand, with notes on its natural history. Journal of Arachnology 45(3): 287–295. https://doi.org/10.1636/JoA-S-17-028.1

Thorell T (1897) Viaggio di Leonardo Fea in Birmania e regionivicine. LXXIII. Secondo saggio sui Ragnibirmani. I. Parallelodontes. Tubitelariae. Annali del Museo Civico di Storia Naturale di Genova 37: 161–267.

World Spider Catalog (2019) World Spider Catalog, Version 20.5. Natural History Museum Bern. http://wsc.nmbe.ch [access on 10 September 2019]

Xu X, Liu FX, Cheng R-C, Chen J, Xu X, Zhang ZS, Ono H, Pham DS, Norma-Rashid Y, Arnedo MA, Kuntner M, Li D (2015a) Extant primitively segmented spiders have recently diversified from an ancient lineage. Proceedings of the Royal Society B: Biological Sciences 282: 20142486. https://doi.org/10.1098/rspb.2014.2486

Xu X, Liu FX, Chen J, Ono H, Li D, Kuntner M (2015b) A genus level taxonomic review of primitively segmented spiders (Mesothelae, Liphistiidae). ZooKeys 488: 121–151. https://doi.org/10.3897/zookeys.488.8726

ZooKeys 882: 41–49 (2019)
doi: 10.3897/zookeys.882.39029
http://zookeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

Review of *Podothrips* from China (Thysanoptera, Phlaeothripidae), with one new species and three new records

Li-Hong Dang[1], Le Zhao[1], Xia Wang[1], Ge-Xia Qiao[2,3]

1 *School of Bioscience and Engineering, Shaanxi University of Technology, Hanzhong, 723000, China* **2** *Key Laboratory of Zoological Systematics and Evolution, Institute of Zoology, Chinese Academy of Science, No.1 Beichen West Road, Chaoyang District, Beijing 100101, China* **3** *College of Life Science, University of Chinese Academy of Sciences, No. 19, Yuquan Road, Shijingshan District, Beijing 100049, China*

Corresponding author: *Ge-Xia Qiao* (qiaogx@ioz.ac.cn)

Academic editor: *L. Mound* | Received 13 August 2019 | Accepted 3 October 2019 | Published 23 October 2019

http://zoobank.org/C4D59916-490F-4C72-A5E0-124441E76F94

Citation: Dang L-H, Zhao L, Wang X, Qiao G-X (2019) Review of *Podothrips* from China (Thysanoptera, Phlaeothripidae), with one new species and three new records. ZooKeys 882: 41–49. https://doi.org/10.3897/zookeys.882.39029

Abstract

Podothrips species occur on the leaves of various Poaceae, including bamboo and grasses. An illustrated identification key is given here to the six *Podothrips* species recorded from China. These include *P. femoralis* Dang & Qiao, **sp. nov.**, and *P. sasacola* Kurosawa, *P. odonaspicola* (Kurosawa), and *P. semiflavus* Hood that are newly recorded from China.

Keywords

Podothrips femoralis, key, taxonomy, Poaceae

Introduction

Haplothripini, a tribe distributed worldwide, is the only well-defined and named tribe in the Phlaeothripinae (Mound and Minaei 2007). Most species of this tribe are related to flower-feeding, but some are thought to be predatory, such as *Podothrips* species. A list of 34 genera in this tribe was provided by Mound and Minaei (2007) in a review of the species recorded from Australia. Subsequently, Minaei and Mound (2008) revised the Haplothripini from Iran with four genera, and Dang et al. (2014) described 19 genera from Southeast Asia and China in this tribe. Until now, this tribe includes 34 genera and approximately 580 species worldwide.

Podothrips species appear to be predators and live on plants of the family Poaceae. The genus is distinguished from other Haplothripini genera by the following characters: prosternal basantra strongly developed and longer than wide; pronotal anteromarginal setae minute. Ritchie (1974) provided a key to 18 species of this genus with three new species and four generic synonyms. Subsequently, four species were described from Thailand, Malaysia, China (Taiwan) and India (Bhatti 1978; Okajima 1978), and two from New Zealand (Mound and Walker 1986). Okajima (2006) recorded three species from Japan, Mound and Minaei (2007) recorded 10 species from Australia, and one species was recently described from Iran (Minaei 2015). In China (Taiwan), two species were recorded, *P. lucasseni* (Krüger) and *P. luteus* Okajima (Okajima 1986). At present, the genus *Podothrips* includes 31 species worldwide (ThripsWiki 2019).

As part of ongoing studies on Haplothripini from China, this review of the genus *Podothrips* provides an illustrated identification key to six species with one new species and three newly recorded species.

Materials and methods

The descriptions, drawings, and photomicrograph images provided here are produced from slide-mounted specimens using an Olympus BX53 and drawing tube. The following abbreviations are used for the pronotal setae:

am anteromarginal,
aa anteroangular,
ml midlateral,
epim epimeral,
pa posteroangular.

The unit of measurements in this paper is micrometre. Specimens from China, including the holotype of the newly described species, are deposited in the National Zoological Museum of China (**NZMC**) Institute of Zoology, Chinese Academy of Sciences, Beijing, China, with some specimens in the School of Bioscience and Engineering, Shaanxi University of Technology, Hanzhong, China.

Taxonomy

Podothrips Hood

Podothrips Hood, 1913: 67. Type species: *Podothrips semiflavus* Hood.

Diagnosis. Small sized, usually bicoloured brown and yellow, but a few uniformly brown. Head smooth, longer than wide, with one pair of postocular setae; antennae eight-segmented, segment III with one or two sense cones, IV with two or three. Pronotum well developed, am always minute; notopleural sutures complete; basantra usually longer than wide; fore tarsus with tooth on inner surface, fore tibia often with a subapical tubercle or tooth. Mesopresternum complete, boat-shaped. Metathoracic sternopleural sutures well developed. Forewing fully developed, slightly constricted medially, with or without duplicated cilia. Pelta bell-shaped. Abdominal tergites II–VII each with two pairs of wing-retaining setae. Tube shorter than head, anal setae long than tube.

Comments. This genus is closely related to *Praepodothrips* with which it shares most morphological characters, but it differs in having larger basantra. It is also similar to *Karnyothrips* and *Okajimathrips*, but *Podothrips* can be recognised by the developed basantra and metathoracic sternopleural sutures (*Karnyothrips* species have normal basantra and metathoracic sternopleural sutures absent), and the pronotal notopleural sutures complete (*Okajimathrips* with pronotal notopleural sutures incomplete).

Key to species from China

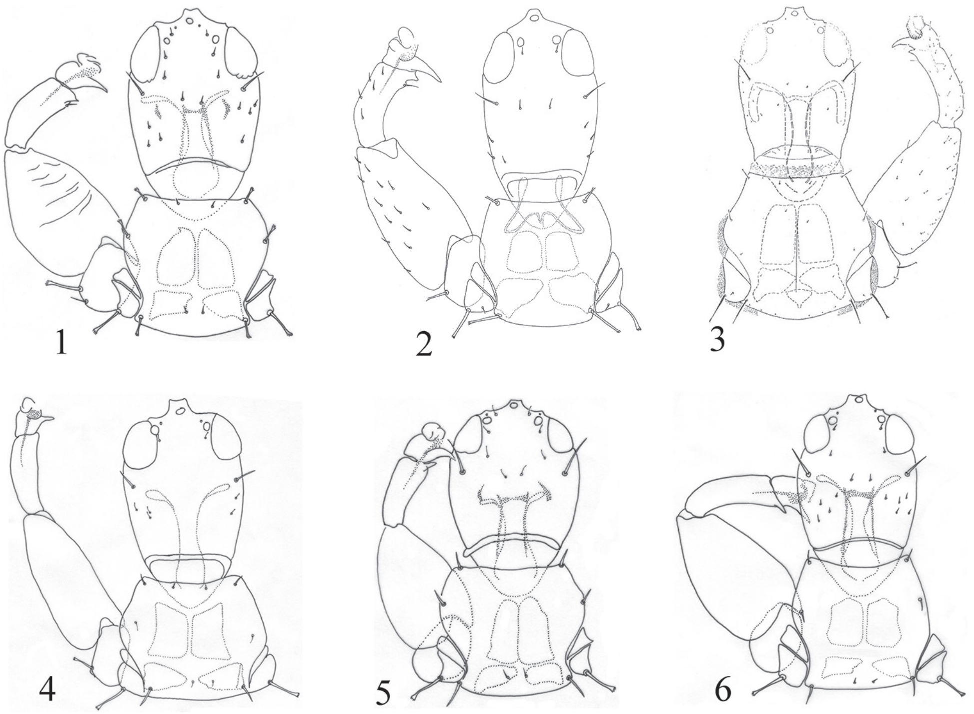
1	Body uniformly brown (Fig. 17)	***P. lucasseni*** **(Krüger)**
–	Body bicoloured (Figs 18–21)	**2**
2	Prothorax yellow, contrasting with brown head (Fig. 19)	**3**
–	Prothorax brown, concolourous with head (Figs 18, 20, 21)	**4**
3	Abdominal segments I–IX yellow, tube yellow in basal third	***P. luteus*** **Okajima**
–	Abdominal segments I–VII yellow, VIII–X brown (Fig. 19)	***P. semiflavus*** **Hood**
4	Metathorax and all femora yellow (Fig. 21)	***P. sasacola*** **Kurosawa**
–	Metathorax and forefemora brown at minimum	**5**
5	Forewing with duplicated cilia; fore tibia without distinct apical tooth (Fig. 4); most pronotal setae pointed except epim setae expanded (Fig. 4); antennal segment VII brown, concolourous with head (Fig. 18)	***P. odonaspicola*** **(Kurosawa)**
–	Forewing without duplicated cilia; fore tibia with a distinct apical tooth (Fig. 1); all developed pronotal setae expanded (Fig. 1); antennal segment VII yellow with apical fifth brown (Fig. 20)	***P. femoralis*** **sp. nov.**

Podothrips femoralis Dang & Qiao, sp. nov.

http://zoobank.org/923F14E1-B82B-436B-BF21-6C52B121770C
Figs 1, 7, 12, 13–16, 20, 22

Female macroptera. Bicoloured with head, thorax and abdominal segments VIII–X brown, I–VII yellow but III–VII with brown median area; antennal segment I brown, II yellow with brown basal part, III–VII uniform yellow with VI–VII a little darker apex, VIII brown. All legs yellow with fore and middle coxae and fore femora brown (Fig. 20).

Head 1.2 times as long as wide, cheeks distinctly constricted towards base (Fig. 1); ocellar setae minute; postocular setae pointed at tips, half the length of eye, wide apart from each other (Fig. 1). Mouth-cone short, maxillary stylets reaching base of



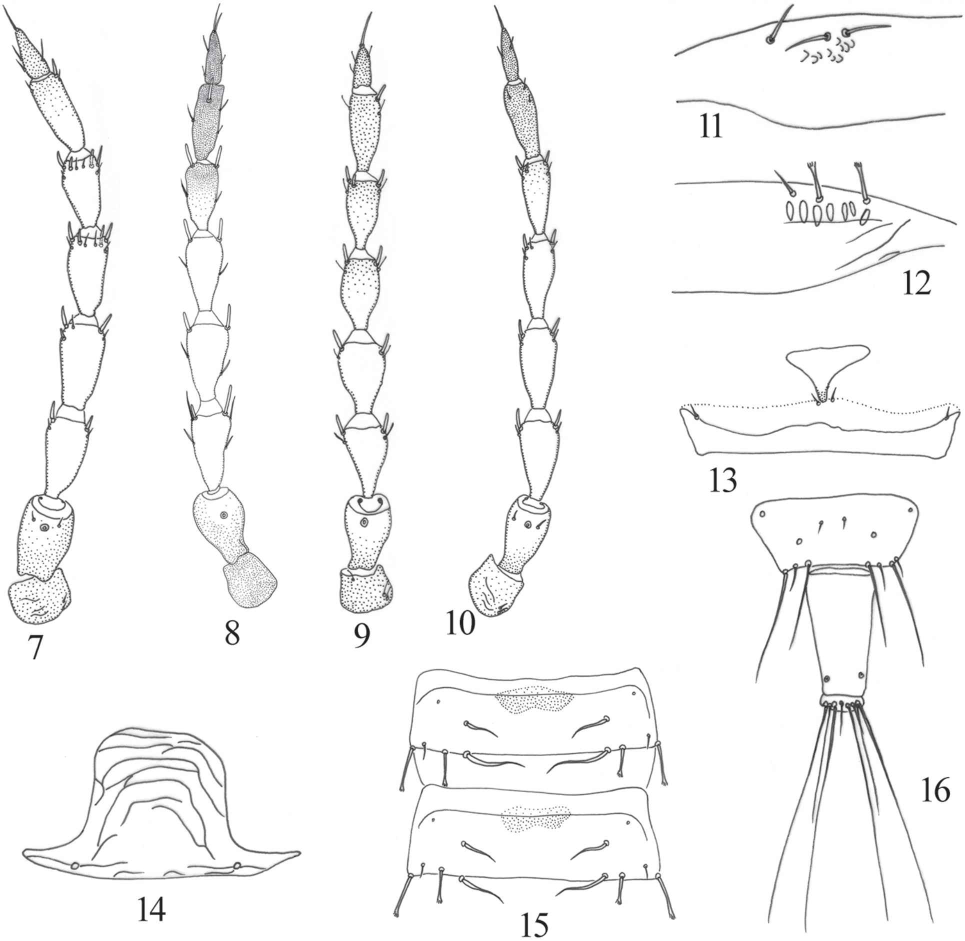
Figures 1–6. *Podothrips* species head, pronotum& fore legs **1** *P. femoralis* sp. nov. **2** *P. lucasseni* **3** *P. luteus* (from Okajima1978) **4** *P. odonaspicola* **5** *P. sasacola* **6** *P. semiflavus*.

postocular setae, maxillary bridge present. Antennal segment sense cones: III with 1+1, IV with 1+1[1], V with 2+2, VI with 1[1]+2, VII with 1 dorsal (Fig. 7).

Pronotum with no sculpture, am reduced, aa, ml, epim, and pa setae well developed with expanded apices, epim setae longest; notopleural sutures complete; basantra well developed, longer than wide (Fig. 1). Metanotum almost smooth; metathoracic sternopleural sutures well developed (Fig. 22). Fore femur expanded; fore tibia with a distinct apical tooth; fore tarsal tooth developed (Fig. 1). Fore wings slightly constricted medially, without duplicated cilia, sub-basal wing setae equal with length, S1 and S2 expanded at apex, S3 acute (Fig. 12).

Pelta hat-shaped with pair of campaniform sensilla (Fig. 14); tergites II–VII with two pairs of wing-retaining setae (Fig. 15); abdominal tergite IX setae S1 and S2 pointed at apex, shorter than tube; tube 0.54 times as long as head; anal setae 1.7 times as long as tube (Fig. 16).

Measurements (holotype female, in μm). Total length 2440. Head length 260, width across behind eyes210; eye length 85, width 55; postocular setae length 40. Antenna length 440, I–VIII length (width): 35(40), 50(30),55(25),60(30),55(25),50 (25),52(25),35(22). Pronotum length 235, width 235; aa 12, ml 12, epim 45, pa 17. Fore wing length 960, sub-basal setae S1-S3 length 20, 15, 15. Pelta length 75, width 130.Tube length 140, anal setae length 240.



Figures 7–16. *Podothrips* species. **7–10** Antenna **7** *P. femoralis* sp. nov. **8** *P. odonaspicola* **9** *P. sasacola* **10** *P. semiflavus*. **11, 12** Base of forewing **11** *P. sasacola* **12** *P. femoralis* sp. nov. Some important features of *P. femoralis* sp. nov. **13** mesopresternum **14** Pelta **15** abdominal tergites IV–V **16** abdominal tergites IX–X.

Specimens examined. Holotype female. CHINA, Yunnan, Mengla County, on Bamboo leaves, 22.iv.1997, Y.F. Han. Paratype: one female with same data as holotype; one female, Fujian Prov., Xiamen City, on Bamboo leaves, 29.iv.1991, Y.F. Han; one female, Guangdong Prov., on Bamboo leaves, 29.iv.1992, Y.F. Han.

Comments. This new species is similar to *P. sasacola* in forewing without duplicated cilia and body bicoloured, but differs in having all legs yellow with fore legs femora brown, antennal segment V–VI uniformly yellow and VII yellow with apical third brown (Fig. 20), meso- and metanotum brown, all developed pronotal setae expanded at apex (Fig. 1), and fore wing sub-basal setae S1 and S2 expanded (Fig. 12). In contrast, *P. sasacola* has all legs yellow, antennal segments V–VI yellow with apical half brown, VII uniformly brown, meso- and metanotum yellow (Fig. 21), pronotum aa, ml and pa pointed at apex, epim setae expanded (Fig. 5), and sub-basal setae S1 and S2 pointed (Fig. 11). It is also related to *P. odonaspicola* and *P. bicolor* Seshadri & Ananthakrishnan in the bicoloured body, but this new species can be distinguished by forewing without duplicated cilia (forewing with duplicated cilia in *P. odonaspicola*), and fore tibia with distinct subapical tooth (fore tibia without distinct subapical tooth in *P. odonaspicola*) (Figs 1, 4), and by fore femora brown (all femora yellow in *P. bicolor*).

Etymology. This species name is composed of one Latin word, *femoralis*, based on the brown fore femora.

Podothrips lucasseni (Krüger)

Figs 2, 17

Phlaeothrips lucasseni Krüger, 1890: 105.

Remarks. Described from Java on sugar cane, and widely distributed in Asia, this is the only *Podothrips* from China that is uniformly brown (Fig. 17). *P. hawaiiensis* from Hawaii and *P. oryzae* from Thailand were placed as synonyms of *P. lucasseni* by Ritchie (1974). This species was recorded by Okajima (1986) from China (Taiwan), and a female and a male from Guizhou Province have been examined here.

Podothrips luteus Okajima

Fig. 3

Podothrips luteus Okajima, 1978: 34.

Remarks. This species is known only from China (Taiwan) on grass. Unfortunately, no specimens were examined here. According to the description, it can be distinguished easily from the other species considered here by the bicoloured body with most of the abdomen yellow – abdominal segments I–IX and basal third of tube yellow (Okajima 1978).

Podothrips odonaspicola (Kurosawa)

Figs 4, 8, 18

Haplothrips odonaspicola Kurosawa, 1937: 266.

Remarks. Described from Japan (Tokyo) on bamboo leaf sheaths, this species is recorded here from China (Sichuan, Hubei) for the first time, based on three females. The brown thorax and yellow abdominal pattern are similar to the new species, *P. femoralis*, but it may be distinguished by the forewing with duplicated cilia and fore tibia without distinct subapical tooth (Fig. 4).

Figures 17–22. *Podothrips* adult colour patterns **17** *P. lucasseni* **18** *P. odonaspicola* **19** *P. semiflavus* **20** *P. femoralis* sp. nov. **21** *P. sasacola*. Some important features of *femoralis* sp. nov. **22** mesopresternum and metathoracic sternopleural sutures. Scale bars: 200 microns.

Podothrips sasacola **Kurosawa**
Figs 5, 9, 11, 21

Podothrips sasacola Kurosawa, 1940: 100.

Remarks. Previously known only from Japan, this species is quite similar to *P. bicolor* in the body colour pattern – head, pronotum, and abdominal segments VIII–X brown. Specimens are identified here as *P. sasacola* have antennal segments III–IV each with two sense cones (Fig. 9), and the fore tibia with a distinct inner apical tubercle (Fig. 5) as described by Okajima (2006). This species is recorded here for the first time from China, Sichuan, based on five males taken from reeds.

***Podothrips semiflavus* Hood**
Figs 6, 10, 19

Podothrips semiflavus Hood, 1913: 67.

Remarks. Described from Puerto Rico, America on *Panicum* leaves, this species is recorded from Egypt and Uganda by Ritchie (1974), with *P. aegyptiacus* Priesner placed as a synonym. This is one of two species from China in which the thorax is yellow (Fig. 19), but *P. luteus* from Taiwan has abdominal segments VIII–X brown, whereas the abdomen of *P. semiflavus* is almost yellow with just the basal third of the tube brown (Fig. 19). One female from Guangdong has been studied here, and this is the first record of the species from China.

Acknowledgements

Many thanks are due to Laurence Mound (CSIRO, Australia) for providing some advice and to Fen-Di Yang and Yang Hu for making microscope slides. This work was supported by National Natural Sciences Foundation of China (No. 31702042), the Science and Technology Research Development Program of Shaanxi Province (2016NY-143), a Young Talent Fund of University Association for Science and Technology in Shaanxi, China (20180209), the Doctoral Start-up Foundation of Shaanxi Sci-Tech University (SLGKYQD2-20), and the Second Tibetan Plateau Scientific Expedition and Research (STEP) program [Grant No. 2019QZKK0501].

References

Bhatti JS (1978) Four new species of Thysanoptera of India. Oriental Insects 12: 419–432. https://doi.org/10.1080/00305316.1978.10432103

Bhatti JS (1992) The Order Tubulifera (Insecta): Its characters and classification into families. Zoology (Journal of Pure and Applied Zoology) 3: 127–162.

Dang LH, Mound LA, Qiao GX (2014) Conspectus of the Phlaeothripinae genera from China and Southeast Asia (Thysanoptera, Phlaeothripidae). Zootaxa 3807(1): 001–082. https://doi.org/10.11646/zootaxa.3807.1.1

Hood JD (1913) Two new Thysanoptera from Porto Rico. Insecutorinscitiaemenstruus1: 65–70. https://doi.org/10.5962/bhl.part.9573

Kurosawa (1937) Descriptions of four new thrips in Japan. Kontyû 11: 266–275.

Kurosawa (1940) Thrips from Hatizyo-Zima, in the Province of Izu, Nippon. Kontyû 14: 93–102.

Minaei K (2015) *Podothrips*: first record from Iran with a new species (Thysanoptera: Phlaeothripidae). Turkish Journal of Zoology 39: 958–961. https://doi.org/10.3906/zoo-1409-38

Minaei K, Mound LA (2008) The Thysanoptera Haplothripini (Insecta: Phlaeothripidae) of Iran. Journal of Natural History 42: 2617–2658. https://doi.org/10.1080/00222930802354159

Mound LA, Minaei K (2007) Australian thrips of the *Haplothrips* lineage (Insecta: Thysanoptera). Journal of Natural History 41: 2919–2978. https://doi.org/10.1080/00222930701783219

Mound LA, Walker AK (1986) Tubulifera (Insecta: Thysanoptera). Fauna of New Zealand 10: 1–140.

Okajima S (1978) Notes on the Thysanoptera from Southeast Asia, vol 1. On the genus *Podothrips* Hood (Phlaeothripidae). Kontyû 46: 29–37.

Okajima S (1986) Studies on the genus *Podothrips* Hood from Taiwan, with description of a new species (Thysanoptera, Phlaeothripidae). Kontyû 54: 713–718.

Okajima S (2006) The Insects of Japan – Vol. 2 The Suborder Tubulifera (Thysanoptera). Touka Shobo Co Ltd, Fukuoka, 720 pp.

Ritchie JM (1974) A revision of the grass-living genus *Podothrips* (Thysanoptera: Phlaeothripidae. Journal of Entomology (B) 43: 261–282. https://doi.org/10.1111/j.1365-3113.1975.tb00135.x

Seshadri A, Ananthakrishnan TN (1954) Some new Indian Thysanoptera – 1. Indian Journal of Entomology 16: 210–226.

ThripsWiki (2019) ThripsWiki – providing information on the World's thrips. https://thrips.info/wiki [20.vi.2019]

ZooKeys 882: 51–85 (2019)
doi: 10.3897/zookeys.882.35532
http://zookeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

The Passalidae (Coleoptera, Scarabaeoidea) from Bolivia, with the descriptions of three new species

Larry Jiménez-Ferbans[1], Pedro Reyes-Castillo[2], Jack C. Schuster[3]

1 *Universidad del Magdalena, Facultad de Ciencias Básicas. Carrera 32 No 22–08, Santa Marta, CZ-470004, Colombia* **2** *Instituto de Ecología, A.C., Red de Biodiversidad y Sistemática. Xalapa, CZ- 91070, Mexico* **3** *Universidad del Valle de Guatemala. Guatemala City, Guatemala*

Corresponding author: *Larry Jiménez-Ferbans* (ljimenezf@unimagdalena.edu.co)

Academic editor: *A. Frolov* | Received 18 April 2019 | Accepted 27 August 2019 | Published 23 October 2019

http://zoobank.org/35743CDB-6EB1-40FB-8635-EF8D40CE3D5C

Citation: Jiménez-Ferbans L, Reyes-Castillo P, Schuster JC (2019) The Passalidae (Coleoptera, Scarabaeoidea) from Bolivia, with the descriptions of three new species. ZooKeys 882: 51–85. https://doi.org/10.3897/zookeys.882.35532

Abstract

Employing data from literature, examination of specimens in collections, and a field trip, a list of the species of Passalidae from Bolivia is elaborated. A total of 38 species is reported, including new records of *Passalus inca* Zang, 1905 and *P. lunaris* (Kaup, 1871), and three new brachypterous species: *Passalus bolivianus* **sp. nov.**, *P. canoi* **sp. nov.**, and *P. gonzalezae* **sp. nov.** Most of the species (27) belongs to the Passalini tribe, especially to the genus *Passalus* Fabricius, 1792 (19 species); the Proculini tribe is represented by eleven species in three genera. The number of species of Bolivia is low and reflects the lack of a systematic exploration of this country; more surveys are needed, especially in ecosystems such as montane forest and tropical rain forest.

Resumen

Empleando datos de literatura, el examen de especímenes en colecciones y recolectados en campo, elaboramos una lista de las especies de Passalidae de Bolivia. Registramos un total de 38 especies, incluidos los nuevos registros de *Passalus inca* Zang, 1905 y *P. lunaris* (Kaup, 1871), y tres nuevas especies braquípteras: *Passalus bolivianus* **sp. nov.**, *P. canoi* **sp. nov.** y *P. gonzalezae* **sp. nov**. La mayoría de las especies (27) pertenecen a la tribu Passalini, especialmente al género *Passalus* Fabricius, 1792 (19 especies); la tribu Proculini está representada por 11 especies de tres géneros. El número de especies registradas para Bolivia es bajo y refleja la falta de una exploración sistemática de este país. Se necesitan más muestreos, especialmente en ecosistemas como el bosque montano y la selva tropical.

Keywords
bess beetles, Central South America, diversity, synopsis

Palabras clave
pasálidos, Suramérica central, diversidad, sinopsis

Introduction

Passalidae is a Pantropical group of Coleoptera. With few exceptions, the species of the family live inside rotting logs, feeding on decomposing wood. In the New World the family is represented by the tribes Passalini and Proculini, and in South America the majority of the species belongs to Passalini.

Zang (1905) described *Veturius spinipes*, constituting the first record of a Passalidae from Bolivia. After that, Gravely (1918) recorded three species and Luederwaldt (1931a) described *Paxillus pleuralis* from La Paz. Subsequently, other authors have cited and described additional species from Bolivia. Here we compile these records into a single annotated checklist that includes bibliographic references and general comments. Three new species from Bolivia are also described.

Materials and methods

Pedro Reyes-Castillo conducted a field trip to Santa Cruz in February 2010 and the material collected is deposited in the collection of the Instituto de Ecología in Xalapa (**IEXA**, Mexico). We examined the material from Bolivia deposited in this collection and also from the Museu de Zoologia, Universidade de São Paulo (**MZSP**, Brazil), Universidad del Valle de Guatemala (**UVGC**, Guatemala), The Field Museum of Natural History (**FMNH**, USA), the Colección Entomológica Universidad del Magdalena (**CEBUMAG-ENT**, Colombia) and the Colección Entomológica del Instituto de Ciencias Naturales of Universidad Nacional de Colombia (**ICN**, Colombia). The material was identified by us employing original descriptions, keys, and diagnoses provided in Kuwert (1898), Luederwaldt (1931a, b), Hincks (1940), Marshall (2000), Gillogly (2005), Boucher (2006), and Jiménez-Ferbans et al. (2013, 2016), and by comparison to the reliably identified material housed in IEXA and UVGC. In addition to the museum specimens, we reviewed the publications regarding the records of Passalinae from Bolivia.

For every species in the list, we included the entomological collection where the specimens from Bolivia are deposited, the authors that have recorded the species, the material examined (labels cited verbatim and separated by slashes), and comments. The classification adopted and the terminology employed for the head is that proposed by Boucher (2006), for the rest of the body that of Reyes-Castillo (1970).

Results

A total of 22 species has been recorded from Bolivia in the literature; meanwhile we found 25 species in the reviewed collections, including the specimens of *Passalus inca* from Conchabamba, Yungas del Palmar and *P. lunaris* from Santa Cruz, Chiquitos, new records for Bolivia, and specimens of 3 new species described below.

Annotated list of the Passalidae from Bolivia

Proculini

1. *Popilius marginatus* (Percheron, 1835)

Popilius marginatus (Percheron, 1835): Gravely (1918: 27), Hincks and Dibb (1935: 18), Doesburg (1942: 330), Gillogly (2005: 84).

Material examined. Bolivia: Guanay. X-1992. sp49. M. Kon, leg. 2004 // *Popilius* sp. ca *marginatus* (Percheron) Reyes-Castillo, det. 2006 (1 IEXA). Santa Cruz, Chajare (San Antonio) (1 IEXA). Sierra Santa Ana (1 IEXA). Santa Cruz. 4–6k SSE Buena Vista. F. & F. Hotel. Nov. 1–8 2002. J.E. Wappes (1 IEXA).

Comments. described from Brazil, this species is, according to Gillogly (2005), distributed throughout the Amazon Basin. It has been recorded from Argentina, Bolivia, Brazil, Colombia, French Guiana, Peru and Suriname (Hincks and Dibb 1935; Gillogly 2005; Jiménez-Ferbans et al. 2013).

2. *Popilius tetraphyllus* (Eschscholtz, 1829)

Popilius tetraphyllus (Eschscholtz, 1829): Gillogly (2005: 96).

Comments. described from Guiana, this species has a South American distribution that includes Bolivia, Brazil, Colombia, French Guiana, Guyana, Tobago, and Venezuela (Gillogly 2005; Jiménez-Ferbans et al. 2015). Gillogly (2005) recorded a specimen from “Bolivia. Beni: Chalcobo Indian Village (on Rio Benicito) (FMNH)”.

3. *Verres furcilabris* (Eschschltz, 1829)

Verres furcilabris (Eschschltz, 1829): Hincks and Dibb (1935: 29), Doesburg (1942: 330), Marshall (2000: 45), Boucher (2006: 352).

Material examined. Bolivia: Departamento de Cochabamba, Prov. Chapare, Sn. Antonio. IV-1953. Alt. 400 m. A. Martínez Col. // Selva tipo Amazónico (1 IEXA). Guanay. Sp48. X-1992. M. Kon leg. 2004. // *Verres furcilabris* (Eschscholtz) P. Reyes Castillo, det. 2005 (1 IEXA). Dpto. Santa Cruz, Prov. Florida, Samaipata, Paredones. 18 Nov 06. 18°8.437'S, 63°48.131'W. Altitud 1730 m. Cultivo abandonado (chaco Viejo). P. Reyes Castillo, col. // *Verres furcilabris* (Eschscholtz) P. Reyes Castillo, det. 2008 (1 IEXA). Dpto. Santa Cruz, Prov. Sara, Santa Rosa. XI-69. A. Martínez col. // *Verres furcilabris* (Eschscholtz) P. Reyes Castillo, det. 78 (1 IEXA). Sara, Santa Rosa, XI 1969, A. Martínez (1 IEXA). San Jose de Uchupiamonas. Alto Limon. 900 m. 19/30.VIII.96. col. A. Lopera B.H.T E.H. // *Verres furcilabris* Esch. Det. Amat 2001 (1 ICN-ENT).

Comments. described from Guiana, this species is distributed in Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Peru, Suriname, Trinidad and Tobago, and Venezuela (Hincks and Dibb 1935; Marshall 2000; Ratcliffe et al. 2015).

4. *Veturius* (*Veturius*) *boliviae* Gravely, 1918

Veturius (*Veturius*) *boliviae* Gravely, 1918: Gravely (1918: 38), Hincks and Dibb (1935: 24), Doesburg (1942: 330), Boucher (2006: 468).

Material examined. Bolivia: // ex coll H. Boileau. 1925. // *Veturius boliviae* Gravely 1918. S. Boucher det. 1988 (1 IEXA). Dpto. Cochabamba, Prov. Carrasco, Yungas. II-1971, Alt. 3200 m. A. Martínez col. // *Veturius boliviae* Gravely 1918. S. Boucher det. 04 // 266 (1 IEXA). Same data // Bosque Húmedo de Montaña. Bosq. de *Podocarpus* // *Veturius boliviae* Gravely 1918. S. Boucher det. 1988 (1 IEXA). Cochabamba, Carrasco, Khara Huasi 1880–1 900 m, E.N. Smith XII.1991 (3 UVGC). Santa Cruz, Florida, Samaipata, Abra de los Toros. 18 Nov. 2006. 18°7.113'S, 63°48.054'W. Altitud 2030 m. Bosque de lauráceas y helechos arborescentes. P. Reyes Castillo, col. // *Veturius boliviae* Gravel. P. Reyes-Castillo, det. 2008 (6 IEXA).

Comments. Gravely (1918) described this species from five specimens from “Chaco, Bolivia”. Boucher (2006) considered it as endemic to the Andes of Bolivia.

5. *Veturius* (*Veturius*) *dreuxi* Boucher, 2006

Veturius (*Veturius*) *dreuxi* Boucher, 2006: Boucher (2006: 470).

Comments. Boucher (2006) described *V. dreuxi* from Bolivia and Paraguay, citing the material from Bolivia as “Bolivie, La Paz, Nor Yungas, Pucara près Caranavi, 850 m, piège lumineux, P. Bleuzen & G. Lecourt X.1993 (MNHN). Bolivie, La Paz, Nor Yungas, Incahuara près Caranavi, 1500 m, piège lumineux, G. Lecourt XI.1991 (MNHN); Bolivia, Coroico [Nor Yungas] // Ex. Staudinger & Bang Haas (MUHD); Bolivia, Yungas de La Paz (MNHB)”. Until now, this species is only known from the type material.

6. *Veturius* (*Veturius*) *guntheri* Kuwert, 1898

Veturius (*Veturius*) *guntheri* Kuwert, 1898: Kuwert (1898: 173), Hincks and Dibb (1935: 25), Doesburg (1942: 330), Boucher (2006: 440).

Comments. Kuwert (1898) described this species based on specimens from "Mons Sorato in Bolivia". Recently, Boucher (2006) proposed *V. platyrrhinoides* Kuwert (Bolivia), *V. peruvianus* Arrow (Peru) and *V. platyrhinus* var. *fassli* Luederwaldt (Ecuador) as synonyms of *V. guntheri*. Thus, the distribution of the species includes Bolivia, Ecuador and Peru.

7. *Veturius* (*Veturius*) *libericornis* Kuwert, 1891

Veturius (*Veturius*) *libericornis* Kuwert, 1891: Hincks and Dibb (1935: 25), Boucher (2006: 472).

Comments. Kuwert (1891) described *V. libericornis* from the Amazon region, without more precision. This species has been recorded from Bolivia, Brazil, Ecuador and Peru (Hincks and Dibb 1935; Boucher 2006; Ratcliffe et al. 2015). Boucher (2006) cited material from Bolivia as "Bolivie, La Paz, Nor Yungas, Incahuara près Caranavi, ± 850 m, piège lumineux, G. Lecourt XI.1991-XI.1992 (MNHN) ; Bolivie, La Paz, Iturralde, rte Rurrenabaque – Ixiamas, 400 m, piège lumineux, P. Bleuzen & G. Lecourt X.1993 (MNHN); Bolivie, La Paz, Nor Yungas, rte Pucara à Caranavi, 850 m, piège lumineux, P. Bleuzen & G. Lecourt X.1993 (MNHN); Bolivie, La Paz, Nor Yungas, rte Caranavi à Carrasco, 1260 m, piège lumineux, G. Lecourt XII.1995 (MNHN); Bolivia, Coroico / *V. libericornis* Kuw. ?, det Hincks (MUHD 1 ex); Bolivia, Yungas de la Paz (MNHB 2 ex). – Bolivie, Santa Cruz, Buena Vista, P. Steinbach (MNHN)".

8. *Veturius* (*Veturius*) *libericornis* Kuwert, 1891

Veturius (*Veturius*) *libericornis* Kuwert, 1891: Boucher (2006: 486).

Comments. described from Brazil, Boucher (2006) reports it from Argentina, Bolivia, Brazil, Colombia, Ecuador, French Guyana, Guiana, Paraguay, Peru, Suriname, Trinidad and Tobago and Venezuela. From Bolivia, Boucher (2006) cited material as "La Paz, Teoponte, Rio Kaka, 400 m, Balogh, Mahunka, Zicsi // XII.1966 // *V. boliviae* Gravely, det. Endrödi 1971 (MTMA). – BENI : Bolivia, Valle del Mamoré, 450 m, XI.1948 (MNHN) ; Bolivia, Beni, B. Malkin VII–VIII.1960 // Chacobo Indian Village on Rio Benicito (FMNH); Bolivia, Beni, Rurrenabaque env., S. & P. Pokorny XI.1998 (CSP)".

9. *Veturius* (*Veturius*) *standfussi* Kuwert, 1891

Veturius (*Veturius*) *standfussi* Kuwert, 1891: Hincks and Dibb (1935: 25, as synonym of *V. platyrhinus*), Boucher (2006: 427).

Comments. originally described from Venezuela, this species is distributed in the Andes of Bolivia, Colombia, Ecuador, Peru and Venezuela (Boucher 2006). Boucher (2006) cited localities from Bolivia as "Bolivie, Riv. Songo, A.H. Fassl (MNHN);

Bolivie, Nor Yungas, Incahuara près Caranavi, 1500 m, piège lumineux, G. Lecourt XI.1991 (MNHN); Bolivie, Caranavi, 1500 m, piège lumineux, G. Lecourt XI.1992 (MNHN); Bolivie, près Caranavi, env. 1 000 m, X.2002 (MNHN); Bolivia, Yungas de La Paz [A. Fassl 1912–13] (MNHB 1 ex); Bolivia, Coroico // Ex. Staudinger & Bang Haas (MUHD); Bolivie, La Paz, Pucara près Caranavi, 850 m, piège lumineux, P. Bleuzen & G. Lecourt X.1993 (MNHN). –Bolivie, Cochabamba, > 2 000 m, piège lumineux, G. Lecourt X.1990 (MNHN)".

10. *Veturius* (*Veturius*) *yahua* Boucher, 2006

Veturius (*Veturius*) *yahua* Boucher, 2006: Boucher (2006: 442).

Material examined. Bolivia: Dpto. Santa Cruz. Prov. Ichilo, Buenavista (Tacú), Alt. 450 m. 6-III-1951. A Martinez, col. // *Veturius* (*V.) yahua*. M. PARATYPE. S. Boucher det. 04 // PARATYPE (2 IEXA).

Comments. Boucher (2006) described *V. yahua* from Bolivia, Brazil, Colombia, Ecuador, and Peru.

11. *Veturius* (*Publius*) *spinipes* (Zang)

Veturius (*Publius*) *spinipes* (Zang): Zang (1905: 231), Hincks and Dibb (1935: 30), Doesburg (1942: 330), Boucher (2006: 524).

Material examined. Bolivia: Chapare. II. 959. Martínez // *Publius crassus* Sm. P. Pereira det. 60 // *Publius spinipes* Zang 1905. S. Boucher det. 89 (1 IEXA).

Comments. described by Zang (1905) from "Bolivia, Mapiri", this species has been recorded also from Peru (Boucher 2006; Ratcliffe et al. 2015). Boucher (2006) also cited material from La Paz, Cochabamba, and Santa Cruz.

Passalini

12. *Paxillus leachi* MacLeay

Paxillus leachi MacLeay: Gravely (1918: 49), Luederwaldt (1931b: 69), Hincks and Dibb (1935: 35, 36 as *Paxillus brasiliensis* and *P. leachi*), Doesburg (1942: 331 as *P. brasiliensis*), Jiménez-Ferbans and Reyes-Castillo (2015: 433).

Material examined. Bolivia: Dpto. Santa Cruz. Prov. Ichilo, Buenavista, Tacú, 6-III-1951, A. Martínez (5 IEXA).

Comments. this species is distributed throughout the American continent, from Mexico to Argentina.

13. *Paxillus forsteri* Luederwaldt, 1927

Paxillus forsteri Luederwaldt, 1927: Hincks (1934: 270), Hincks and Dibb (1935: 36).

Comments. Described from "Caminas (Goyas)" in Brazil (Luederwaldt 1927), this species is also known from Bolivia and Peru (Hincks and Dibb 1935). Hincks (1934) recorded specimens from "Coroico: Bolivia".

14. *Paxillus pleuralis* Luederwaldt, 1931

Paxillus pleuralis Luederwaldt, 1931: Luederwaldt (1931a: 64), Hincks and Dibb (1935: 37), Doesburg (1942: 331), Mattos and Mermudes (2013), Jiménez-Ferbans and Reyes-Castillo (2015: 434).

Material examined. Bolivia: Los Molinos, 2000m, 17-VIII-1980 // Comparado con holotipo // *Paxillus pleuralis* Luederwaldt Reyes-Castillo, det. 1988 (1 IEXA). Dpto. La Paz, Bez. Süd-Yungas, Lambate hahe Chulumani, 1600 m // Ch. Bock leg. XI- 1916, ded. 12 8. 1921 // *Paxillus pleuralis* Lueder. det. 31 // 06425 // *Paxillus pleuralis* Luederwaldt 1931, holotipo, Reyes-Castillo, det. 1988 (1 MZSP).

Comments. This species was described by Luederwaldt (1931a) from Bolivia; Jiménez-Ferbans and Reyes-Castillo (2015) extended its range to Peru.

15. *Paxillus camerani* (Rosmini, 1902)

Paxillus camerani (Rosmini, 1902): Jiménez-Ferbans and Reyes-Castillo (2015: 432).

Material examined. Bolivia: Dpto. Cochabamba. Prov. Chapares, S.F. del Chipisi, 400 m, IV-1953, Martínez (2 IEXA). Same data // ICN-7078 (ICN-ENT).

Comments. this species is from the Amazon Basin: Bolivia, Brazil, Colombia, Ecuador, French Guiana, and Peru (Hincks and Dibb 1935; Amat-García et al. 2004; Mattos and Mermudes 2013). Jiménez-Ferbans and Reyes-Castillo (2015) recorded *P. camerani* for the first time from Bolivia, citing the two specimens from Cochabamba studied here.

16. *Paxillus martinezi* Jiménez-Ferbans & Reyes-Castillo, 2015

Paxillus martinezi Jiménez-Ferbans and Reyes-Castillo, 2015: Jiménez-Ferbans and Reyes-Castillo (2015: 428).

Material examined. Bolivia: Dpto. Cochabamba. Prov. Carrasco, Khora Huasi, 1880–1900 m, 30-XII-91-8-I-92, B.N. Smith // *Paxillus pentaphyloides* Lued. Det.: J. Schuster, 1993 // *Paxillus borellii* (Pangella) Det.: J.C.S. 1999 // Paratype (2 UVGC).

Dpto. Cochabamba. Yungas del Palmar, 2000m, III-63, A. Martínez // Paratype (1 IEXA). Chapare. Paratipo: 2200 m, 2-3-II-76 // Achat Pena // Pedro 92 No 3 // Paratype (2 UVGC). Dpto. Santa Cruz. Prov. Florida. El Chape, 1990–2250 m, 8-XII- 91, B.N. Smith // Paratype (1 IEXA). Dpto. Santa Cruz. Prov. Florida. Samaipata: Abra de los Toros, 18°7.113'S, 63°48.054'W, 2030m, 18-XI-2006, Bosque de lauráceas y helechos arborescentes, P. Reyes-Castillo // Holotype (1 IEXA). Same data // Paratype (2 IEXA). Same data // *Paxillus pleuralis* Luederwaldt, P. Reyes-Castillo, det. 2008 // Paratype (2 IEXA).

Comments. described from Bolivia, this species is only known by the type material.

17. *Passalus* (*Mitrorhinus*) *lunaris* (Kaup, 1871)

Material examined. Bolivia: Dpto. Santa Cruz, Prov. Chiquitos, Santiago de Chiquitos, río Tucavaca 18°18'45.2"S, 59°33'0.4"W, 16.xi.2008 Alt. 319 m // Bosque seco chiquitano, Bajo corteza W.D. Edmonds, P. Reyes, T. Vidaurre, cols. // *Passalus* (*Mitrorhinus*) *lunaris* (Kaup, 1869) Reyes-Castillo, det. 2010 (4 IEXA). Dpto. Santa Cruz, Prov. Chiquitos, Santiago de Chiquitos-Rio Tucavaca 18°16'9.7"S, 59°31'0.7"W 19.xi.2008. Alt. 360 m // Bosque seco chiquitano. En galería inicial, dentro de tronco W.D. Edmonds, P. Reyes, T. Vidaurre, cols. // *Passalus* (*Mitrorhinus*) *lunaris* (Kaup, 1869) Reyes-Castillo, det. 2010 (2 IEXA). Santa Cruz, Florida, Samaipata, río Paredones 19.xi.2006, 18°8.937'S, 63°48.792'W, Altitud 1390 m P. Reyes Castillo, col. (3 IEXA). Dpto. Santa Cruz, 4-6 SSE Buena Vista FandF Hotel 27–29.x.2000 Wappes and Morris // *Passalus* (*M.*) *lunaris* Kaup Mattos det 2014 (1 IEXA). Dpto. Santa Cruz, Reserva Nat. Potrerillo de Guenda 16–22.x.2006, Wappes, Nearns and Ella (1 specimen, IEXA). Prov. Inchilo [Ichilo] Buenavista I. 1950 A. Martínez leg. // *Passalus* (*M.*) *lunaris* Kaup. Mattos det 2014 (1 IEXA). Sp50 M. Kon, leg. 2004. Guanay, Bolivia xi.1992 // *Passalus* (*Mitrorhinus*) *lunaris* (Kaup) Reyes Castillo, det. 2004 (1 IEXA).

Comments. Described from Brazil, Luederwaldt (1931b) recorded it from “Campinas (Goyaz)”. Fonseca and Reyes-Castillo (2004: 17) recorded it from the states of Amazonas, Pará, Goiás and Sao Paulo. Outside of Brazil, it has been recorded from Argentina by Bruch (1942) and Jiménez-Ferbans et al. (2013). This is the first record for Bolivia.

18. *Passalus* (*Pertinax*) *catharinae* Gravely, 1918

Passalus (*Pertinax*) *catharinae* Gravely, 1918: Hincks and Dibb (1935: 43).

Comments. This species was described by Gravely (1918: 55) based on two specimens, one from “Santa Catharina” and the other from “Chaco”, without more precision. Hincks and Dibb (1935: 43) assumed “Chaco” as Chaco, Bolivia. We believe nobody has examined specimens of this species after its description.

19. *Passalus* (*Pertinax*) *convexus* Dalman, 1817

Passalus (*Pertinax*) *convexus* Dalman, 1817: Boucher (1990: 354).

Material examined. Bolivia: Dpto. Santa Cruz, Prov. Ichilo, Buenavista, 6.III.951. Alt. 450 m. A Martinez, col. (3 IEXA). Santa Cruz, Prov. Ichilo, Loc. Yapacani (BEEM). 8.VIII.2006 // Leg. I. Garcia, Ma. Julieta Ledezma et al. (3 IEXA). Depto. Beni, Rurrenabaque erea. I-2006. Alt. 230 m. M Kon, col. (1 IEXA). Chajare. II.1952. Antonio Martínez // *Passalus* (*Pertinax*) *convexus* Dalm., P. Pereita det.96 (1, MZSP).

Comments. Species with a broad distribution in South America, Boucher (1990) recorded specimens from Cochabamba and Santa Cruz, Bolivia; it has been recorded also from Argentina, Brazil, Colombia, Ecuador, French Guiana, Guyana, Peru, Trinidad and Tobago, Suriname and Venezuela (Luederwaldt 1931b; Hincks and Dibb 1935; Boucher 1990; Amat-García et al. 2004). Luederwaldt (1931b) erroneously recorded it from Chile.

20. *Passalus* (*Pertinax*) *morio* Percheron, 1835

Passalus (*Pertinax*) *morio* Percheron, 1835: Hincks and Dibb (1935: 45), Doesburg (1942: 331), Luederwaldt (1931b).

Comments. Described from Brazil, this species is broadly distributed in South America: Bolivia, Brazil, Colombia, Guiana, Paraguay, Suriname and Argentina (Hincks and Dibb 1935; Doesburg 1942). Luederwaldt (1931b) cited a specimen as "Museu Berlim-Dahlem: Yungas de la Paz (Bolivia) 1000 m".

21. *Passalus* (*Pertinax*) *nodifrons* Dibb, 1948

Passalus (*Pertinax*) *nodifrons* Dibb, 1948: Dibb (1948: 284); Hincks and Dibb (1958: 16).

Comments. Dibb (1948) described this species citing the following information: "Bolivia: La Paz, received, xii.1928, H. Clemens. Type and paratype (same data) in United States National Museum Collection, Washington". Until now, nobody has cited more specimens of it.

22. *Passalus* (*Pertinax*) *rhodocanthopoides* (Kuwert, 1891)

Passalus (*Pertinax*) *rhodocanthopoides* (Kuwert, 1891): Hincks (1949: 58, as *Paxillus tumupasae*), Hincks and Dibb (1958: 17).

Material examined. Bolivia: San José de Uchupiamonas, Pie Eslabón, 1200 msnm, 20.vii.1996. Col: A. Lopera B.H.T. // ICN-7085 // *Passalus* (*Pertinax*) *rhodocanthopoides* (Kuwert) det.: Reyes-Castillo 1998 (6 ICN-ENT).

Comments. In the catalogue of Hincks and Dibb (1935), this species is recorded from Brazil, Peru, and Suriname. Hincks (1949) described *Paxillus tumupasae* based on specimens from Bolivia; however, Hincks and Dibb (1958) synonymized it with *Passalus rhodocanthopoides*.

23. *Passalus* (*Passalus*) *abortivus* Percheron, 1835

Passalus (*Passalus*) *abortivus* Percheron, 1835: Hincks and Dibb (1935: 50).

Material examined. Bolivia: Buenavista, Ichilo, Santa Cruz. I.49[1949]. A. Mtz [Martínez] Col. // *Passalus* (*Passalus*) *abortivus* Perch. Det.: Jiménez-Ferbans 2016 (1 IEXA).

Comments. Species with a Guyano-amazonian distribution, present in Bolivia, Brazil, Colombia, French Guiana, Guyana, Peru, Suriname, Trinidad and Tobago, and Venezuela (Luederwaldt 1931b; Hincks and Dibb 1935; 1958, Reyes-Castillo 1973; Amat-García et al. 2004).

24. *Passalus* (*Passalus*) *armatus* Perty, 1890

Passalus (*Passalus*) *armatus* Perty, 1890: Hincks (1940: 488), Hincks and Dibb (1958: 17).

Comments. This species is distributed in Bolivia, Brazil, Guiana, Suriname (Hincks and Dibb 1935, 1958; Fonseca and Reyes-Castillo 2004). Hincks (1940) recorded material from Bolivia as "Bolivia: Isiamas Dec. (W. M. Mann, Mulford Biol. Expl. 1921–1922)".

25. *Passalus* (*Passalus*) *barrus* Boucher & Reyes-Castillo, 1991

Passalus (*Passalus*) *barrus* Boucher & Reyes-Castillo, 1991: Boucher and Reyes-Castillo (1991: 433).

Material examined. Bolivia: 6.VIII.1942. ex. Collection G. Griveau // PARATYPE (1 IEXA).

Comments. this species was described from Peru and Bolivia.

26. *Passalus* (*Passalus*) *coniferus* Eschscholtz, 1829

Passalus (*Passalus*) *coniferus* Eschscholtz, 1829: Hincks and Dibb (1935: 52).

Material examined. Bolivia: Dpto. de Cochabamba, Prov. Chapare, Sn. Antonio. IV-1953. Alt. 400 m. A. Martinez Col. // Selva tipo Amazónico (1 IEXA). Dpto. Cochabamba, Yungas del Palmar. III-1963. Alt. 2000 m. A Martínez col. // *Passalus coniferus*

Eschscholtz. P. Reyes Castillo, det. 2005 (1 IEXA). Guanay. X.1989. sp65. M. Kon leg. 2004 (1 IEXA). Santa Cruz. Prov. Cordillera. Loc. Incahuasi. 16.III.2008 // Leg: Tito Vidaurre // Tipo de cebo Insectos (1 IEXA). Dpto. Santa Cruz, Prov. Florida, Samaipata, Abra de los Toros. 18 Nov. 2006. 18°7.113'S, 63°48.054'W. Altitud 2030 m. Bosque de lauráceas y helechos arborescentes. P. Reyes Castillo, col. // *Passalus coniferus* Eschscholtz. P. Reyes Castillo, det. 2008 (1 IEXA). Dpto. Santa Cruz, Prov. Florida, Samaipata, Paredones. 18 Nov 06. 18°8.437'S, 63°48.131'W. Altitud 1730m. Cultivo abandonado (chaco Viejo). P. Reyes Castillo, col. // *Passalus coniferus* Eschscholtz. P. Reyes Castillo, det. 2008 (4 IEXA). Dpto. Santa Cruz, Prov. Ichilo, Buenavista, III-951. Alt. 450 m. A Martinez, col. (2 IEXA). Santa Cruz. Ichilo, Buenavista. I-49. A Martínez, col. (1 IEXA). Santa Cruz. 4–6k SSE Buena Vista. F. & F. Hotel. 23–26 Oct. 2000. Wappes & Morris (1 IEXA). Santa Cruz. 4–6k SSE Buena Vista. F. & F. Hotel. Nov. 1–8 2002. J.E. Wappes (1 IEXA). Santa Cruz. Portachuelo. Sare. I-49 (2 IEXA).

Comments. Species with South American distribution: Argentina, Bolivia, Brazil, Colombia, Ecuador, Paraguay, Peru (Hincks and Dibb 1935, 1958; Amat-García et al. 2004). It was recorded erroneously from the Antilles (Jiménez-Ferbans et al. 2015).

27. ***Passalus* (*Passalus*) *coarctatus* Percheron, 1835**

Passalus (*Passalus*) *coarctatus* Percheron, 1835: Jiménez-Ferbans et al. (2016: 171).

Material examined. Bolivia: Beni; VII-26-VIII-4-1960; leg. B. Malkin// Chacobo Indian Village on Rio Benicito 66°–12°20' // *Passalus* (*P.) coniferus* Eschsch. Det: J. Schuster 2001 // *Passalus* (*Passalus*) *coarctatus* Percheron Det.: Jiménez-Ferbans, 2015 (1 FMNH). Santa Cruz, 5 km SSE Buena Vista, Hotel Flora y Fauna, 11.II.2007, CW LB O'Brien (1 UVGC).

Comments. Described from Brazil, *P. coarctatus* was then recorded from Bolivia, Brazil, Trinidad and Tobago, and Venezuela by Jiménez-Ferbans et al. (2016).

28. ***Passalus* (*Passalus*) *inca* Zang, 1905**

Material examined. Bolivia: Cochabamba, Yungas del Palmar. Alt. 2000 m. A. Martínez. Col. // *Passalus* (*Passalus*) *inca* Zang. Reyes-Castillo, det 85 (1 IEXA).

Comments. Zang (1905) described this species from "Peru: Chanchamayo". This is the first record since the original description and first record from Bolivia.

29. ***Passalus* (*Passalus*) *interruptus* (Linneo, 1758)**

Passalus (*Passalus*) *interruptus* (Linneo, 1758): Hincks and Dibb (1935: 57).

Material examined. Bolivia: Dpto. Cochabamba, Prov. Chapare, Sn. Antonio. IV-1953. Alt. 400 m. A. Martínez col. Selva Amazónica (8 IEXA). Dpto. Cochabamba, El Palmar (Chapare), III-1953. Alt. 1000 m. A. Martínez col. // Bosque mixto de altura

V. Amazónico (4 IEXA). Guanay. 21.VIII.1989. sp63. M. Kon leg. 2004 // *Passalus* (*Passalus*) *interruptus* (Linneo) Reyes-Castillo, det. 2005 (1 IEXA). Santa Cruz. Chiquitos, Santiago de Chiquitos-Río Tucavaca. 18°18'45.2"S, 59°33'0.4"W. 16-XI-2008. Alt. 319 m. // Bosque seco chiquitano. Bajo corteza de árbol pequi. W.D. Edmonds, P. Reyes, T. Vidaurre, col. // *Passalus* (*Passalus*) *interruptus* (Linnaeus, 1758) Reyes-Castillo, det. 2010 (5 IEXA). Dpto. Santa Cruz, Prov. Cordillera Parapeti. Dic. 1960. A. Martínez col. Bosque tropical caducifolio (1 IEXA). Santa Cruz. Ichilo, Buenavista, I-49. A Martínez, col. (2 IEXA). Depto. de Santa Cruz, Prov. Ichilo, Buenavista, III-49. Alt. 450 m. A Martínez, col. (1 IEXA). Dpto. Santa Cruz, Prov. Santa Cruz de la Sierra, Jardín Botánico. 7 noviembre 2006. W.D. Edmonds, col. (1 IEXA). Santa Cruz. Portachuelo. Sare. I-49 (1 IEXA). Dpto. Santa Cruz, Prov. Sara, Santa Rosa. XI-69. A. Martínez Col. (5 IEXA).

Comments. This species is distributed in South America and Panama (Reyes-Castillo and Castillo 1992).

30. *Passalus* (*Passalus*) *interstitialis* Eschschltz, 1829

Passalus (*Passalus*) *interstitialis* Eschschltz, 1829: Hincks and Dibb (1935: 58).

Material examined. Bolivia: Dpto. de Beni, Rurrenabaque erea. I-2006. Alt. 230 m. M. Kon, col. (2 IEXA). Depto. Cochabamba, Chapare, El Palmar. III-1953. Alt. 1000 m. A. Martinez Col. // Bosque mixto de altura V. Amazónico // *Passalus* (*Passalus*) *interstitialis* Eschscholtz, 1829. Reyes-Castillo, det. 2005 (3 IEXA). Dpto. Cochabamba, El Palmar (Chapare), III-1953. Alt. 1000 m. A. Martínez Col. // Bosque mixto de altura V. Amazónico // *Passalus* (*Passalus*) *interstitialis* Eschscholtz, 1829. Reyes-Castillo, det. 2005 (6 IEXA). Dpto. de Cochabamba, Prov. Chapare, Sn. Antonio. IV-1953. Alt. 400 m. A. Martinez col. // Selva tipo Amazónico (16 IEXA). Same data // Bosque tipo amazónico (11 IEXA). Guanay. Sp67. 19-VII-1989. M. Kon leg. 2004. (1 IEXA). Guanay. Sp60. XI-1989. M. Kon leg. 2004. (1 IEXA). Dpto. Santa Cruz. Provincia Chiquitos, Santiago de Chiquitos-Río Tucavaca. 18-diciembre-2008. Alt. 39 m. // 18°18'45.2"S, 59°33'0.4"W. W.D. Edmonds, P. Reyes, T. Vidaurre, col. Bajo corteza, tronco árbol de toboroche // *Passalus* (*Passalus*) *interstitialis* Eschscholtz, 1829. Reyes-Castillo, det. 2010 (26 IEXA). Santa Cruz: Chiquitos, Santiago de Chiquitos-Río Tucavaca. 16-XI-2008. Alt. 319 m. // 18°18'45.2"S, 59°33'0.4"W// Bosque seco chiquitano, bajo corteza de árbol de Pequi. W.D. Edmonds, P. Reyes, T. Vidaurre, col. // *Passalus* (*Passalus*) *interstitialis* Eschscholtz, 1829. Reyes-Castillo, det. 2010 (3 IEXA). Dpto. Santa Cruz, Provincia Cordillera Parapeti. Diciembre, 1960. A. Martínez col. // Bosque tropical caducifolio (1 IEXA). Dpto. Santa Cruz: Prov. Ichilo, Buena Vista. 16 noviembre 2006. Alt. 410 m. P. Reyes, col. // *Passalus* (*Passalus*) *interstitialis* Eschscholtz, 1829. Reyes-Castillo, det. 2008 (1 IEXA). Santa Cruz. 4–6k SSE Buena Vista. F. & F. Hotel. Nov. 2–12 Feb. 2000. J.E. Wappes // transition tropical forest 420–450 m (1 IEXA). Dpto. Santa Cruz. Prov. Ichilo. Buenavista (Tacú). 6-III-951. A Martínez, col. (1 IEXA). Santa Cruz. Reserva Natural Potrerillo del Guenda. 6–9 Oct.

2006. Wappes, Nearns & Eya // Snake Farm. 17°40.26'S, 63°27.43'W. Elevation 400 m (1 IEXA). Same data 16–22 Oct. 2006 (1 IEXA). Santa Cruz. Portachuelo. Sare. I-49 (23 IEXA). Dpto. Santa Cruz, Prov. Sara, Santa Rosa. XI-69. A. Martínez col. (10 IEXA). Sta. Cruz, Sierra, Sn. Miguel. 63°34'W, 17°27'S. VIII.77. Y. Camberfort, leg. // *Passalus* (*Passalus*) *interstitialis* Eschscholtz. Reyes-Castillo, det. 80 (1 IEXA). Santa Cruz. Rd. To Amboro above Achira. 14–15 Oct. 2006. Wappes, Nearns & Eya // Ag cut/burn area 18°07.43'S, 63°47.98'W. Elevation 1940 m (1 IEXA).

Comments. This is a common species distributed from Mexico to Argentina.

31. *Passalus* (*Passalus*) *opacus* Gravely (1918)

Passalus (*Passalus*) *opacus* Gravely (1918): Gravely (1918: 63), Hincks (1933: 179), Hincks and Dibb (1935: 60), Doesburg (1942: 334).

Comments. This species was described from a single specimen from "Farinas, Bolivia" (Gravely 1918). Hincks (1933) studied two specimens from "Coroico, Bolivia".

32. *Passalus* (*Passalus*) *pugionatus* Burmeister

Passalus (*Passalus*) *pugionatus* Burmeister: Hincks (1940: 490), Hincks and Dibb (1958: 18).

Comments. described from Colombia, Hincks (1940) cited specimens from Bolivia, Colombia, Peru, and Venezuela. The specimens from Bolivia are referenced as "Coll. U.S.N.M.: Bolivia, Tumupasa Dec. (W. M. Mann, Mulford Biol. Expl. 1921–22)".

33. *Passalus* (*Passalus*) *pugionifer* Kuwert, 1891

Passalus (*Passalus*) *pugionifer* Kuwert, 1891 Hincks (1933: 179, 1940: 488), Hincks and Dibb (1935: 56), Doesburg (1942: 333).

Comments. Originally described from Peru; Hincks (1933) cited "several specimens from Coroico, Bolivia".

34. *Passalus* (*Passalus*) *punctiger* Lepeletier & Serville, 1825

Passalus (*Passalus*) *punctiger* Lepeletier & Serville, 1825: Hincks and Dibb (1935: 60).

Material examined. Bolivia: Dpto. Cochabamba, Chapare, El Palmar. III-1953. Alt. 1000 m. A. Martínez Col. // Bosque mixto de altura V. Amazónico // *Passalus* (*Passalus*) *interstitialis* Eschscholtz, 1829. Reyes-Castillo, det. 2005 (3 IEXA). Guanay. X.1992. sp52. M. Kon leg. 2004 // *Passalus* (*Passalus*) *punctiger* Lepeletier & Serville, 1825. Reyes-Castillo, det. 2005 (1 IEXA). Santa Cruz: Chiquitos, Santiago de Chiquitos-Río

Tucavaca. 18°20'19.2"S, 59°35'9.7"W. 15-XI-2008. Alt. 725 m. // Bosque en galería. En parte húmeda y dura de tocón. Pareja en galería inicial. P. Reyes col. // *Passalus* (*Passalus*) *punctiger* Lepeletier & Serville, 1825. Reyes-Castillo, det. 2010 (1 IEXA). Santa Cruz: Chiquitos, Santiago de Chiquitos-Río Tucavaca. 18°19'6.8"S, 59°34'36.5"W. 14-XI-2008. Alt. 706 m. // Bosque seco chiquitano. En galería de tronco podrido de paquio Ficus sp. P. Reyes col. // *Passalus* (*Passalus*) *punctiger* Lepeletier & Serville, 1825. Reyes-Castillo, det. 2010 (1 IEXA). Santa Cruz: Chiquitos, Santiago de Chiquitos-Río Tucavaca. 18°16'9.7"S, 59°31'0.7"W. 19-XI-2008. Alt. 360 m. // Bosque seco chiquitano. En galería inicial de tronco delgado. P. Reyes col. // *Passalus* (*Passalus*) *punctiger* Lepeletier & Serville, 1825. Reyes-Castillo, det. 2010 (2 IEXA). Santa Cruz: Chiquitos, Santiago de Chiquitos-Río Tucavaca. 18°16'9.7"S, 59°31'0.7"W. 16-XI-2008. Alt. 360 m. // Bosque seco chiquitano. Bajo corteza. W.D. Edmonds, P. Reyes, T. Vidaurre, col. // *Passalus* (*Passalus*) *punctiger* Lepeletier & Serville, 1825. Reyes-Castillo, det. 2010 (1 IEXA). Same data // sp55 (1 IEXA). Same data // sp62 (1 IEXA).

Comments. This is a common species distributed from Mexico to Argentina.

35. *Passalus* (*Passalus*) *unicornis* Lepeletier & Serville, 1825

Passalus (*Passalus*) *unicornis* Lepeletier & Serville, 1825 Luederwaldt (1931b: 188), Hincks and Dibb (1935: 63).

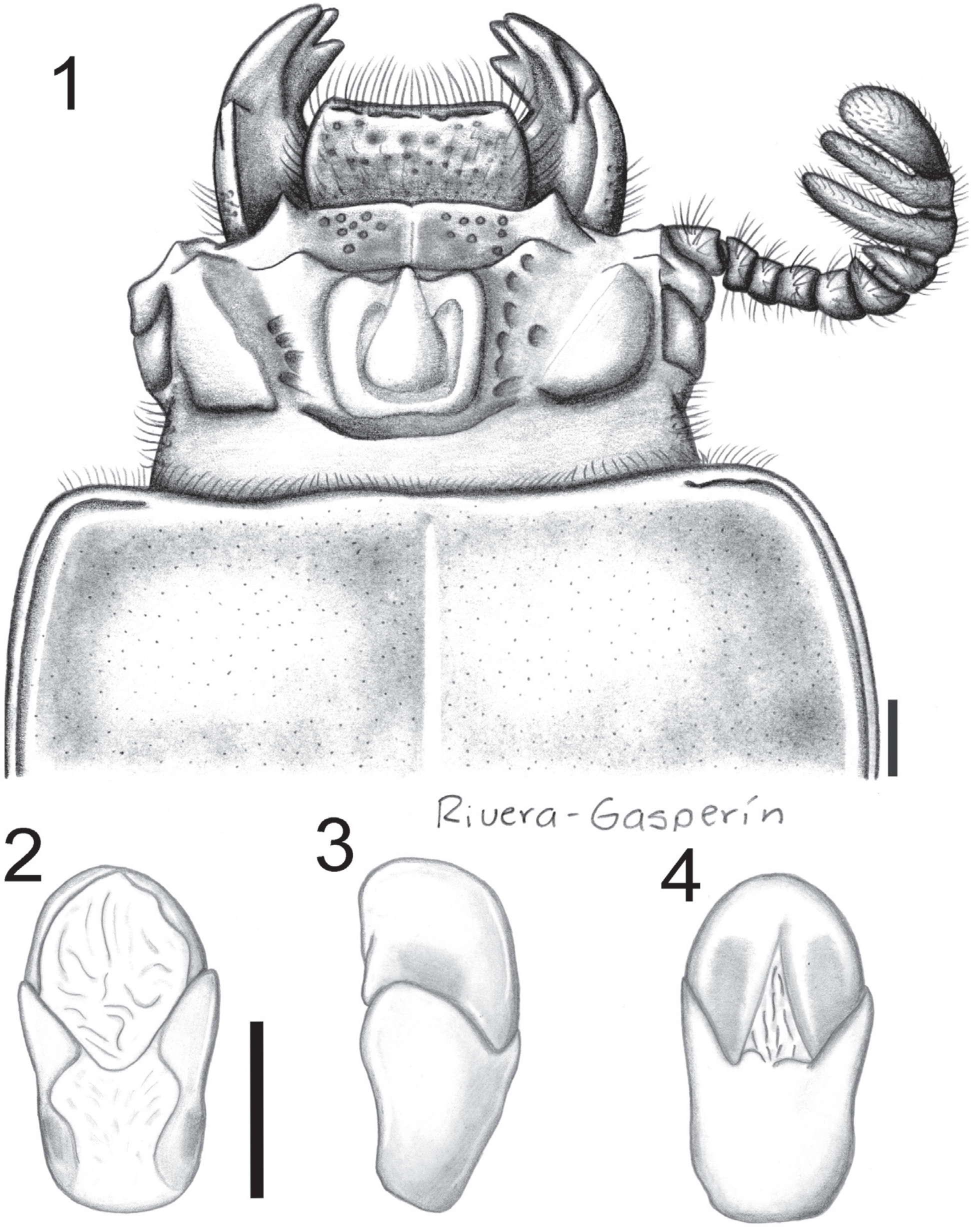
Comments. Described from Cayenne, French Guiana, this species has been recorded from the Lesser Antilles, Bolivia, Brazil, and Colombia. Jiménez-Ferbans et al. (2013) considered the citation from Argentina as dubious. Similarly, we consider the record from Guatemala by Hincks and Dibb (1935) as dubious. Luederwaldt (1931b) cited an exemplar from "Bolivia, Steinbach leg., immature", remarking that it only has 29 mm total length. We doubt that this specimen belongs to *P. unicornis*, a species with a total length of 36–45 mm (Jiménez-Ferbans et al. 2016).

Descriptions of new species

Passalus (*Pertinax*) *bolivianus* sp. nov.

http://zoobank.org/E6304B84-71B7-481C-A525-CB6B2B4692AE
Figs 1–4

Material examined. Holotype: female, pinned, BOLIVIA: COCHABAMBA, Prov. Carrasco, Yungas. ii.1971. alt. 3200 m. A. Martínez col. // Bosque húmedo de montaña de *Podocarpus* (CEBUMAG-ENT). Paratypes: 2 males, 8 females, 18 unsexed, same data as holotype (IEXA, FMNH). 1 female, BOLIVIA: COCHABAMBA, Prov. Carrasco, Serranía de Siberia, Chua Khocha // 30.viii.1990, No. 093, cloud forest, 2300 m inside log, M. Ledezma Field Museum // #93 // *Passalus* (*Pertinax*) n. sp. det.: Jiménez-Ferbans 2015 // Ilustrado por Rivera-Gasperin (FMNH). 1 specimen, BO-



Figures 1–4. *Passalus* (*Pertinax*) *bolivianus* sp. nov. **1** dorsal view of the head and anterior part of pronotum **2–4** Aedeagus **2** dorsal view **3** lateral view **4** ventral view. Scale bars: 1 mm.

LIVIA: SANTA CRUZ, Florida, 4km S. De Samaipata 1800 m alt., 7.xii. 1991, B.N. Smith (IEXA).

Diagnosis. *Passalus* (*Pertinax*) *bolivianus* sp. nov. differs from other brachypterous species of *Passalus* (*Pertinax*) by having lateroposterior tubercles larger that central tubercle, anterior border of frons almost straight with small middle indentation, rounded punctures on both lateral and dorsal elytral striae, and elytral humeri heavily pubescent.

Description. ***Habitus:*** midsize, total length 32.8–36.8 mm, brachypterous, body convex, shiny, black.

Head: labrum with anterior border straight or slightly concave, covered with setae that are less dense anteriorly. Clypeus hidden under the frons, with anterior angles reduced under the mediofrontal tubercles and smaller than mediofrontal tubercles. Frons narrow, anterior frontal edge with small middle indentation, without secondary mediofrontal tubercles. Mediofrontal tubercles projected forward, larger than internal tubercles. Internal tubercles small, conical, with apex not free, joined to mediofrontal tubercles by a weak ridge, located midway between mediofrontal tubercles and central tubercle apex. Posterofrontal ridges V-shaped. Area between the frontal ridges with scarce punctures on the anterior half, divided by a longitudinal sulcus running from border of frons to the base of central tubercle. Cephalic tumescence (= mamelon sensu Jiménez-Ferbans and Reyes-Castillo 2014) divided. Mesofrontal structure of the "marginatus" type (Reyes-Castillo 1970), central tubercle wide at the base with a sulcus posteriorly, apex not free. Lateroposterior tubercles marked, conical and large, larger than central tubercle. Lateropostfrontal areas glabrous, shiny, and impunctate. Eyes reduced, canthus glabrous, covering ½ of the eye in lateral view. Postorbital pits weak. Postfrontal groove semicircular and complete, with small inverted v-shape in central part. Hypostomal process slightly separated from mentum, glabrous, extending anteriorly to the superior part of the middle zone of the mentum. Medial basal mentum protruding ventrally, laterally pubescent. Mentum with large lateral fossae that are shallow and pubescent. Antennal club trilamellate, lamellae elongate. Internal tooth of the left mandible bidentate, simple on right mandible. Dorsal tooth longitudinally straight in dorsal view but slightly sinuous in lateral view. Dorsal mandibular pubescence covering the base of mobile tooth. Mandibular fossae reaching base of mobile tooth. Maxilla with lacinia apically bidentate. Ligula tridentate, middle tooth longer than lateral teeth. Middle palpomere of the labial palp 1.3 times wider, and 1.1 times longer, than distal palpomere.

Thorax: Pronotum rounded in dorsal view, wider than elytra, with punctures restricted to areas around lateral fossae and marginal groove. Marginal groove narrow, clearly visible along anterior angles, extending along approximately 1/3 of the anterior margin of the pronotum; median longitudinal sulcus and lateral fossae well marked. Inferolateral area of pronotum with abundant pubescence. Prosternellum rhomboidal, opaque. Pre-epimeron (sensu Reyes-Castillo 1970) shiny and fully pubescent. Mesosternum with small, rounded, mesosternal scar, glabrous, lateral area opaque. Posterior corner of the mesepisternum and mesepimeron glabrous. Metasternum pubescent anteriorly and in lateral fossa; metasternal disc delimited by numerous punctures medially and posteriorly. Metasternal lateral fossa and epipleuron of similar width.

Elytron: Shiny, anterior border rounded and pubescent. Humerus and epipleuron pubescent. Rounded punctures on lateral and dorsal striae (but more strongly on lateral striae).

Leg: Femur I with ventral anterior marginal sulcus narrow and complete (reaching the apical pubescence). Tibia I with dorsal sulcus complete. Tibia II with one weak spine and tibia III unarmed.

Abdomen: Marginal groove of posterior-most sternite complete.

Aedeagus: Basal piece fused with parameres in ventral view (Fig. 4). Ventral surface of median lobe almost entirely sclerotized, measured along media ventral line, length of medial lobe 0.9 times that of basal piece and parameres. Lateral projections of parameres small and apices rounded in lateral view (Fig. 3).

Etymology. Named after the country, Bolivia.

Variations. The anterior border of the labrum can be straight or slightly concave. The longitudinal sulcus on the area between frontal ridges can be weak or marked. Medial basal mentum can be fully pubescent or only laterally so.

Taxonomic discussion. *Passalus* (*Pertinax*) *bolivianus* sp. nov. is similar in size and habitus to *Passalus nudifrons* Dibb, from which it differs by having anterior border of head straight with central excision, humeri pubescent and anterior area of metasternum punctate and pubescent. Likewise, the total length of *P. bolivianus* sp. nov. is similar to that of *P. gonzalezae* sp. nov., but the former has elytral striae with rounded punctures, marked on both lateral and dorsal striae (weak punctures on striae 7–10 in *P. gonzalezae*) and humeri heavily pubescent.

***Passalus* (*Pertinax*) *gonzalezae* sp. nov.**
http://zoobank.org/BF2BA672-2764-4F13-8021-A0B9C4F04988
Fig. 5

Material examined. Holotype: female, pinned, BOLIVIA: Yungas, Incachaca, 2800 m, xii.1960, Zischka leg. // *Passalus* (*Pertinax*) n. sp. Det.: Jiménez-Ferbans, 2016.

Diagnosis. Among the brachypterous species of *Passalus* (*Pertinax*), *P. gonzalezae* sp. nov. is recognizable by the absence of punctures on frontal area (delimited by the frontal ridges), by having anterior border of head with strong (deep) middle indentation, insinuating secondary mediofrontal tubercles, and weak punctures on elytral striae 7–10.

Description. ***Habitus:*** midsize, total length 31.3 mm, brachypterous, body convex, reddish (teneral).

Head: labrum with anterior border almost straight, covered with setae uniformly. Clypeus hidden under the frons, with anterior angles reduced under the mediofrontal tubercles and smaller than mediofrontal tubercles. Frons narrow, anterior frontal edge with strong median indentation, insinuating secondary mediofrontal tubercles. Mediofrontal tubercle projected anteriorly and similar in size to internal tubercle. Internal tubercle midway between mediofrontal tubercles and apex of central tubercle, apex not free, nor joined to mediofrontal tubercles by a ridge. Posterofrontal ridges V-shaped. Area between the frontal ridges without punctures, divided by a longitudinal sulcus from the border of frons to the base of cephalic tumescence (= mamelon sensu Jimén-

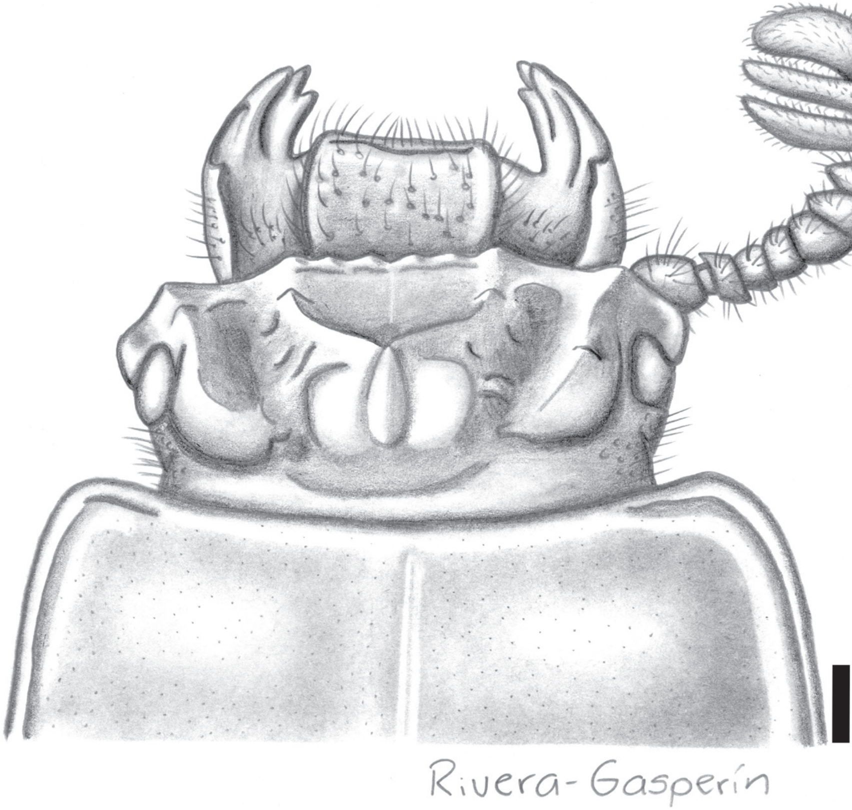


Figure 5. *Passalus* (*Pertinax*) *gonzalezae* sp. nov., dorsal view of the head and anterior part of pronotum. Scale bar: 1 mm.

ez-Ferbans and Reyes-Castillo 2014). Cephalic tumescence not divided. Mesofrontal structure of the "marginatus" type (Reyes-Castillo 1970), with central tubercle wide at the base, lacking posterior sulcus, apex not free. Lateroposterior tubercle marked but small, smaller than central tubercle. Lateropostfrontal area glabrous, shiny, and impunctate. Eye reduced, canthus covering 2/3 of eye in lateral view. Left canthus with two setae, right canthus glabrous. Postorbital pit weak. Postfrontal groove semicircular, complete and with small inverted v-shape in central part. Hypostomal process slightly separated from mentum, glabrous and extending anteriorly to superior part of the middle zone of the mentum. Medial basal mentum protruding ventrally, laterally pubescent. Mentum with large lateral fossae, shallow and pubescent. Antennal club tri-lamellate, with lamellae elongate. Internal tooth of left mandible bidentate, simple on right mandible. Dorsal tooth straight in dorsal view and slightly sinuous in lateral view. Dorsal mandibular pubescence covering base of mobile tooth. Mandibular fossae reaching base of mobile tooth. Lacinia apically bidentate. Ligula tridentate, middle tooth slightly longer than lateral teeth. Middle labial palpomere same width as, and 1.1 times longer than, distal palpomere.

Thorax: Pronotum rounded in dorsal view, wider than elytra, with 34 punctures on lateral fossae areas and three punctures restricted to the area of the marginal groove. Marginal groove narrow, visible at anterior angles and extending 1/3 length of anterior margin of pronotum. Longitudinal sulcus and lateral fossa well marked. Inferolateral area of pronotum with sparse pubescence. Prosternellum rhomboidal, shiny. Preepimeron (sensu Reyes-Castillo 1970) shiny and glabrous. Mesosternum with mesosternal scar oval, glabrous, lateral area opaque. Posterior corner of the mesepisternum and mesepimere glabrous. Anterolateral part of metasternum smooth and glabrous. Metasternum glabrous anteriorly and in lateral fossa; metasternal disc smooth (without punctures), delimited by numerous punctures posteriorly. Posterior metasternal lateral fossa less wide than epipleura.

Elytron: Shiny, anterior border rounded and glabrous. Humerus and epipleuron glabrous. Striae with rounded punctures, barely perceptible on striae 5–10.

Leg: Femur I with ventral anterior marginal sulcus narrow and complete, reaching the apical pubescence. Tibia I with dorsal sulcus complete. Tibia II with one weak spine and tibia III unarmed.

Abdomen: Marginal grove of posterior-most sternite complete.

Etymology. This species is named in honor of Dr. Dolores Gonzalez from Instituto de Ecología A.C. (Mexico), who has collaborated with the authors in molecular phylogenetic studies of Passalidae.

Taxonomic discussion. *Passalus gonzalezae* sp. nov. is similar to *P. catharinae* Gravely, 1918 (31–33 mm) from which it differs by the absence of punctures on frontal area, by having anterior border of head with strong (deep) middle indentation, so strong that it produces the appearance of being flanked by secondary mediofrontal tubercles, apex of central tubercle not free (attached to the frons), the reduced wings, and weak punctures on striae 7–10. From other brachypterous species, *P. gonzalezae* sp. nov. is similar to *P. nudifrons* and *P. bolivianus* sp. nov. However, *P. nudifrons* has the head with anterior margin shallowly concave, without central excision, while in *P. gonzalezae* sp. nov. the anterior frontal edge has a strong median indentation, insinuating secondary mediofrontal tubercles. From *P. bolivianus* sp. nov., *P. gonzalezae* sp. nov. differs by having weak punctures on striae 7–10 (strong in *P. bolivianus* sp. nov.) and humeri glabrous.

***Passalus* (*Pertinax*) *canoi* sp. nov.**

http://zoobank.org/3E5C476C-2106-4100-B3E1-9402E5EDDD65
Figs 6–9

Material examined. Holotype: female, pinned, BOLIVIA: Yungas del Palmar, 15.iii.1958, 2000 m M. Zlsekka // "*Publius*" *spinipes* Zang Det.: JCS [Jack C. Schuster] '95 [1995] // *Passalus* (*Pertinax*) sp. n. Reyes-Castillo det. 2013 (UVG). Paratype: female, pinned BOLIVIA: COCHABAMBA, Yungas del Palmar // iii.1963, Alt. 2000 m A. Martínez col. // *Passalus* (*Pertinax*) n. sp. det.: Jiménez-Ferbans 2015 // Ilustrado por Rivera-Gasperin (CEBUMAG-ENT)

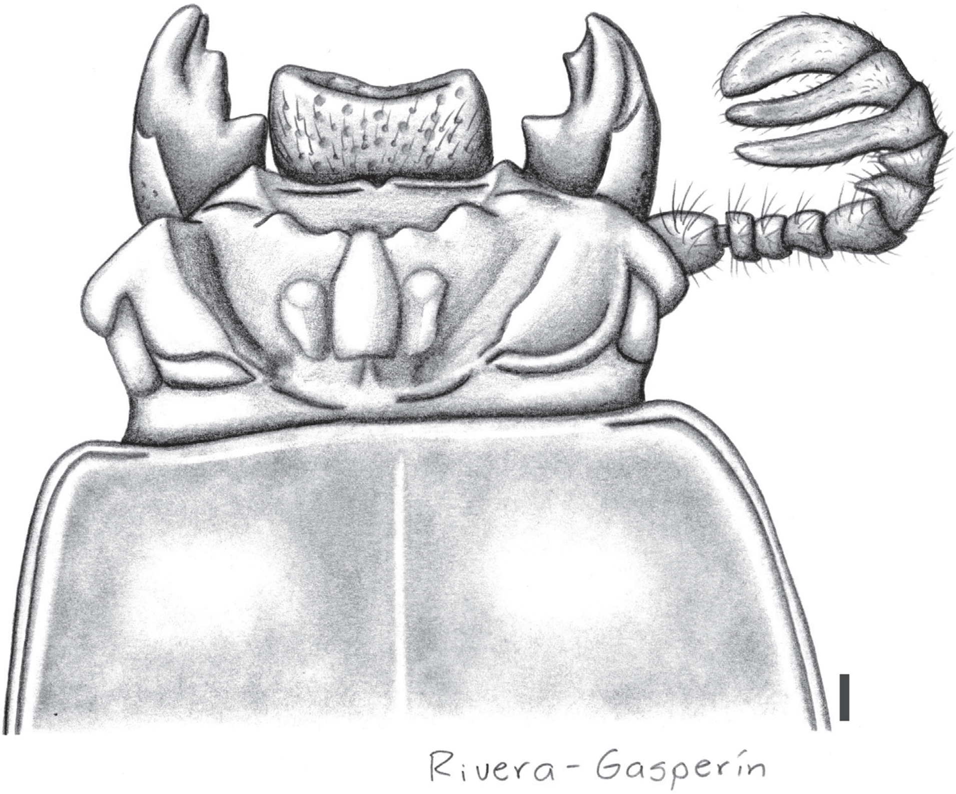
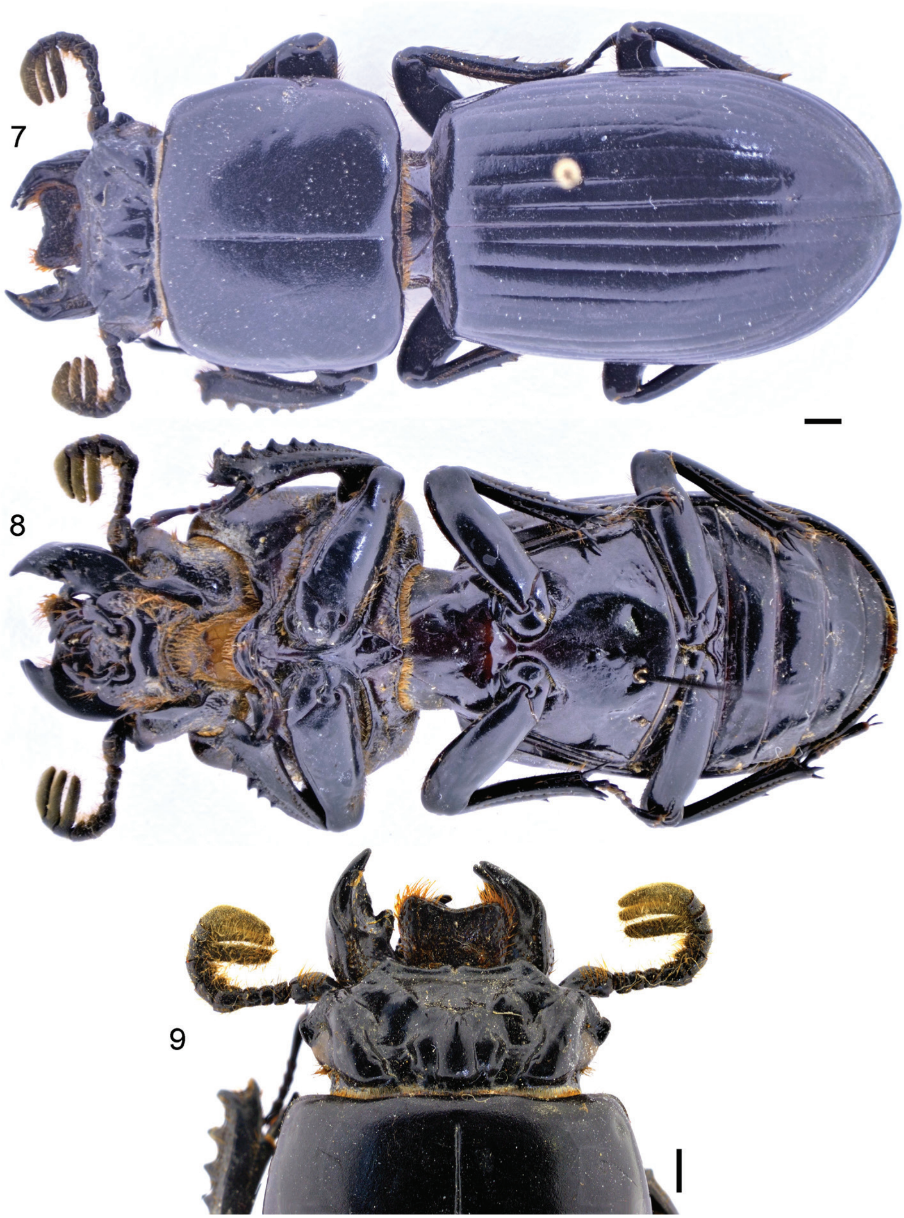


Figure 6. *Passalus* (*Pertinax*) *canoi* sp. nov., dorsal view of the head and anterior part of pronotum. Scale bar: 1 mm.

Diagnosis. *P. canoi* sp. nov. is diagnosable by its large size (45.0–46.0 mm), strong indentation on frontal edge, internal tubercles joined to medifrontal tubercles by a weak ridge, humeri and epipleura glabrous, inferolateral area of pronotum with sparse pubescence, and metasternal disc delimited by punctures only posteriorly.

Description. ***Habitus:*** large size, total length 45.2–46.0 mm, brachypterous, body convex, shiny, black.

Head: labrum with anterior border concave, covered with setae that are less dense in anterior border. Clypeus hidden under the frons, anterior angles reduced under mediofrontal tubercles and smaller than mediofrontal tubercles. Frons narrow, anterior frontal edge with strong middle indentation, insinuating secondary mediofrontal tubercles. Mediofrontal tubercle projected forward, larger than internal tubercle. Internal tubercle located midway between mediofrontal tubercles and the central tubercle apex, apex not free, weakly joined to mediofrontal tubercles by a weak ridge. Posterofrontal ridges V-shaped. Area between the frontal ridges lacking punctures. Cephalic tumescence (= mamelon sensu Jiménez-Ferbans and Reyes-Castillo 2014) not divided. Mesofrontal structure of the "marginatus" type (Reyes-Castillo 1970), with central tubercle wide at the base, lacking posterior sulcus, apex not free. Lateroposterior tubercle



Figures 7–9. *Passalus* (*Pertinax*) *canoi* sp. nov. **7** dorsal habitus **8** ventral habitus **9** dorsal view of the head and anterior part of pronotum. Scale bars: 2 mm.

large. Lateropostfrontal area glabrous, shiny, and impunctate. Eye reduced, canthus covering 3/4 of eye in lateral view. Canthus glabrous. Postorbital pit weak. Postfrontal groove semicircular and complete, with small inverted v-shape in central part. Hypostomal process slightly separated from mentum, glabrous and extending anteriorly to the superior part of the middle zone of the mentum. Medial basal mentum protruding ventrally, glabrous. Mentum with large lateral fossae, shallow and pubescent (the fossae is glabrous). Antennal club tri-lamellate, with lamellae elongate. Internal tooth of left mandible bidentate, simple on right mandible. Dorsal tooth straight in dorsal view and slightly concave in lateral view. Dorsal mandibular pubescence covering base of mobile tooth. Mandibular fossae reaching base of mobile tooth. Lacinia apically bidentate. Ligula tridentate, middle tooth longer than lateral teeth. Middle labial palpomere same length as, and 1.5 times wider than, distal palpomere.

Thorax: Pronotum rounded, wider than elytra, with punctures restricted to lateral fossae (12 on right and 14 on left). Marginal groove narrow, visible in anterior angles, and extending along 1/3 of anterior margin of pronotum; longitudinal sulcus well marked. Lateral fossae marked. Inferolateral area of pronotum with sparse pubescence. Prosternellum rhomboidal, opaque. Pre-epimeron (sensu Reyes-Castillo 1970) shiny and fully pubescent. Mesosternum with mesosternal scar small and rounded, glabrous; lateral area opaque. Posterior corner of mesepisternum and mesepimeron glabrous. Anterolateral part of metasternum smooth and glabrous. Anterior portion and lateral fossa of metasternum glabrous; metasternal disc delimited by punctures posteriorly; metasternal lateral fossa narrower than epipleura.

Elytron: Shiny, anterior border rounded and glabrous. Humerus and epipleuron glabrous. Striae with rounded punctures (weak), stronger on lateral striae than on dorsal striae.

Leg: Femur I with ventral anterior marginal sulcus narrow and complete (reaching the apical pubescence). Tibia I with dorsal sulcus complete. Tibia II and III with one weak spine.

Abdomen: Marginal groove of posterior-most sternite complete.

Etymology. This species is named in honor of Dr. Enio Cano from Guatemala, a passionate scholar of Scarabaeoidea.

Variation. Five punctures on the anterior half (paratype), punctations restricted to the lateral fossae (11 on right and 82 on the left).

Taxonomic discussion. The size of *P. canoi* sp. nov. easily differentiates this species from other brachypterous *Passalus* (*Pertinax*). However, the habitus and strong indentation on frontal edge can make it similar to *P. gonzalezae* sp. nov., from which *P. canoi* sp. nov. differs by having a weak ridge joining the internal tubercles with mediofrontal tubercles; this characteristic also makes *P. canoi* sp. nov. different from *P. nudifrons*. Another difference is the medial basal mentum glabrous in *P. canoi* sp. nov. and laterally pubescent in *P. gonzalezae* sp. nov., and the frontal area divided by a longitudinal sulcus from the border of frons to the base of cephalic tumescence in *P. gonzalezae* sp. nov. (there is no sulcus in *P. canoi* sp. nov.).

Key to the Passalidae from Bolivia

Since the fauna of Passalidae from Bolivia is still poorly known, this key must be used with caution. It is probable that future surveys will yield new species and new country; for this reason, it is convenient to use this key and then confirm the determination with original description or diagnosis of the species.

1 Clypeus hidden below frons, with anterior angles below mediofrontal tubercles (Fig. 11) **2**
– Clypeus (frontoclypeus) exposed dorsally, with anterior angles in front of border of frons (Fig. 10) **28**
2 Maxilla with lacinia unidentate or bidentate in apical third (Fig. 14). Antennal club with five lamellae (Fig. 18). Mediobasal area of mentum flat (Fig. 12). Prosternellum pentagonal (*Paxillus*) (Fig. 16) **3**
– Maxilla with lacinia bidentate in apical third (Fig. 15). Antennal club with three lamellae (five in *Passalus rhodocanthopoides* and four in *P. interstitialis*) (Figs 19–21). Mediobasal area of mentum protruding (Fig. 13). Prosternellum rhomboidal (Fig. 17) (*Passalus*) **7**
3 Maxilla with lacinia unidentate in apical third (Fig. 14). Anterior border of frons straight, without secondary mediofrontal tubercles (Fig. 11) **4**
– Maxilla with lacinia bidentate in apical third (Fig. 15). Anterior border of frons with two small secondary mediofrontal tubercles (Fig. 18) **5**
4 Dorsal mandibular tooth with a concave expansion (in dorsal view). Mesosternum smooth, without punctures over mesosternal scar. Body length 16.0–19.5 mm .... ***Paxillus leachi* MacLeay**
– Dorsal mandibular tooth thin, without a concave expansion. Mesosternum with punctures over mesosternal scar and beyond. Body length 14.0–16.0 mm .... ***Paxillus camerani* (Rosmini)**
5 Mesosternal scar oval, weakly defined, shiny. Metasternal fossae and epipleura glabrous. Body length 18.0–19.0 mm .... ***Paxillus forsteri* Luederwaldt**
– Mesosternal scar elongate, well-defined, and rugose. Metasternal fossae and epipleura pubescent **6**
6 First lamella of antennal club reduced. Body length 22.7–23.1 mm (Fig. 18) .... ***Paxillus martinezi* Jiménez-Ferbans & Reyes-Castillo**
– First lamella of antennal club not reduced, almost equal in width to second lamella. Body length 18.5–19.5 mm .... ***Paxillus pleuralis* Luederwaldt**
7 Anterior border of frons straight or almost straight, without secondary mediofrontal tubercles (Fig. 19). Central tubercle with apex not free, fused with frontal ridges (subgenus *Pertinax*) **8**
– Anterior border of frons with one or two secondary mediofrontal tubercles (Figs 20–21); if not, and border is straight, then central tubercle with apex distinctly free (reaching or almost reaching frons border) **15**
8 Antennal club with 5 lamellae, first two reduced (half width of third lamella). Body length 22.0–25.0 mm .... ***Passalus* (*Pertinax*) *rhodocanthopoides***
– Antennal club with three lamellae (Fig. 19) **9**
9 Wings reduced (brachypterous) (Fig. 7) **10**
– Wings fully developed (macropterous) **13**
10 Lateroposterior tubercles larger that central tubercle (Fig. 1). Elytral humeri heavily pubescent. Body length 32.8–36.8 mm .... ***Passalus* (*Pertinax*) *bolivianus* sp. nov.**
– Lateroposterior tubercles smaller that central tubercle (Figs 5–7). Elytral humeri glabrous **11**

11 Internal tubercles joined to mediofrontal tubercles by a weak ridge. Frontal area, between frontal ridges, not divided by a longitudinal sulcus (Figs 6, 9). Medial basal mentum glabrous (Fig. 8). Body longer (45.0–46.0 mm) .... ***Passalus* (*Pertinax*) *canoi* sp. nov.**

– Internal tubercles not joined to mediofrontal tubercles by a ridge (Fig. 5). Frontal area divided by a longitudinal sulcus from border of frons to base of cephalic tumescence. Medial basal mentum laterally pubescent. Body shorter (31.0–32.0 mm).. **12**

12 Anterior frontal border with strong median indentation, insinuating secondary mediofrontal tubercles (Fig. 5). Body length 31.3 mm.. ***Passalus* (*Pertinax*) *gonzalezae* sp. nov.**

– Anterior frontal edge straight, without median indentation. Body length 32.0 mm .... ***Passalus* (*Pertinax*) *nodifrons* Dibb**

13 Apex of central tubercle slightly free (the very tip not detached to the frontal ridgeds and frontal area). Body length 31.0–33.0 mm .... ***Passalus* (*Pertinax*) *catharinae* Gravely**

– Apex of central tubercle not free, fused with frontal ridges (Fig. 19)................ **14**

14 Humeri with sparse pubescence at base. Body shorter (25.1–28.0 mm) .... ***Passalus* (*Pertinax*) *morio* Percheron**

– Humeri glabrous. Body longer (42.2–44.3 mm) (Fig. 19).. ***Passalus* (*Pertinax*) *convexus* Dalman**

15 Anterior border of frons with one secondary mediofrontal tubercle. Central tubercle with apex not free. Hypostomal process with a matt groove over apex.. ***Passalus* (*Mitrorhinus*) *lunaris* (Kaup)**

– Anterior border of frons with two secondary mediofrontal tubercles; if border straight, then central tubercle with apex distinctly free ("Petrejus" group). Hypostomal process without a matt groove over apex (subgenus *Passalus*) **16**

16 Anterior border of frons with two secondary mediofrontal tubercles joined at bases **17**

– Anterior border of frons with or without mediofrontal tubercles, when present secondary mediofrontal tubercles separated.. **18**

17 Secondary mediofrontal tubercles large and fused with each other almost totally. Lateropostfrontal area glabrous. Body length 24.3–27.0 mm .... ***Passalus* (*Passalus*) *barrus* Boucher & Reyes-Castillo**

– Secondary mediofrontal tubercles only contiguous at base. Lateropostfrontal area pubescent. Body length 31.1–33.0 mm........ ***Passalus* (*Passalus*) *abortivus* Percheron**

18 Central tubercle with apex very free, reaching or surpassing anterior border of frons. Secondary mediofrontal tubercles absent or rudimentary ("Petrejus" group).. **19**

– Central tubercle with apex not free or slightly free (Fig. 21); if reaching anterior border of frons, then metasternum densely pubescent (anterior and lateral areas). Secondary mediofrontal tubercles always present and large (Figs 20–21) ("Neleus" group) **22**

19 Central tubercle surpassing widely anterior margin of head, fused to median portion of head almost to anterior margin. Body length 24.0 mm.......................... ....***Passalus* (*Passalus*) *pugionifer* Kuwert**
– Central tubercle not fused to median portion of head....................................**20**
20 Central tubercle concave at apex. Body longer (40.0–51.0 mm) ....***Passalus* (*Passalus*) *armatus* Perty**
– Central tubercle acute, not concave at apex. Body shorter (23.0–30.0 mm) **21**
21 Central tubercle strongly sulcate at base. Humeri pubescent. Body length 30.0 mm .... ***Passalus* (*Passalus*) *inca* Zang**
– Central tubercle not sulcate at base. Humeri glabrous. Body length 23.0–30.0 mm ....***Passalus* (*Passalus*) *pugionatus* Burmeister**
22 Habitus opaque. Body length 39.5 mm ...... ***Passalus* (*Passalus*) *opacus* Gravely**
– Habitus shiny...**23**
23 Mesosternal fossae glabrous or with only 1–3 setae (*P. interruptus*) **24**
– Mesosternal fossae densely pubescent **27**
24 Antennal club with four lamellae, fourth one very reduced and tomentose. Body length 27.1–34.0 mm ....***Passalus* (*Passalus*) *interstitialis* Eschscholtz**
– Antennal club with three lamellae **25**
25 Central tubercle very free, reaching anterior border of head. Pronotum pubescent on lateral fossae. Body length 36.0–45.1 mm.. ....***Passalus* (*Passalus*) *unicornis* Lepeletier & Serville**
– Central tubercle slightly free, not reaching anterior border of head. Lateral fossa of pronotum glabrous **26**
26 Last abdominal sternite with incomplete groove. Body longer (44.4–52.8 mm) (Fig. 20)..***Passalus* (*Passalus*) *interruptus* (Linneo)**
– Last abdominal sternite with medially complete groove. Body shorter (29.1–42.0 mm) (Fig. 21) ....***Passalus* (*Passalus*) *punctiger* Lepeletier & Serville**
27 Central tubercle with apex very free, reaching anterior cephalic border. Body length 33.0–38.0 mm ....***Passalus* (*Passalus*) *coarctatus* Percheron**
– Central tubercle with apex not free or barely free. Body length 34.2–39.1 mm... ....***Passalus* (*Passalus*) *coniferus* Eschscholtz**
28 Frontoclypeal suture present...**29**
– Frontoclypeal suture absent..**30**
29 Antennal club with three lamellae. Body length 18.2–23.1 mm......................... ....***Popilius marginatus* (Percheron)**
– Antennal club with four or five lamellae. Body length 17.0–21.0 mm ....***Popilius tetraphyllus* (Eschscholtz)**
30 Anterior labral border deeply concave, with an excavation behind concavity (dorsal depression sensu Marshall 2000). Body length 38.5–40.2 mm...................... ....***Verres furcilabris* (Eschschltz)**
– Anterior labral border straight or slightly concave or convex, without an excavation behind border (*Veturius*) **31**

31 Brachypterous. Body length 34.0–45.0 mm ***Veturius (Publius) spinipes* (Zang)**
– Macropterous (subgenus *Veturius*) **32**
32 Mesosternum glabrous (not including anterior angles, which can have some scarce short setae) **33**
– Mesosternum with dense pubescence **36**
33 Central tubercle with apex free. Body length 36.0–40.0 mm .... ***Veturius* (*Veturius*) *libericornis* Kuwert**
– Central tubercle with apex not free **34**
34 Lateropostfrontal areas pubescent (rarely glabrous). Metasternum with pubescence beyond anterior border (mesocoxal cavity) and lateral fossa, reaching lateromedial metasternum. Body length 37.0–49.0 mm .... ***Veturius* (*Veturius*) *standfussi* Kuwert**
– Lateropostfrontal areas glabrous. Metasternum with pubescence restricted to anterior border (mesocoxal cavity) and lateral fossa **35**
35 Postfrontal groove (occipital sulcus sensu Reyes-Castillo 1970) absent. Superior spurs of mesotibiae and metatibiae curved. Body length 39.0–43.0 mm .... ***Veturius* (*Veturius*) *guntheri* Kuwert**
– Postfrontal groove present. Superior spurs of mesotibiae and metatibiae straight or almost straight. Body length 39.0–46.0 mm .... ***Veturius* (*Veturius*) *yahua* Boucher**
36 Lateropostfrontal area glabrous. Body length 33.0–41.0 mm .... ***Veturius* (*Veturius*) *sinuosus* (Drapiez)**
– Lateropostfrontal area pubescent **37**
37 Lateropostfrontal area with 2–15 long setae. Central tubercle high, in lateral view higher than internal tubercles. Body length 30.0–37.0 mm .... ***Veturius* (*Veturius*) *boliviae* Gravely**
– Lateropostfrontal area with 2–10 short setae. Central tubercle almost at same level of internal tubercles in lateral view. Body length 28.0–30.0 mm .... ***Veturius* (*Veturius*) *dreuxi* Boucher**

Clave para las especies de Passalidae de Bolivia

Dado que la fauna de Passalidae de Bolivia aún es poco conocida, esta clave debe usarse con precaución. Es probable que estudios futuros encuentren nuevas especies y registros para el país; por ese motivo, es conveniente utilizar esta clave y luego confirmar la determinación con la descripción original o el diagnóstico de la especie.

1 Clípeo oculto debajo de la frente, con ángulos anteriores debajo de los tubérculos mediofrontales (Fig. 11) **2**
– Clípeo (clípeo-frente) expuesto dorsalmente, con ángulos anteriores por delante del borde frontal (Fig. 11) **28**

2 Maxila con lacinia uni o bidentada en el tercio apical (Fig. 14). Maza antenal con cinco lamelas (Fig. 18). Parte mediobasal del mentón plana (Fig. 12). Presternelo pentagonal (*Paxillus*) (Fig. 16)..**3**

– Maxilla con lacinia bidentada en el tercio apical (Fig. 15). Maza antenal con tres lamelas (cinco en *Passalus rhodocanthopoides* y cuatro en *P. interstitialis*) (Figs 19–21). Parte mediobasal del mentón abultada (Fig. 13). Presternelo romboidal (Fig. 17) (*Passalus*)..**7**

3 Maxilla con lacinia bidentada en el tercio apical (Fig. 14). Borde anterior de la frente recto, sin tubérculos mediofrontales secundarios (Fig. 11).......................**4**

– Maxilla con lacinia unidentada en el tercio apical (Fig. 15). Borde anterior de la frente con dos tubérculos mediofrontales secundarios, rudimentarios o grandes (Fig. 18)..**5**

4 Diente dorsal mandibular con una expansión cóncava (en vista dorsal). Mesosternón liso, sin puntos sobre la cicatriz mesosternal. Longitud total 16.0–19.5 mm..***Paxillus leachi* MacLeay**

– Diente dorsal mandibular delgado, sin expansión cóncava. Mesosternón con puntos sobre la cicatriz mesosternal y más allá. Longitud total 14.0–16.0 mm ....***Paxillus camerani* (Rosmini)**

5 Cicatriz mesosternal oval, poco marcada y brillante. Foseta metasternal y epipleura glabras. Longitud total 18.0–19.0 mm ......***Paxillus forsteri* Luederwaldt**

– Cicatriz mesosternal alargada, bien definida y opaca. Foseta metasternal y epipleura pubescentes **6**

6 Primer artejo de la maza antenal reducido. Longitud total 22.7–23.1 mm (Fig. 18)............................***Paxillus martinezi* Jiménez-Ferbans and Reyes-Castillo**

– Primer artejo de la maza antenal no reducido, de largo similar al segundo. Longitud total 18.5–19.5 mm.................................. ***Paxillus pleuralis* Luederwaldt**

7 Borde frontal anterior recto o casi recto, sin tubérculos mediofrontales secundarios. Tubérculo central corto, con ápice no libre (fusionado a la frente y quillas frontales) (Fig. 19) (subgénero *Pertinax*)..**8**

– Borde frontal anterior con uno o dos tubérculos mediofrontales secundarios (Figs 20–21); si no, entonces el tubérculo central con ápice muy libre (alcanzando o casi alcanzando el borde frontal anterior) **15**

8 Maza antenal con cinco lamelas, las dos primeras reducidas. Longitud total 22.0–25.0 mm..***Passalus* (*Pertinax*) *rhodocanthopoides***

– Maza antenal con tres lamelas (Fig. 19)..**9**

9 Alas reducidas (braquíptero) (Fig. 7) **10**

– Alas desarrolladas (macróptero) **13**

10 Tubérculos lateroposteriores de mayor tamaño que el tubérculo central (Fig. 1). Humeri densamente pubescentes. Longitud total 32.8–36.8mm........................ ....***Passalus* (*Pertinax*) *bolivianus* sp. nov.**

– Tubérculos lateroposteriores más pequeños que el tubérculo central (Figs 5–7). Humeri glabros **11**

11 Tubérculos internos unidos a tubérculos mediofrontales por una quilla débil. Área frontal, entre quillas frontales, no dividida longitudinalmente por un surco (Figs 6, 9). Parte media basal del mentón glabra (Fig. 8). Talla grande, longitud total 45.0–46.0 mm..***Passalus* (*Pertinax*) *canoi* sp. nov.**
– Tubérculos internos no unidos a tubérculos mediofrontales por una quilla (Fig. 5). Área frontal dividida longitudinalmente por un surco, desde el borde anterior hasta la base del mamelón cefálico. Parte media basal del mentón pubescente. Talla mediana (31.0–32.0 mm)...**12**
12 Borde frontal anterior con fuerte hendidura media, insinuando dientes mediofrontales secundarios (Fig. 5). Longitud total 31.3 mm ....***Passalus* (*Pertinax*) *gonzalezae* sp. nov.**
– Borde frontal anterior sin hendidura media. Longitud total 32.0 mm ....***Passalus* (*Pertinax*) *nodifrons* Dibb**
13 Ápice del tubérculo central ligeramente libre, con solo una pequeña porción despegada de la frente. Longitud total 31.0–33.0 mm..***Passalus* (*Pertinax*) *catharinae* Gravely**
– Ápice del tubérculo central no libre, unido a la frente (Fig. 19).......................**14**
14 Humeri con pubescencia escasa en la base. Talla pequeña (25.1–28.0 mm)..***Passalus* (*Pertinax*) *morio* Percheron**
– Humeri glabros. Talla grande (42.2–44.3 mm) (Fig. 19)... ***Passalus* (*Pertinax*) *convexus* Dalman**
15 Borde frontal anterior con un tubérculo mediofrontal secundario. Proceso hipostomal con un surco mate sobre el ápice ....***Passalus* (*Mitrorhinus*) *lunaris* (Kaup)**
– Borde frontal anterior con dos tubérculos mediofrontales secundarios; si el el borde es recto, sin tubérculos, entonces el tubérculo central es muy libre (grupo "Petrejus"). Proceso hipostomal sin surco sobre el ápice (subgénero *Passalus*)...**16**
16 Borde frontal anterior con dos tubérculos mediofrontales secundarios, contiguos en su base...**17**
– Borde frontal anterior sin tubérculos mediofrontales secundarios o con dos tubérculos separados en sus bases **18**
17 Tubérculos mediofrontales secundarios grandes, fusionados entre si en casi toda su extensión. Áreas lateroposfrontales glabras. Longitud total 24.3–27.0 mm ..... ***Passalus* (*Passalus*) *barrus* Boucher and Reyes-Castillo**
– Tubérculos mediofrontales secundarios pequeños, solo contiguos en su base. Áreas lateroposfrontales pubescentes. Longitud total 31.1–33.0 mm ....***Passalus* (*Passalus*) *abortivus* Percheron**
18 Tubérculo central con ápice muy libre, alcanzando o sobrepasando el borde frontal anterior. Tubérculos mediofrontales ausentes o rudimentarios (grupo "Petrejus") **19**
– Tubérculo central con ápice no libre o ligeramente libre (Fig. 21); si es muy libre (alcanzando el borde anterior), entonces el metasternón está densamente pu-

bescente (parte anterolateral). Tubérculos mediofrontales siempre presentes (Figs 20–21) (grupo “Neleus”)..**22**

19 Tubérculo central sobrepasando ampliamente el margen de la frente, fusionado a la parte media de la cabeza, casi hasta el borde anterior. Longitud total 24.0 mm ....***Passalus* (*Passalus*) *pugionifer* Kuwert**

– Tubérculo central no fusionado a la parte media de la cabeza **20**

20 Tubérculo central con concavidad en el ápice. Talla grande (40.0–51.0 mm) ....***Passalus* (*Passalus*) *armatus* Perty**

– Tubérculo central sin concavidad en el ápice. Talla mediana (23.0–30.0 mm) .**21**

21 Tubérculo central con surco marcado en la base. Humeri pubescentes. Longitud total 30.0 mm .... ***Passalus* (*Passalus*) *inca* Zang**

– Tubérculo central sin surco en la base. Humeri glabros. Longitud total 23.0–30.0 mm ....***Passalus* (*Passalus*) *pugionatus* Burmeister**

22 Habitus opaco. Longitud total 39.5 mm .... ***Passalus* (*Passalus*) *opacus* Gravely**

– Habitus brillante...**23**

23 Foseta mesosternal glabra o con solo 1–3 sedas (*P. interruptus*) **24**

– Foseta mesosternal densamente pubescente **27**

24 Maza antenal con cuatro lamelas, la cuarta muy reducida y tomentosa.....27.1–34.0 mm ....***Passalus* (*Passalus*) *interstitialis* Eschschltz**

– Maza antenal con tres lamelas **25**

25 Tubérculo central muy libre, alcanzando el borde anterior de la cabeza. Foseta lateral del pronoto pubescente. Longitud total 36.0–45.1 mm ....***Passalus* (*Passalus*) *unicornis* Lepeletier & Serville**

– Tubérculo central solo ligeramente libre, nunca alcanzando el borde anterior de la cabeza. Foseta lateral del pronoto glabra...**26**

26 Surco marginal sobre último esternito abdominal incompleto. Talla grande (44.4–52.8 mm) (Fig. 20) ....***Passalus* (*Passalus*) *interruptus* (Linneo)**

– Surco marginal sobre último esternito abdominal completo. Talla mediana a grande (29.1–42.0 mm) (Fig. 21) ....***Passalus* (*Passalus*) *punctiger* Lepeletier & Serville**

27 Ápice del tubérculo central muy libre, alcanzando el borde frontal anterior. Longitud total 33.0–38.0 mm..................***Passalus* (*Passalus*) *coarctatus* Percheron**

– Ápice del tubérculo central no libre o apenas ligeramente libre, no alcanzando el borde frontal anterior. Longitud total 34.2–39.1 mm ....***Passalus* (*Passalus*) *coniferus* Eschscholtz**

28 Sutura frontoclipeal presente..**29**

– Sutura frontoclipeal ausente (Fig. 10)...**30**

29 Maza antenal con tres lamelas. Longitud total 18.2–23.1 mm............................ ....***Popilius marginatus* (Percheron)**

– Maza antenal con cuatro o cinco lamelas. Longitud total 17.0–21.0 mm ....***Popilius tetraphyllus* (Eschscholtz)**

30 Borde anterior del labro profundamente cóncavo, con una excavación por detrás de la concavidad ("dorsal depression" *sensu* Marshall 2000). Longitud total 38.5–40.2 mm...***Verres furcilabris* (Eschschltz)**

– Borde anterior del labro recto o ligeramente cóncavo o convexo, sin excavación por detrás del borde (*Veturius*)...**31**

31 Braquíptero. Longitud total 34.0–45.0 mm ***Veturius (Publius) spinipes* (Zang)**

– Macróptero (subgénero *Veturius*)..**32**

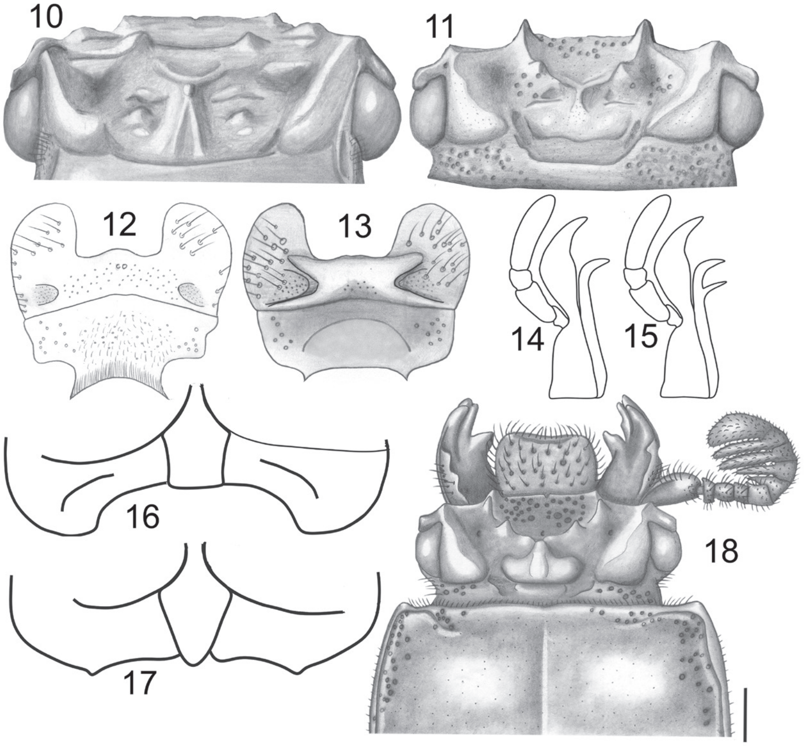
32 Mesosternón glabro (no incluyendo el ángulo anterior, que puede tener sedas cortas y dispersas)...**33**

– Mesosternón con pubescencia abundante..**36**

33 Tubérculo central con ápice libre. Longitud total 36.0–40.0 mm........................ ....***Veturius* (*Veturius*) *libericornis* Kuwert**

– Tubérculo central con ápice no libre...**34**

34 Áreas lateroposfrontales pubescentes (raramente glabras). Metasternón con pubescencia más allá del borde anterior (cavidad metacoxal) y foseta lateral, alcanzando el área lateromedial del metasternón. Longitud total 37.0–49.0 mm......... .... ***Veturius* (*Veturius*) *standfussi* Kuwert**



Figures 10–18. 10, 11 Head: **10** *Veturius* sp. **11** *Paxillus* sp. **12, 13** mentum, ventral view: **12** *Paxillus leachi* **13** *Passalus* sp. **14, 15** ventral view of right maxilla: **14** *Paxillus* **15** *Passalus* **16, 17** Prosternelum: **16** *Paxillus* **17** *Passalus* **18** head and anterior part of pronotum of *Paxillus martinezi*. Scale bar: 1 mm.

– Áreas lateroposfrontales glabras. Metasternón con pubescencia restringida al borde anterior (cavidad metacoxal) y foseta lateral..**35**

35 Surco posfrontal (occipital *sensu* Reyes-Castillo 1970) ausente. Espolones superiores de meso y metatibias curvados. Longitud total 39.0–43.0 mm.................... .... ***Veturius* (*Veturius*) *guntheri* Kuwert**

– Surco posfrontal presente. Espolones superiores de meso y metatibias rectos o casi rectos. Longitud total 39–46 mm............... ***Veturius* (*Veturius*) *yahua* Boucher**

36 Áreas lateroposfrontales glabras. Longitud total 33.0–41.0 mm .... ***Veturius* (*Veturius*) *sinuosus* (Drapiez)**

– Áreas lateroposfrontales pubescentes **37**

37 Áreas lateroposfrontales con sedas largas (2–15 sedas). Tubérculo central alto, en vista lateral mucho más elevado que tubérculos internos. Longitud total 30.0–37.0 mm... ***Veturius* (*Veturius*) *boliviae* Gravely**

– Áreas lateroposfrontales con sedas cortas (2–10 sedas). Tubérculo central bajo, en vista lateral casi al mismo nivel que tubérculos internos. Longitud total 28.0–30.0 mm .... ***Veturius* (*Veturius*) *dreuxi* Boucher**

Figures 19–21. Head and pronotum: **19** *Passalus convexus* **20** *Passalus interruptus* **21** *Passalus punctiger*. Scale bars: 2 mm.

Discussion

Bolivia has a total area of 1,098,581 km^2 and its territory includes a high variety of ecosystems. The country is divided in 12 ecoregions (Ibisch et al. 2003), of which, the Southwest Amazonia, Cerrado, Chiquitania, and Yungas seem to be suitable for Passalidae and we expected them to have high diversity of passalids. However, given its relative size, suitable climatic, ecological features, and mountainous areas, the real number of taxa occurring in the country is probably higher than the number of taxa registered to date.

The number of species known from Bolivia is small in comparison with other tropical countries of the New World. For example, Mexico, Guatemala, Colombia, and Brazil have more than 80 species recorded for each country (Fonseca and Reyes-Castillo 2004; Schuster 2006; Jiménez-Ferbans et al. 2018). Similarly, the number of endemic species is low, with *Veturius boliviae*, *Paxillus martinezi*, *Passalus* (*Pertinax*) *nodifrons* and *Passalus* (*Passalus*) *opacus* being the only endemic species of Bolivia.

Without doubt, the number of species of Bolivia is underestimated due to the lack of a systematic exploration of this country. Thus, more surveys are needed, especially in ecosystems such as montane forest and tropical rain forest, which normally harbor many species. Some departments with a domain of tropical rain forest have not been sampled for Passalidae; for example, Pando department has no records of passalid beetles, and for Beni department there are records of only 5 species. The majority of the specimens examined by us came from La Paz, Cochabamba and Santa Cruz departments, especially from mid-montane range locations, corresponding with the Yungas ecoregion. Several studies have reported this pattern in Passalidae, with a high level of richness at mid-mountain ranges (MacVean and Schuster 1981, Jiménez-Ferbans et al. 2010, Chamé-Vázquez et al. 2018). However, due to the extension of these departments, the amount of known species is still considered low, pointing out the need of sampling in the mid-range montane ecosystems of Bolivia.

Reliability of the species records

From the total of 38 species listed above, we have studied material for 23 species. For the other 15 species, some authors have recorded specimens of all of them. However, three species can be discussed. The record of *P. unicornis* is based on a specimen recorded by Luederwaldt (1931b). However, Luedewaldt himself pointed out some differences of the Bolivian specimens regarding other specimens of *P. unicornis*. Likewise, the length of the specimen is too small and perhaps it corresponds to *P. coarctatus*, since these two species are commonly confused with each other.

Passalus morio has been recorded for Colombia, Guiana and Suriname; nonetheless, as far as we know, it is distributed mostly in the Atlantic Forest (Fonseca and Reyes-Castillo 2004; Jiménez-Ferbans et al. 2013), and its record for Bolivia must be confirmed.

Finally, the record of *Passalus catharinae* from Bolivia must be confirmed because no records of this species are available except for the original description. Its record for Bolivia is based on the interpretation of "Chaco" (Gravely 1918) as "Bolivia: Chaco" made by Hincks and Dibb (1935). A similar situation occurred with *Veturius sinuatosulcatus* Gravely. Hincks and Dibb (1935) recorded *V. sinuatosulcatus* from "Bolivia: Chaco". However, Boucher (2006) stating that Hincks and Dibb (1935) must have misinterpreted the type locality "Chaco" as "Chaco, Bolivia", since *V. sinuatosulcatus* (now synonym *V. sinuatocollis* sensu Boucher (2006)) does not occur in Bolivia. Then, probably the reference of "Chaco" by Gravely may not correspond to the Chao from Bolivia.

Acknowledgements

We thank the curators of collections: Germán Amat (ICN-ENT), Enio Cano (UVGC), Carlos Campanero (MZSP), Sonia Casari (MZSP), and Crystal Maier (FMNH) for their support in reviewing material from museum collections. The drawings of new species were made by Sara Rivera. Edwin Ariza, Mayelis Barros, and Ana Maestre assisted us to digitize the label information. Cristian Beza and the two reviewers helped us to improve the manuscript significantly. This work was partially funded by the Vicerrectoría de Investigación of the Universidad del Magdalena.

References

Amat-García G, Blanco-Vargas E, Reyes-Castillo P (2004) Lista de especies de los escarabajos pasálidos (Coleoptera: Passalidae) de Colombia. Biota Colombiana 5: 173–182.

Boucher S (1990) Note systématique, chorologique et éco-altitudinale sur quelques *Pertinax* Kaup: *convexus* Dalman (*sulcifrons* Kuwert, reval.), *radiatus* Kuwert et *pseudoconvexus* n. sp. (Coleoptera, Passalidae). Nouvelle Revue d'Entomologie (NS) 7: 349–367.

Boucher S (2006) Évolution et phylogénie des coléoptères Passalidae (Scarabaeoidea). Les taxons du groupe famille la tribu néotropicale des Proculini et son complexe *Veturius*. Annales de la Société Entomologique de France 41: 239–603. https://doi.org/10.1080/00379271.2005.10697444

Boucher S, Reyes-Castillo P (1991) *Passalus barrus*, espece nouvelle des Andes orientales (Coleoptera, Passalidae). Nouvelle Revue d'Entomologie (NS) 8: 433–436.

Bruch C (1942) Misceláneas Entomológicas IX. 2, Lista de los Passalidae señalados hasta ahora con procedencia Argentina. Notas del Museo de La Plata, Zoología 7: 9–12.

Chamé-Vázquez E, Reyes-Castillo P, Gómez y Gómez B, Ibarra-Núñez G (2018) Distribución de la familia Passalidae (Coleoptera: Scarabaeoidea) en un gradiente altitudinal en el Soconusco, Chiapas, México. Dugesiana 25: 115–124.

Dibb JR (1948) Description of a new species of Passalidae (Col.) from Bolivia. The Entomologist's Monthly Magazine 84: 284.

Doesburg PH (1942) Passalidae (Col.). In: Titschack E (Ed.) Beiträge zur Fauna Perus. Nach der Ausbeute der Hamburger Südperu-Expedition, Vol. I. Fischer Verlag, Jena, 329–335.

Fonseca CRV, Reyes-Castillo P (2004) Synopsis on Passalidae family (Coleoptera: Scarabaeoidea) of Brazil with description of a new species of *Veturius* Kaup, 1871. Zootaxa 790: 1–20. https://doi.org/10.11646/zootaxa.789.1.1

Gillogly A (2005) Review of the genus *Popilius* and preliminary phylogeny of Passalidae (Coleoptera), PhD Thesis, Texas A&M University, College Station.

Gravely FH (1918) Contribution towards the Revision of the Passalidae of the World. Memoirs of the Indian Museum 7: 1–144. https://doi.org/10.5962/bhl.title.9238

Hincks WD (1933) Notes on the Passalidae (Coleoptera), N° 3. New synonymy and some little-known species with the description of a new Publius. The Entomologist's Monthly Magazine 59: 175–182.

Hincks WD (1934) Notes on the Passalidae (Coleoptera), N° 5. Synonymic Notes, with the Descriptions of a New Genus and New Species. The Entomologist's Monthly Magazine 20: 270–274.

Hincks WD (1940) Preliminary key to the "Petrejus" section of the genus *Passalus* (Coleoptera, Passalidae). The Annals and Magazine of Natural History 5: 486–496. https://doi.org/10.1080/03745481.1940.9723705

Hincks WD (1949) Systematic and synonymic notes on Passalidae (Col.). The Annals and Magazine of Natural History 12: 56–64. https://doi.org/10.1080/00222934908653958

Hincks WD, Dibb JR (1935) Pars 142, Passalidae. In: Junk W (Ed.) Coleopterorum Catalogus. W. Junk, s'Gravenhage, 1–118.

Hincks WD, Dibb JR (1958) Supplementa. Passalidae. In: Junk W (Ed.) Coleopterorum Catalogus. W. Junk, s'Gravenhage, 1–32.

Jiménez-Ferbans L, Reyes-Castillo P (2014) Description, phylogeny and biogeography of *Ameripassalus*, a new Mesoamerican genus of Passalidae (Coleoptera). Invertebrate Systematics 28: 124–144. https://doi.org/10.1071/IS13009

Jiménez-Ferbans L, Reyes-Castillo P (2015) Phylogeny and taxonomy of *Paxillus* MacLeay and *Passipassalus* Reyes-Castillo and Fonseca (Coleoptera: Passalidae: Passalini), with the description of new species. Annals of the Entomological Society of America 108: 415–434. https://doi.org/10.1093/aesa/sav019

Jiménez-Ferbans L, Amat-García G, Reyes-Castillo P (2010) Diversity and distribution patterns of Passalidae (Coleoptera Scarabaeoidea) in the Caribbean Region of Colombia. Tropical Zoology 23: 147–164.

Jiménez-Ferbans L, Reyes-Castillo P, Schuster JC (2015) Passalidae (Coleoptera: Scarabaeoidea) of the Greater and Lesser Antilles. Zootaxa 3956: 491–512. https://doi.org/10.11646/zootaxa.3956.4.3

Jiménez-Ferbans L, Amat-García G, Reyes-Castillo P (2018) Estudios de los escarabajos pasálidos (Coleoptera: Passalidae) de Colombia. In: Deloya C, Gasca H (Eds) Escarabajos del Neotrópico (Insecta: Coleoptera). S y G Editore, Cuidad de México, México, 81–94.

Jiménez-Ferbans L, Reyes-Castillo P, Schuster JC, Salazar-Niño K (2013) A checklist and key for the identification of bess beetles (Coleoptera: Passalidae) of Argentina. Zootaxa 3701: 192–206. https://doi.org/10.11646/zootaxa.3701.2.4

Jiménez-Ferbans L, Reyes-Castillo P, Schuster JC, Upegui-Vélez C (2016) *Passalus coarctatus* Percheron, 1835 (Coleoptera: Passalidae): redescription and new distributional records. Acta Zoológica Mexicana (n.s.) 32: 168–173. https://doi.org/10.21829/azm.2016.322944

Kuwert A (1891) Systematische Uebersicht der Passaliden-Arten und Gattugen. Deutsche Entomologische Zeitschrift 1: 161–192. https://doi.org/10.1002/mmnd.48018910135

Kuwert A (1898) Die Passaliden dichotomisch bearbeitet. 2 ter. Theil. – Die Arten. Novitates Zoologicae 5: 137–205. https://doi.org/10.5962/bhl.part.1649

Luederwaldt H (1927) Cinco novas especies da familia dos Passalideos (Col.). Boletim do Museu Nacional 2: 37–38.

Luederwaldt H (1931a) Notas sobre Passalideos Americanos (Col. Lamell.). Revista de Entomologia 1: 61–65.

Luederwaldt H (1931b) Monographia dos Passalideos do Brasil (Col.). Revista do Museu Paulista 17: 1–265.

MacVean C, Schuster JC (1981) Altitudinal distribution of passalid beetles, Coleoptera Passalidae, and Pleistocene dispersal on the volcanic chain of northern Central America. Biotropica 13: 29–38. https://doi.org/10.2307/2387868

Marshall C (2000) The taxonomy, phylogeny and biogeography of the Neotropical genus, *Verres* Kaup (Coleoptera: Passalidae, Proculini), PhD thesis, Cornell University, New York, USA.

Mattos I, Mermudes JR (2013) Synopsis of *Paxillus* MacLeay, 1819 (Coleoptera: Passalidae): distributional records and descriptions of four new species from Brazil. Zootaxa 3652: 327–342. https://doi.org/10.11646/zootaxa.3652.3.2

Ratcliffe BC, Jameson ML, Figueroa L, Cave RD, Paulsen MJ, Cano EB, Beza-Beza C, Jimenez-Ferbans L, Reyes-Castillo P (2015) Beetles (Coleoptera) of Peru: A Survey of the Families. Scarabaeoidea. Journal of the Kansas Entomological Society 88: 186–207. https://doi.org/10.2317/kent-88-02-186-207.1

Reyes-Castillo P (1970) Coleoptera, Passalidae: Morfología y división en grandes grupos; géneros americanos. Folia Entomológica Mexicana 20–22: 1–217.

Reyes-Castillo P (1973) Passalidae de la Guayana Francesa (Coleoptera, Lamellicornia). Bulletin du Muséum national d'Histoire naturelle. Zoologie 197: 1541–1587.

Reyes-Castillo P, Castillo C (1992) Bess Beetles of Panama (Coleoptera: Lamellicornia: Passalidae). In: Quintero D, Aiello A (Eds) Insects of Panama and Mesoamerica. Selected Studies. Oxford University Press, Oxford, 356–371.

Schuster JC (2006) Passalidae (Coleoptera) de Mesoamérica: diversidad y biogeografía. In: Cano EB (Ed.) Biodiversidad de Guatemala, Vol. I. Universidad del Valle de Guatemala, Guatemala City, 379–392.

Zang R (1905) Dreizehn neue Passaliden. Deutsche Entomologische Zeitschrift 2: 225–245. https://doi.org/10.1002/mmnd.48119050317

ZooKeys 882: 87–125 (2019)
doi: 10.3897/zookeys.882.36634
http://zookeys.pensoft.net

REVIEW ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

Lepidopteran biodiversity of Ethiopia: current knowledge and future perspectives

Tesfu Fekensa Tujuba[1,2], Andrea Sciarretta[2], Axel Hausmann[3], Getnet Atnafu Abate[4]

1 *Ethiopian Biodiversity Institute, Addis Ababa, Ethiopia* **2** *Department of Agriculture, Environment and Food Sciences, University of Molise, Campobasso, Italy* **3** *SNSB-Bavarian State Collection of Zoology, Munich, Germany* **4** *Department of Biology, Debre Markos University, Debre Markos, Ethiopia*

Corresponding author: *Tesfu Fekensa Tujuba* (t.tujuba@studenti.unimol.it; tesfuaau@yahoo.com)

Academic editor: *Alberto Zilli* | Received 30 May 2019 | Accepted 27 August 2019 | Published 23 October 2019

http://zoobank.org/4154DE03-2ABD-4A91-9429-576ED4D2DC88

Citation: Tujuba TF, Sciarretta A, Hausmann A, Abate GA (2019) Lepidopteran biodiversity of Ethiopia: current knowledge and future perspectives. ZooKeys 882: 87–125. https://doi.org/10.3897/zookeys.882.36634

Abstract

Lepidoptera is the second largest order of insects. Encompassing moths and butterflies, it is regarded as one of the most important components of biodiversity. Here, an updated comprehensive overview of Lepidoptera recorded in Ethiopia is presented, composed of 2,438 taxa in 48 families, of which 664 are endemic. Records were compiled from various literature sources and website databases. Although still being far from complete, this review provides important baseline data for understanding zoogeographic patterns and thus for undertaking effective conservation action. Further research on Ethiopian Lepidoptera is encouraged.

Keywords

Africa, butterflies, checklist, DNA barcoding, endemic, Ethiopian moths

Introduction

Ethiopia is among the largest countries in the African continent, located in the horn of Africa, covering a total area of 1,127,127 km^2 (Gordon and Carillet 2003; EBI 2015; Tesfu et al. 2018). It belongs to the Afro-tropical Region (former Ethiopian Region) and, based on the bioclimatic classification of Burgess et al. (2004), comprises the zones “Sahelian Savanna”, “Somalian Xeric Bushland and Shrubland” and “Ethiopian

Montane forest and Alpine Moorland" (Hacker 2019). The country's topography is very diverse, with 20 mountains peaks above 4,000 meters. The highest mountain, Ras Dashen, peaks 4,620 m above sea-level, the fourth-highest in Africa, whilst the third-lowest point in Africa, the Danakil Depression, reaches down to 125 m below sea level. The dominating topographic element is the vast and fertile central highland that accounts for 37% of the land area of the country with an average elevation from 1,500 to 2,400 m that deserved the country to be known as 'roof of Africa'. It is the largest block of land above 1,500 m in Africa (Clausnitzer and Dijkstra 2005), dissected by the Great Rift Valley and surrounded by lowlands along the periphery (Gordon and Carillet 2003). The mean annual rainfall ranges from 500 mm to 2,800 mm and the mean annual temperatures range from around 10° to above 30 °C. Because of these diverging abiotic parameters, the country is endowed with an amazingly diversity of plant, animal and microbial organisms (EBI 2015). According to Clausnitzer (2014), the rate of endemism in Ethiopia's flora and fauna is exceptionally high as a result of vast highlands being isolated by the surrounding dry lowlands. Only the most eurytopic and mobile species (usually those of the lowlands) tend to be found in both Ethiopia and the rest of tropical Africa. In the same manner, Kravchenko et al. (2007) stated that the territory of Ethiopia hosts an extraordinarily diverse landscape including high mountains, lowlands, deserts and tropical rain forests that resulted in a hyperdiverse fauna and flora. Likewise, in consequence of its rich biodiversity, Ethiopia is acknowledged as one of the 20-mega-biodiverse countries in the world (Mittermeier et al. 2011; Tesfu et al. 2018).

Lepidoptera represent the second largest insect order, which consists of approximately 140 different families and 160,000 species that have been described and recognised worldwide, so far (Biodiversity Institute of Ontario 2006; Kristensen et al. 2007; Nieukerken et al. 2011). Lepidoptera comprise nearly 17% of all insect species, and some recent estimates suggest that the real number of Lepidoptera species would set up to 500,000 species (Brandao et al. 2009).

The aims of this paper are to give an updated comprehensive presentation of the actual knowledge of Ethiopian Lepidoptera and to provide some estimates for the expected biodiversity of this major insect order in the country.

Materials and methods

The present review is based on all pertinent published scientific papers. In addition, records from up to date and relevant online databases were also included, particularly, records from the Natural History Museum of London website ("NHMUK": Beccaloni et al. 2003), the Barcode of Life Data Systems ("BOLD": Ratnasingham and Hebert 2007), the African moth website (Goff 2008), LepiMap (Navarro 2007), the African Butterfly Database (Sáfián et al. 2009), the Afromoth website (De Prins and De Prins 2019) and the Afrotropical Butterflies and Skippers digital encyclopaedia (Williams 2018). In all cases, records were included only when sample identifications were made at specific (or subspecific) level, and the provenience from Ethiopia was clearly indicated. Data from entomological collections but not publicly accessible were not considered.

We followed the classification system and nomenclature (valid names and synonymies) used in De Prins and De Prins (2019) with some updates coming from more recent publications. For Rhopalocera, the Afrotropical Butterflies and Skippers digital encyclopaedia (Williams 2018) served as reference. These two outstanding references have also represented the fundamental database and resource for our compilation of the lepidopteran fauna of Ethiopia.

Lepidoptera exploration in Ethiopia: from early explorers to present

Many entomologists have contributed to our current knowledge of the Ethiopian Lepidoptera fauna. The following selection provides the most significant contributions made by past pioneers and current explorers.

Johann Christoph Friedrich Klug in 1829 was the first to mention Abyssinia, the former name of Ethiopia, in the description of a new Lepidoptera species, the butterfly *Pontia eupompe* (Klug, 1829) now *Colotis danae* ssp. *eupompe* (Nazari et al. 2011), indicating as locus typicus "in Arabia deserta, in Sinai monte, in Dongala et Habessinia".

From the mid-nineteenth century, additional descriptions came from few authors such as Félix Edouard Guérin-Méneville (1849), Louis Reiche (1850), and Hippolyte Lucas (1852). However, the most significant advance in the nineteenth century was made by the French entomologist Achille Guenée, who published various contributions between 1852 and 1858. He described 31 new species belonging to the Noctuoidea and Geometroidea, based on material collected mainly by Georg Wilhelm Schimper in 1850. In all cases, the locus typicus was indicated as "Abyssinia" (Guénée 1852).

Other important contributions to the study of Ethiopian Lepidoptera were made subsquently, many of which have reported the description of new species from specimens collected in the country. For instance, George Hampson described 23 species from different families in the period between 1896 and 1930 (Hampson 1896, 1898, 1899, 1905, 1909, 1910, 1913, 1916, 1918, 1919, 1926, 1930). Edward Meyrick firstly reported Microlepidoptera from the country, with 40 new species, from the material collected during the expeditions carried out by Hugh Scott and Omer-Coper in 1926–1927 (Meyrick 1932). The most important contribution to the study of butteflies was made by Lionel Walter Rothschild and Karl Jordan, during the first decades of the twentieth century, with 34 new taxa (Rothschild 1902, 1926; Rothschild and Jordan 1900, 1903, 1905). Debauche (1937) reported 42 geometrid species from Ethiopia with eight new descriptions. Likewise, Emilio Berio published many papers dedicated to the Erebidae and Noctuidae of East Africa, describing from Ethiopia 12 and 37 species, respectively (Berio 1939a, 1940a, 1943, 1944, 1945, 1947, 1954, 1962, 1975, 1977), some of them from the localities of Adu-Abuna and Metema, at that time part of Eritrea, but now in Tigray, Northern Ethiopia (Berio 1937, 1939b, 1939c, 1940b, 1973, 1976). Pierre-Claude Rougeot has explored the country several times in 1970s and described 55 new species belonging to various families (Rougeot 1974, 1975, 1977, 1984, Plantrou and Rougeot 1979; Laporte and Rougeot 1981; Rougeot and Laporte 1983). The two French entomologists Bernard Laporte and Claude Herbulot in their publications described from Ethiopia 137 new noctuid (specifically, eight species of Erebidae, two species of Nolidae, and 127 Noctuidae) and 22 new geometrid taxa, respectively (Herbulot 1983, 1993, 2002; Laporte 1974, 1975, 1976, 1978; Rougeot 1977, 1984; Laporte and Rougeot 1981; Rougeot and Laporte 1983; Rougeot et al. 1991).

With the new millennium, the country has awakened a renewed interest from entomologists, which led to the description of 255 new taxa in 18 years. In particular, major contributions to Ethiopian Lepidoptera were made by Hermann H. Hacker, with various colleagues, for Erebidae, Nolidae and Noctuidae (178 new taxa); David Agassiz for Yponomeutidae (five new taxa); Jósef Razowski and Pasquale Trematerra for Tortricidae (34 new taxa described); Axel Hausmann, Andrea Sciarretta and Francesco Parisi for Geometridae (27 new taxa); Ulf Eitschberger and Tomas Melichar for Sphingidae, with eleven new taxa (Hacker and Fibiger 2007; Hacker and Zilli 2007; Haxaire and Melichar 2008; Hausmann et al. 2014, 2016; Hacker et al. 2008, 2012; Razowski and Trematerra 2010, 2012; Hacker and Mey 2010; Hacker 2011, 2013, 2014, 2016, 2019; Eitschberger and Ströhle 2011; Melichar and Řezáč 2015; Eitschberger and Melichar 2016 Melichar et al. 2016; Razowski et al. 2018; Agassiz 2019).

Many of these and other minor contributions resulted from dedicated expeditions, such as the "Joint Ethiopian-Russian Biological Expedition" lead by Vasiliy Kravchenko from Tel Aviv University, Israel; the "Ethiopian Insects Project", between the Ethiopian Wildlife Conservation Authority (EWCA), the Bavarian State Collection of Zoology (ZSM) and the Museum Thomas Witt (MWM) in Munich, Germany; the projects carried out by the Italian entomologists of the University of Molise with EWCA and Ethiopian Biodiversity Institute (Kravchenko et al. 2007; Sciarretta et al. 2014; Hausmann et al. 2016).

Current state of knowledge on Ethiopian Lepidoptera

Based on the results of our current review, 2,438 Lepidoptera taxa (species or subspecies) are known to occur in Ethiopia hitherto, belonging to 48 families (Table 1; full list at: https://doi.org/10.5281/zenodo.3234617). This number includes 170 taxa which are not reported by the scientific literature but have been extracted from the above-mentioned websites.

In particular, 929 species or subspecies were described from type specimens collected in Ethiopia, 131 of them, mostly butterflies, at subspecific level (Table 2). It is interesting to note that endemic taxa number 664, approximately 27% of the total Lepidoptera. This high number can be explained by the particular physical and biogeographical history of the country and a broad range of different ecosystems with great diversity of habitats.

Figures 1–6. 1 *Acraea oscari* Rothschild, 1902 **2** *Epiphora fournierae* (Le Moult, 1945) **3** *Pingasa pallidata* (De Joannis, 1913) **4** *Odontopera protecta* Herbulot, 1983 **5** *Metarctia flavivena* Hampson, 1901 **6** *Stoermeriana laportei* (Rougeot, 1977). Photos credit: Alenuccio Palladino (**1**); Francesco Parisi (**2**); Dirk Stadie (**3–6**).

Given these numbers, knowledge on the Ethiopian butterflies and moths appear to be particularly unsatisfactory, when compared to their (estimated) potential total numbers with other countries. For instance, the two most diverse European Mediterranean countries, i.e., France and Italy, with a combined land surface comparable to Ethiopia, have ca. 5,109 and 5,086 species of Lepidoptera, respectively (Stoch 2003; Wikipedia 2011).

To better evaluate the level of knowledge of the lepidopteran fauna in Ethiopia, and to roughly estimate the real biodiversity, we can compare it with neighboring

Table 1. Ethiopian Lepidoptera families and number of taxa (species and subspecies) reported.

No.	Family	Total number of taxa	Common name
1	Bedelliidae	1	Narrow-winged moths
2	Blastobasidae	2	Scavenger moths
3	Bombycidae	2	Silkworm moths
4	Brahmaeidae	2	Brahmin moths
5	Carposinidae	1	Fruitworm moths
6	Choreutidae	2	Metalmark moths
7	Cosmopterigidae	4	Cosmet moths
8	Cossidae	17	Carpenterworm moths
9	Crambidae	109	Grass moths
10	Depressariidae	2	Flat-bodied moths
11	Drepanidae	1	Hook-tips
12	Elachistidae	1	Grass miner moths
13	Epermeniidae	1	Fringe-tufted moths
14	Erebidae	523	Tiger moths
15	Eupterotidae	8	Snout moths
16	Euteliidae	10	Euteliid moths
17	Gelechiidae	10	Twirler moths
18	Geometridae	306	Geometer moths
19	Glyphipterigidae	1	Sedge moths
20	Gracillariidae	13	Leafminer moths
21	Hesperiidae	36	Skipper butterflies
22	Hyblaeidae	1	Teak moths
23	Lasiocampidae	38	Lappet moths
24	Limacodidae	15	Slug caterpillar moths
25	Lycaenidae	116	Gossamer-winged butterflies
26	Lyonetiidae	2	Lyonet moths
27	Metarbelidae	4	Wood-borer moths
28	Noctuidae	471	Owlet moths
29	Nolidae	85	Tuft moths
30	Notodontidae	28	Prominent moths
31	Nymphalidae	178	Brush-footed butterflies
32	Oecophoridae	1	Concealer boths
33	Papilionidae	17	Swallowtail butterflies
34	Pieridae	79	Yellows, Whites, & Sulphurs
35	Plutellidae	5	Diamondback moths
36	Psychidae	6	Bagworm moths
37	Pterophoridae	39	Plume moths
38	Pyralidae	31	Snout moths
38	Saturniidae	53	Emperor moths
40	Scythrididae	7	Flower moths
41	Sesiidae	6	Clearwing moths
42	Sphingidae	81	Hawk moths
43	Thyrididae	9	Picture-winged leaf moths
44	Tineidae	38	Fungus moths
45	Tortricidae	60	Leafroller moths
46	Uraniidae	3	Swallowtail moths
47	Yponomeutidae	6	Ermine moths
48	Zygaenidae	8	Burnet moths
Total		**2438**	

Table 2. List of Lepidoptera taxa originally described from Ethiopia (only valid names are listed). An asterisk (*) denotes that the town is in Sudan, but the river originates in Ethiopia. The type locality is recorded with the corrected spelling or current locality name in square brackets. The endemic taxa from Ethiopia are indicated with E in the last column. Synonymies are not reported. De Prins and De Prins (2019) and Williams (2018) have been used as a basic reference for the preparation of the list.

	Family	Taxon	Author	Type Locality	
1	Blastobasidae	*Blastobasis eridryas*	Meyrick, 1932	Mt Chillálo	E
2	Brahmaeidae	*Dactyloceras richinii*	Berio, 1940	Adi Abuna [in Tigray, Ethiopia]	
3	Carposinidae	*Carposina candace*	Meyrick, 1932	Jem-Jem Forest	E
4	Choreutidae	*Choreutis argyrastra*	Meyrick, 1932	Mt Zukwala/Cuqala	E
5		*Telosphrantis aethiopica*	Meyrick, 1932	Mt Chillálo	E
6	Cosmopterigidae	*Ascalenia secretifera*	Meyrick, 1932	Mt Chillálo	E
7		*Cosmopterix derrai*	Koster, 2016	14 km S of Debre Tabor, Alemsaga Forest	E
8		*Cosmopterix epismaragda*	Meyrick, 1932	Jem-Jem Forest	E
9	Cossidae	*Aethalopteryx obscurascens*	(Gaede, 1930)	Centr. Abyss., Maraquo	
10		*Afroarabiella strohlei*	Yakovlev & Witt, 2016	Turmi, Mango Lodge	E
11		*Azygophleps brehmi*	Yakovlev & Witt, 2016	Bale Mountains, Karcha near Rira	E
12		*Camellocossus abyssinica*	(Hampson, 1910)	Abyssinia [Ethiopia]	
13		*Camellocossus lalibela*	Yakovlev & Witt, 2017	Arba Minch	E
14		*Camellocossus strohlei*	Yakovlev & Witt, 2017	Arba Minch	E
15		*Macrocossus sidamo*	Rougeot, 1977	near Kébré-Mengist [Kebre Mengist]	E
16		*Oreocossus ungemachi*	Rougeot, 1977	Ioubdo, Birbir	E
17		*Strigocossus kushit*	Yakovlev, 2011	Ethiopia SE, Bale, 11 km SW Goba, Bale Mts	E
18	Crambidae	*Adelpherupa aethiopicalis*	Maes, 2002	SW Abyssinia [Ethiopia], Djimma [Jimma]	E
19		*Agathodes dufayi*	Rougeot, 1977	Koffolé [Kofale]	E
20		*Alphacrambus cristatus*	Bassi, 1995	Maraqo	E
21		*Ancylolomia jacquelinae*	Rougeot, 1984	Arba Minch	E
22		*Ancylolomia shafferi*	Rougeot, 1977	Koffolé [Kofale]	E
23		*Ancylolomia shefferialis*	Rougeot, 1984	Bahar Dar	E
24		*Chilo luniferalis*	Hampson, 1896	Abyssinia [Ethiopia]	E
25		*Classeya aphrodite*	Błeszyński, 1964	Dire Dawa	E
26		*Crambus arnaudiae*	Rougeot, 1977	Koffolé [Kofale]	E
27		*Crambus bachi*	Bassi, 2012	Bahar Dar, Lake Tana	E
28		*Crambus bellinii*	Bassi, 2014	Bale Mts, Sanetti Plateau	
29		*Crambus boislamberti*	Rougeot, 1977	Dinsho Reserve	E
30		*Crambus dedalus*	Bassi, 2000	Karsan, Kollubi	E
31		*Crambus descarpentriesi*	(Rougeot, 1977)	Koffolé [Koffale]	E
32		*Crambus jupiter*	Błeszyński, 1963	Ethiopia SW, Gamu-Gofa, Konso	E
33		*Crambus netuncus*	Bassi, 2012	Near Debra Libanos	E
34		*Crambus richteri*	Błeszyński, 1963	Kaffa, Ghimira	E
35		*Dembea venulosella*	Ragonot, 1888	Abyssinia [Ethiopia]	
36		*Euchromius donum*	Schouten, 1988	Haro-Ali, Gurra	E
37		*Euclasta sidamona*	Rougeot, 1977	Koffolé [Koffale]	E
38		*Euctenospila castalis*	Warren, 1892	Abyssinia [Ethiopia]	
39		*Leucinodes ethiopica*	Mally, Korycinska, Agassiz, Hall, Hodgetts & Nuss, 2015	Dire Dawa Region, Dire Dawa District, Dire Dawa	
40		*Lygropia nigricornis*	Hampson, 1898	Abyssinia [Ethiopia]	
41		*Noorda trimaculalis*	Amsel, 1965	Ethiopia SW, Gammu-Gofa, Konso	E

	Family	Taxon	Author	Type Locality	
42	Crambidae	*Noorda unipunctalis*	Amsel, 1963	Konso	E
43		*Pagyda pulvereiumbralis*	(Hampson, 1918)	Diré Daouá [Dire Dawa]	
44		*Pediasia ferruginea*	Błeszyński, 1963	Kaffa, Gembi	
45		*Pediasia simiensis*	Błeszyński, 1962	Soddu Province, Wolamo [Walita]	E
46		*Prionapteryx selenalis*	(Hampson, 1919)	Taddecha Mullka	E
47		*Prionotalis friesei*	Błeszyński, 1963	Ethiopia SW, Gamu-Gofa, Konso	E
48		*Tegostoma richteri*	Amsel, 1963	Awash	E
49	Depressariidae	*Odites aethiopicus*	Lvovsky, 2001	Kaffa, Gembi	
50	Elachistidae	*Elachista delocharis*	Meyrick, 1932	Jem-Jem Forest	E
51	Erebidae	*Achaea monodi*	Laporte, 1975	near Kebré-Mengist [Kibre Mengist]	E
52		*Afrasura rivulosa ethiopica*	Durante, 2009	Menegesha-Suba state Forest	E
53		*Afrasura indecisa orientalis*	Durante, 2009	Menegesha-Suba state Forest	E
54		*Afrasura terlinea*	Durante, 2009	Langano Lake	E
55		*Afrojavanica kostlani*	(Gaede, 1923)	Adis-Abeba	
56		*Alpenus geminipuncta*	(Hampson, 1916)	Abyssinia [Ethiopia]	E
57		*Amata alicia*	(Butler, 1876)	Abyssinia [Ethiopia]	
58		*Amata magrettii*	Berio, 1937	Metema [in Tigray, Ethiopia]	E
59		*Amata rufina*	(Oberthür, 1878)	Abyssinia [Ethiopia]	
60		*Amata shoa*	(Hampson, 1898)	Abyssinia [Ethiopia]	
61		*Amata velatipennis*	Walker, 1865	Marako	
62		*Amphicallia kostlani*	Strand, 1911	Gipfel des Sugyala	E
63		*Amsacta nigrisignata*	Gaede, 1923	Addis Ababa	E
64		*Amsactarctia radiosa*	(Pagenstecher, 1903)	Darassum	
65		*Anomis sabulifera*	(Guenée, 1852)	Abyssinia [Ethiopia]	
66		*Antiophlebia bourgognei*	Laporte, 1975	Arba Minch	E
67		*Aroa quadriplagata*	Pagenstecher, 1903	Galata	E
68		*Asura xanthophaea*	Toulgoët, 1977	Ethiopia	E
69		*Beriodesma smithii*	(Holland, 1897)	River Darde	
70		*Brunia birketsmithi*	(Toulgoët, 1977)	Kébré-Mengist [Kibre Mengist]	E
71		*Brunia dorsti*	(Toulgoët, 1977)	Kébré-Mengist [Kibre Mengist]	E
72		*Callophisma viettei*	Laporte, 1975	Arba Minch	E
73		*Carcinarctia rougeoti*	Toulgoët, 1977	Bale Reserve, Dinsho	E
74		*Casama impura*	(Hering, 1926)	Abyssinia [Ethiopia]	
75		*Cautatha abyssinia*	Hacker, Fiebig & Stadie, 2019	Reg. South Nations, Bonga Guesthouse	
76		*Cautatha bifasciata*	Hacker, Fiebig & Stadie, 2019	Reg. South Nations, road Shishinda-Bonga, 6 km, w Wushwush	E
77		*Cerocala confusa*	Warren, 1913	Abyssinia [Ethiopia]	E
78		*Clytie thibauti*	Laporte, 1991	Kibre Mengist	E
79		*Corgatha hyperxantha*	Hacker, Fiebig & Stadie, 2019	Reg. South Nations, Bonga Guesthouse	E
80		*Corgatha minutulana*	Hacker, 2019	Southern Prov., 6 km ENE Weyto, Segen river	
81		*Cortyta canescens septentrionalis*	Hacker, 2016	12 km W of Jinka, near border of Mago National Park	
82		*Crambiforma leucostrepta*	Hampson, 1926	Harrar	E
83		*Crypsotidia digitata*	Kühne, 2005	Harar	E
84		*Crypsotidia gigantea*	Kühne, 2005	Harar	
85		*Ctenusa curvilinea*	Hampson, 1913	Taddecha Mullka	
86		*Cyana abyssinica*	Karisch, 2003	Akaki River, Addis Ababa	E

	Family	Taxon	Author	Type Locality	
87	Erebidae	*Cyana ethiopica*	Karisch, 2013	near Kebré-Mengist [Kibre Mengist]	E
88		*Dasychira grisea*	Pagenstecher, 1903	Bone	E
89		*Dasychira plesia*	Collenette, 1938	Abyssinia [Ethiopia]	
90		*Digama meridionalis deliae*	Berio, 1939	Adu-Abuna [in Tigray, Ethiopia]	E
91		*Donuctenusa fiorii*	Berio, 1940	Ogaden, Uarder [Warder]	E
92		*Enargeiosia elegans*	(Butler, 1877)	Atbara*	
93		*Eublemma accedens aethiopica*	Hacker, 2019	Ethiopia, 3 km N Turmi, Mango Camping Site	
94		*Eublemma aethiopiana*	Hacker, 2019	Jinka, Mago Nat. Park, Magoriverside	
95		*Eublemma baccatrix*	Hacker, 2019	Southern Prov., 2.6 km EE Wondo Genet	
96		*Eublemma collacteana*	Hacker, 2019	12 km W Jimma, border Mago Nat. Park	
97		*Eublemma costivinata*	Berio, 1945	Borana Nagelli [Borena Nagelle]	E
98		*Eublemma diredaoua*	Hacker, 2019	Dire Daoua, Abyssinia	E
99		*Eublemma ferruginata*	Hacker, 2019	20 ESE Sashamane, Wendo Genet	
100		*Eublemma heteropaura*	Hacker, 2019	Oromia, 7 km NW Yabelo	
101		*Eublemma joergmuelleri*	Hacker & Schrier, 2019	Ethiopia, Awash N.P., Headquarter	E
102		*Eublemma perturbata*	Hacker, 2019	Oromia prov., 6.5 km ne Shebe	
103		*Eublemma plectoversa*	Hacker, 2019	8 km N Turmi	
104		*Eublemma schreieri*	Hacker, 2019	Oromia, 1km W vill. Aluweya	
105		*Eublemma sidamonia*	Hacker, Fiebig & Stadie, 2019	Sidamo, Yabello, vic. 6km SO near Deritu village	E
106		*Eublemma siticulina*	Hacker, 2019	Dire Daoua, Abyssinia	E
107		*Eublemma uhlenhuthi*	Wiltshire, 1988	Abyssinia, Dire Daoua [dire-dawa]	
108		*Euproctis chrysophaea*	(Walker, 1865)	Abyssinia [Ethiopia]	
109		*Eyralpenus scioana*	(Oberthür, 1880)	Scioa [Shoa]	
110		*Galtara doriae*	(Oberthür, 1880)	Mahal Uonz, between Harrar and Addis Abeba [Awash River]	
111		*Kenyarctia melanogastra*	(Holland, 1897)	Gof [Gofa]	
112		*Hypena abyssinialis*	Guenée, 1854	Abyssinia [Ethiopia]	
113		*Hypena padelekorum*	Lödl, 1995	Djem-Djem [Jem Jem] Forest	E
114		*Hypena philippi*	Laporte, 1991	Arba Minch	E
115		*Hyposada zavattarii*	Berio, 1944	Gondaraba	
116		*Hypotacha fiorii*	Berio, 1943	Diredaua [Dire Dawa]	
117		*Hypotacha glaucata*	(Holland, 1897)	Sjeikh Husein [Shek Hussein]	
118		*Ischnarctia cinerea*	(Pagenstecher, 1903)	Gogoru	
119		*Laelia dabano*	Collenette, 1934	Dabano River	
120		*Lithacodia awassensis*	Berio, 1984	Awassa Lake	E
121		*Lithacodia persubtilis*	Berio, 1984	Kebré-Mengist	E
122		*Marcipa rougeoti*	Pelletier, 1975	Kebré-Mengist	E
123		*Metachrostis debivar*	(Berio, 1947)	Ogaden, Ualual [Walwal]	E
124		*Metachrostis phaeographa*	Hacker, 2011	12 km W of Jinka, border Mago National Park	
125		*Metarctia carmel*	Kiriakoff, 1957	SW Abyssinia [Ethiopia], Kambatta	E

	Family	Taxon	Author	Type Locality	
126	Erebidae	*Metarctia gada*	Rougeot, 1977	Dinsho Reserve, Réserve de Balé	E
127		*Metarctia haematricha*	Hampson, 1905	Kutai Metha	
128		*Metarctia kumasina*	Strand, 1920	Zegi Tsana [Zegie Tana]	
129		*Metarctia negusi*	Kiriakoff, 1957	Abyssinia [Ethiopia]	E
130		*Metarctia noctis*	Druce, 1910	Diré Daouá [Dire Dawa]	E
131		*Metarctia saalfeldi*	Kiriakoff, 1960	Villagio	E
132		*Metarctia unicolor*	(Oberthür, 1880)	Oromo Country, Fin-Fekéré	
133		*Micralarctia punctulatum purus*	(Butler, 1878)	Abyssinia [Ethiopia]	
134		*Oediblemma peregrina*	Hacker, Fiebig & Stadie, 2019	Reg. South Nations, Sheiko Forest Road Teppi Mizan Teferi	E
135		*Ophiusa dianaris*	(Guenée, 1852)	Abyssinia [Ethiopia]	
136		*Pantydia dufayi*	Laporte, 1975	Near Koffolé [Koffalé]	
137		*Paramarbla abyssinica*	Collenette, 1956	Birbir, Joubdo [Yubdo]	E
138		*Paraonagylla zavattarii*	Berio, 1939	Neghelli [Nagelle]	E
139		*Pericyma schreieri*	Hacker, 2016	Gamu-Gofa Province, 3 km N of Turmi	
140		*Phytometra angensteini*	Hacker, 2019	Arba Minch	E
141		*Plecopterodes melliflua*	(Holland, 1897)	Sjeikh Husein [Shek Hussein]	
142		*Plecopterodes molybdena*	Berio, 1954	Gorgorà, Lake Tana	E
143		*Podomachla antinorii*	(Oberthür, 1880)	Mahal Uonz [Awash River]	
144		*Polymona rufifemur ellisoni*	Collenette, 1938	Abyssinia [Ethiopia]	
145		*Proluta ethiopica*	(Hacker, 2011)	Arba Minch Region, Omo Province, Gemu Gofa	
146		*Pseudomicrodes varia*	Berio, 1944	Elolo	
147		*Pteredoa atripalpia*	Hampson, 1910	Atbara River	
148		*Rhabdophera exarata*	(Mabille, 1890)	Abyssinia [Ethiopia]	
149		*Ruanda nuda*	(Holland, 1897)	River Darde	
150		*Seydelia geometrica*	(Oberthür, 1883)	Scioa [Shoa]	
151		*Spilosoma mediopunctata*	(Pagenstecher, 1903)	Arbarone	
152		*Spilosoma quadrimacula*	Toulgoët, 1977	Lalokéli	E
153		*Stenilema aurantiaca*	Hampson, 1909	Abyssinia [Ethiopia]	
154		*Stenilema hailesellassiei*	(Birket-Smith, 1965)	Addis Ababa, University College Campus	E
155		*Stracena aegrota*	Le Cerf, 1922	Harar	E
156		*Stracilla translucida*	(Oberthür, 1880)	Scioa [Shoa], Mahal Uonz	
157		*Syngatha eremita*	Hacker, Fiebig & Stadie, 2019	Reg. South Nations, Bonga Guesthouse	E
158		*Syngatha parascotoides*	Hacker, 2019	12 km W Jinka, border Mago National Park	
159		*Syngatha simplicicata*	Hacker, Fiebig & Stadie, 2019	Reg. South Nations, Sheiko Forest Road Teppi Mizan Teferi	E
160		*Tegiapa ambiguosa*	Hacker, Fiebig & Stadie, 2019	Reg. South Nations, road Shishinda-Bonga, 6 km W Wushwush	
161		*Tegiapa obliqua*	Hacker, Fiebig & Stadie, 2019	Sidamo, Yabello vic., 10km W road to Konso	
162		*Tegiapa schreieri*	Hacker, 2019	Oromia Prov., 6 km ESE Jimma	
163		*Teracotona abyssinica*	(Rothschild, 1933)	Central Abyssinia [Ethiopia], Maraco [Marako]	
164		*Teracotona neumanni*	Rothschild, 1933	SW Abyssinia [Ethiopia], Kambatta	E

	Family	Taxon	Author	Type Locality	
165	Erebidae	*Teracotona postalbida*	(Gaede, 1926)	Abyssinia [Ethiopia]	E
166		*Teracotona clara rubiginea*	(Toulgoët, 1977)	Fisha Genet	E
167		*Teracotona seminigra*	(Hampson, 1905)	Zegi Tsana [Tana]	E
168		*Thyretes negus*	Oberthür, 1878	Abyssinia [Ethiopia]	
169		*Tigreana nathaliannae*	Laporte, 1991	Wollo, Ataye	E
170		*Tigreana sandrae*	Laporte, 1991	Wollo Ataye	E
171		*Trigonodes exportata*	Guenée, 1852	Abyssinia [Ethiopia]	
172		*Tytroca alabuensis alabuensis*	Wiltshire, 1970	Alabu	
173		*Tytroca balnearia mutabilis*	Hacker, 2016	15 km N of Arba Minch, 2 km after junction to Chencha	E
174		*Tytroca heterophysa*	Hacker, 2016	Omo Region, Gemu Gofa Province, Arba Minch	E
175		*Ulotrichopus phaeoleucus griseus*	Kühne, 2005	Addis Ababa	
176		*Utetheisa amhara*	Jordan, 1939	Abyssinia [Ethiopia]	
177		*Zekelita heteroleuca*	Hacker, 2016	Southern Province, 11.2 km W of Bonga	E
178		*Zekelita lehmanni magnificaria*	Hacker, 2016	10.5 km W of Weyto	E
179		*Zekelita nilotica*	Hacker, 2016	30 km SE of Bahir Dar, Tisisat above Blue Nile falls	E
180	Eupterotidae	*Phiala abyssinica*	Aurivillius, 1904	Zegi Tsana [Tana]	E
181		*Phiala bergeri*	Rougeot, 1975	Bale	E
182		*Rhodopteriana abyssinica*	(Rothschild, 1917)	Harrar [Harar]	
183		*Rhodopteriana sidamoensis*	Darge, 2013	Sidamo Province, near Mega	E
184	Euteliidae	*Eutelia favillatrix*	(Guenée, 1852)	Abyssinia [Ethiopia]	
185		*Stenosticta schreieri*	Hacker, 2010	3 km N Turmi, Mango Camping Site	E
186	Gelechiidae	*Aphanostola maxima*	Bidzilya & Mey, 2016	Lake Tana, Bahir Dar	E
187		*Chrysoesthia parilis*	(Vári, 1963)	Little Akaki River, near Addis Ababa	E
188		*Stegasta sattleri*	Bidzilya & Mey, 2011	Addis Ababa	
189		*Stomopteryx ochrosema*	Meyrick, 1932	Addis Alam [Alem], ca. 20 miles W. of Addis Ababa	E
190		*Chiasmia abyssinica*	Krüger, 2001	Harrar [Harar]	E
191		*Chiasmia procidata*	(Guenée, 1858)	Abyssinia [Ethiopia]	
192		*Chiasmia streniata*	(Guenée, 1858)	Abyssinia [Ethiopia]	
193		*Chiasmia trinotatula*	Krüger, 2001	Kabarutar, 56 miles W of Lake Tana	E
194		*Cleora oculata sidamo*	Herbulot, 1977	Kébré-Mengist [Kibre Mengist]	E
195		*Cleora pavlitzkiae etesiae*	Fletcher, 1967	Harar	
196		*Coenina dentataria*	Swinhoe, 1904	Abyssinia [Ethiopia]	
197		*Comibaena theodori*	Hausmann & Parisi, 2014	Kaffa Province, 10 km N of Bonga	E
198		*Drepanogynis nigerrima*	(Swinhoe, 1904)	Abyssinia [Ethiopia]	E
199		*Epigynopteryx flavedinaria*	(Guenée, 1857)	Abyssinia [Ethiopia]	
200		*Epigynopteryx rougeoti*	Herbulot, 1977	Dinsho Marshes	E
201		*Epigynopteryx scotti*	Fletcher, 1959	Ethiopia N, Simien, near Mindigabsa	E
202		*Erastria marginata*	(Swinhoe, 1904)	Abyssinia [Ethiopia]	E
203		*Eupithecia angulata*	Fletcher, 1951	Harar	E
204		*Eupithecia dinshoensis*	Herbulot, 1983	Dinsho Col	E
205		*Eupithecia incommoda*	Herbulot, 1983	Dinsho Reserve	E
206		*Eupithecia inquinata*	Fletcher, 1950	Lekamti [Naqamte]	

	Family	Taxon	Author	Type Locality	
207	Geometridae	*Eupithecia ochralba*	Herbulot, 1983	Dinsho Reserve	E
208		*Eupithecia pseudoabbreviata*	Fletcher, 1951	Harar	E
209		*Eupithecia rougeoti*	Herbulot, 1983	Dinsho Reserve	E
210		*Eupithecia urbanata*	Fletcher, 1956	Harar	E
211		*Geodena brunneomarginata*	Karisch, 2003	Shoa, 50 km W of Adis Ababa	E
212		*Hemistola aetherea*	Debauche, 1937	Addis Ababa	E
213		*Henicovalva negus*	Krüger, 2017	Dire Daoua [Dawa]	E
214		*Heterostegane serrata*	(Fletcher, 1958)	Diré Daouá [Dire Dawa]	
215		*Hydrelia candace*	Prout, 1929	Addis Ababa	E
216		*Hypochrosis chiarinii*	(Oberthür, 1883)	Scioa [Shoa]	
217		*Idaea glomerata*	(Prout, 1937)	Abyssinia [Ethiopia]	E
218		*Lomographa indularia*	(Guenée, 1858)	Abyssinia [Ethiopia]	
219		*Mimoclystia pudicata cecchii*	(Oberthür, 1883)	Scioa [Shoa], Let-Marefia [Jet Marafia]	E
220		*Nothofidonia xenoleuca*	Prout, 1928	Wolisso, between Hauash [Awash] and Omo	E
221		*Odontopera briela*	(Debauche, 1937)	Mt Chillálo [Chilalo]	E
222		*Odontopera integraria*	Guenée, 1858	Abyssinia [Ethiopia]	
223		*Odontopera protecta*	Herbulot, 1983	Dinsho Reserve	E
224		*Omphacodes pulchrifimbria pulchritacta*	Prout, 1923	Abyssinia [Ethiopia] Central Moraqui [Marako]	
225		*Oreometra ras*	Herbulot, 1983	near Mount Batu	E
226		*Piercia zukwalensis*	Debauche, 1937	Mt Zukwala/Cuqala	
227		*Pingasa abyssiniaria*	(Guenée, 1858)	Harar	
228		*Platypepla bifida*	Herbulot, 1984	near Kébré-Mengist [Kibre Mengist]	E
229		*Platypepla uhlenhuthi*	Krüger, 2001	Diré Daouá [Dire Dawa]	E
230		*Prasinocyma aquamarina*	Hausmann, Sciarretta & Parisi, 2016	Bale Mts, 10 km S Rira	E
231		*Prasinocyma aetheraea*	(Debauche, 1937)	Addis Ababa	E
232		*Prasinocyma albivenata*	Herbulot, 1983	Dinsho Marsh	E
233		*Prasinocyma amharensis*	Hausmann, Sciarretta & Parisi, 2016	SW Debre Sina & Sembo, Umg. Debre Sina	E
234		*Prasinocyma angolica pseudopedicata*	Hausmann, Sciarretta & Parisi, 2016	7 km NW Yabello	E
235		*Prasinocyma angulifera*	Hausmann, Sciarretta & Parisi, 2016	southern Bale Mts, Harenna Forest	E
236		*Prasinocyma batesi distans*	Hausmann, Sciarretta & Parisi, 2016	Addis Ababa	E
237		*Prasinocyma baumgaertneri*	Hausmann, Sciarretta & Parisi, 2016	Harenna Forest	E
238		*Prasinocyma beryllaria*	Hausmann, Sciarretta & Parisi, 2016	13 km W Yabello Motel	E
239		*Prasinocyma bongaensis*	Hausmann, Sciarretta & Parisi, 2016	Bonga, 12 km E	E
240		*Prasinocyma discipuncta*	Hausmann, Sciaretta & Parisi, 2016	16 km SW Kibre Mengist	E
241		*Prasinocyma fallax*	Hausmann, Sciarretta & Parisi, 2016	SW. Debre Sina & Sembo, Umg. Debre Sina	E
242		*Prasinocyma fusca*	Hausmann, Sciarretta & Parisi, 2016	Harenna Forest	E
243		*Prasinocyma gajdacsi*	Prout, 1930	Adis Abeba [Addis Ababa]	E
244		*Prasinocyma gemmifera*	Hausmann, Sciaretta & Parisi, 2016	Wushwush, 7.4 km w	E

	Family	Taxon	Author	Type Locality	
245	Geometridae	*Prasinocyma germinaria*	(Guenée, 1857)	Abyssinia [Ethiopia]	
246		*Prasinocyma getachewi*	Hausmann, Sciarretta & Parisi, 2016	Arba Minch	E
247		*Prasinocyma hailei*	Debauche, 1937	Addis Ababa	E
248		*Prasinocyma immaculata thiaucourti*	Herbulot, 1993	Debre Zeit	E
249		*Prasinocyma leveneorum*	Hausmann, Sciarretta & Parisi, 2016	Harenna Forest, Karcha clearing	E
250		*Prasinocyma lutulenta*	Hausmann, Sciarretta & Parisi, 2016	Arba Minch	E
251		*Prasinocyma magica*	Hausmann, Sciarretta & Parisi, 2016	Mago National park	E
252		*Prasinocyma monikae*	Hausmann, Sciarretta & Parisi, 2016	13 km W Yabello, Motel	E
253		*Prasinocyma pedicata aethiopica*	Hausmann, Sciarretta & Parisi, 2016	16 km SW Kibre Mengist	E
254		*Prasinocyma robusta*	Hausmann, Sciarretta & Parisi, 2016	13 km W Yabello, Motel	E
255		*Prasinocyma septentrionalis*	Hausmann, Sciarretta & Parisi, 2016	Arba Minch	E
256		*Prasinocyma shoa shoa*	Herbulot, 1993	Debre Zeit	E
257		*Prasinocyma shoa yabellensis*	Hausmann, Sciarretta & Parisi, 2016	13 km W Yabello, Motel	E
258		*Prasinocyma stefani*	Hausmann, Sciarretta & Parisi, 2016	Bonga, 12 km E	E
259		*Prasinocyma tranquilla*	Prout, 1917	NW of Harar, Diredaua [Dire Dawa]	E
260		*Prasinocyma trematerrai simienensis*	Hausmann, Sciarretta & Parisi, 2016	Semien Mountains, chennek Camp	E
261		*Prasinocyma trematerrai trematerrai*	Hausmann, Sciarretta & Parisi, 2016	Dinsho	E
262		*Problepsis fiebigi*	Stadie & Stadie, 2016	Omo Region, Province of Gemu Gofa, Arba Minch	E
263		*Problepsis neumanni*	Prout, 1932	Djiren, Djimma [Jimma]	E
264		*Problepsis sihvoneni*	Stadie & Stadie, 2016	Sidamo, 13 km W of Yabello, Motel	E
265		*Protosteira decolorata*	Herbulot, 1984	Semyen, Sankaber	E
266		*Rhodometra labdoides*	Herbulot, 1997	Choa [Shoa], Debré Zeit	E
267		*Rhodometra plectaria*	(Guenée, 1857)	Abyssinia [Ethiopia]	
268		*Rougeotiella pseudonoctua*	Herbulot, 1983	Kébré-Mengist [Kibre Mengist]	E
269		*Scopula erymna*	Prout, 1928	Gurra, Dagaje	E
270		*Scopula scotti*	Debauche, 1937	Addis Ababa	
271		*Scopula silonaria*	(Guenée, 1858)	Abyssinia [Ethiopia]	
272		*Scopula simplificata*	Prout, 1928	NE Africa, Ganale River	E
273		*Sesquialtera lonchota*	Prout, 1931	Diré Daouá [Dire Dawa], NW of Harrar	E
274		*Somatina pythiaria*	(Guenée, 1857)	Abyssinia [Ethiopia]	
275		*Tephronia aethiopica*	Herbulot, 1983	Shoa, Menagesha Forest	E
276		*Traminda neptunaria*	(Guenée, 1857)	Abyssinia [Ethiopia]	
277		*Trimetopia aetheraria*	Guenée, 1858	Abyssinia [Ethiopia]	E
278		*Xanthisthisa copta*	Herbulot, 1977	Boré Forest	E
279		*Xanthisthisa terna*	Herbulot, 1984	Shoa, Menagesha Forest	E
280		*Xanthorhoe abyssinica*	Herbulot, 1983	Chensha	E
281		*Xanthorhoe alta*	Debauche, 1937	Mt Chillálo, Albaso	E

	Family	Taxon	Author	Type Locality	
282	Geometridae	*Xanthorhoe cadra*	(Debauche, 1937)	Mt Chillálo, from forest of Kosso-trees	E
283		*Xanthorhoe cuneosignata*	Debauche, 1937	Mt Chillálo, Albaso	E
284		*Xanthorhoe excelsissima*	Herbulot, 1977	Mt Batu	E
285		*Xenimpia sabae amarei*	Hausmann, 2006	Arba Minch, Region of Omo, Gemu Gofa,	E
286		*Xylopteryx emunctaria*	(Guenée, 1858)	Abyssinia [Ethiopia]	
287		*Xylopteryx gada*	Herbulot, 2000	Balé, Harena Forest	E
288		*Xylopteryx raphaelaria*	(Oberthür, 1880)	Scioa [Shoa]	E
289		*Zamarada excavata pollex*	Fletcher, 1974	Jlubador [Ilubabor] Gore	E
290		*Zamarada hyalinaria*	(Guenée, 1857)	Abyssinia [Ethiopia]	
291		*Zamarada melasma*	Fletcher, 1974	Dire Daoua [Dire Dawa]	
292		*Zamarada secutaria*	(Guenée, 1857)	Abyssinia [Ethiopia]	
293		*Zamarada shoa*	Herbulot, 2002	Shoa, 50 km W of Addis Ababa	E
294		*Zamarada torrida*	Fletcher, 1974	Dire Daoua [Dire Dawa]	
295	Glyphipterigidae	*Ussara semicoronis*	Meyrick, 1932	Jem-Jem Forest	E
296	Gracillariidae	*Acrocercops heteroloba*	Meyrick, 1932	Jem-Jem Forest	E
297		*Acrocercops orianassa*	Meyrick, 1932	Mt Zukwala/Cuqala	
298		*Caloptilia macropleura*	(Meyrick, 1932)	Jem Jem Forest	
299		*Metacercops hexactis*	(Meyrick, 1932)	Jem-Jem Forest	E
300		*Metriochroa carissae*	Vári, 1963	Addis Ababa, Little Akaki River	E
301		*Metriochroa scotinopa*	Vári, 1963	Dabra Zeit [Debre Zeit]	E
302	Gracillariidae	*Porphyrosela homotropha*	Vári, 1963	Addis Ababa, Little Akaki River	E
303		*Stomphastis heringi*	Vári, 1963	Near Addis Ababa, Little Akaki River	E
304		*Stomphastis horrens*	(Meyrick, 1932)	Jem-Jem Forest	E
305	Hesperiidae	*Abantis meneliki*	Berger, 1979	Harrar	
306		*Apallaga menageshae*	Libert, 2014	Mt Menagesha, NW Addis Abeba	
307		*Coeliades chalybe immaculata*	Carpenter, 1935	Alanga River	E
308		*Coeliades menelik menelik*	(Ungemach, 1932)	Lilmo, dans la pays de Sayo	
309		*Eretis mixta*	Evans, 1937	Dire Daouna [Dire Dawa]	
310		*Metisella formosus mittoni*	Carcasson, 1961	Mega	E
311		*Sarangesa lucidella helena*	Evans, 1947	Harar	E
312	Lasiocampidae	*Beralade perobliqua monostrigata*	Berio, 1940	Adi-Abuna [in Tigray, Ethiopia]	E
313		*Bombycopsis abyssinica*	Joannou & Krüger, 2009	Addis Abeba	E
314		*Mallocampa toulgoeti*	Rougeot, 1977	Kébré-Mengist [Kibre Mengist]	E
315		*Odontocheilopteryx eothina*	Tams, 1931	Djoubdo [Yubdo], Birbir	E
316		*Odontocheilopteryx lajonquieri*	Rougeot, 1977	near Kébré-Mengist [Kibre Mengist]	E
317		*Pallastica hararia*	Zolotuhin & Gurkovich, 2009	Harar	E
318		*Sena donaldsoni rougeoti*	Lajonquière, 1977	Arba Minch	E
319		*Sena scotti*	(Tams, 1931)	Djem-Djem [Jem-Jem] Forest	
320		*Stoermeriana abbayensis*	(Rougeot, 1984)	Bahar-Dar, marais du Nil Bleu, Abbay	E
321		*Stoermeriana chavailloni*	(Rougeot, 1984)	Melka-Kontouré	E
322		*Stoermeriana das*	(Hering, 1928)	Eli	E
323		*Stoermeriana laportei*	(Rougeot, 1977)	Kébré-Mengist [Kibre Mengist]	E
324		*Stoermeriana murinuscolor*	(Rougeot, 1984)	Shoa, Menagesha Forest	E
325		*Stoermeriana saanayetae*	(Rougeot, 1984)	Awassa Lake	E
326		*Stoermeriana tamsi*	(Rougeot, 1977)	Dinsho Marshes, Balé	E
327		*Stoermeriana viettei*	(Rougeot, 1977)	Dinsho Marshes	E

	Family	Taxon	Author	Type Locality	
328	Limacodidae	*Crothaema flava*	Berio, 1940	Adi-Abuna [in Tigray, Ethiopia]	E
329		*Hamartia johanni*	Rougeot, 1977	Kébré-Mengist [Kibre Mengist]	E
330		*Hamartia medora moulini*	Rougeot, 1977	Kébré-Mengist [Kibre Mengist]	E
331		*Jordaniana lactea*	(Pagenstecher, 1903)	Ganale	
332	Lycaenidae	*Anthene amarah*	(Guérin-Méneville, 1849)	Dire Dawa	
333		*Anthene butleri butleri*	(Oberthür, 1880)	Mantek; Mahal-Uonz	
334		*Anthene chojnackii*	Libert, 2010	10 km NW of Neghelli	E
335		*Anthene confusa*	Libert, 2010	Touloudimtou [Tullu Dimtu]	
336		*Anthene contrastata*	(Ungemach, 1932)	Bedelle	E
337		*Anthene definita nigrocaudata*	(Pagenstecher, 1902)	Ginir	E
338		*Anthene dulcis*	(Pagenstecher, 1902)	Gambe beim Abasse-See	
339		*Anthene hodsoni*	(Talbot, 1935)	Kibish River	
340		*Anthene opalina janna*	Gabriel, 1949	Fich-Babile Road	
341		*Anthene opalina opalina*	Stempffer, 1946	Callafo[Kalafo], Webi Shebeli, Ogaden	
342		*Anthene pitmani aethiopana*	Libert, 2010	Ghibe River, Addis Abeba-Jimma road	
343		*Anthene princeps*	(Butler, 1876)	Atbara*	
344		*Anthene saddacus*	(Talbot, 1935)	Ethiopia	E
345		*Anthene suquala*	(Pagenstecher, 1902)	Suquala	
346		*Axiocerses maureli*	Dufrane, 1954	Harrar	E
347		*Azanus jesous*	(Guérin-Méneville, 1849)	Abyssinie [Ethiopia]	
348		*Cacyreus ethiopicus*	(Tite, 1961)	25 km north of Quiha	E
349		*Cacyreus fracta ghimirra*	Talbot, 1935	Shoa Ghimirra province	E
350		*Chilades elicola*	(Strand, 1911)	Eli, Ethiopia	
351		*Deudorix lorisona baronica*	Ungemach, 1932	Baro River	E
352		*Deudorix ungemachi*	Libert, 2004	Ethiopia	E
353		*Eicochrysops antoto*	(Strand, 1911)	Umgebung unterhalb Antotos [Entoto]	E
354		*Eicochrysops meryamae*	Rougeot, 1983	Province de Gondar, environs de Debarek	E
355		*Eicochrysops messapus sebagadis*	(Guérin-Méneville, 1849)	Abyssinie [Ethiopia]	
356		*Euchrysops abyssinicus*	(Aurivillius, 1922)	Tchafianani; Debasso	E
357		*Euchrysops cyclopteris*	(Butler, 1876)	Atbara*	
358		*Euchrysops mauensis Abyssinia [Ethiopia]e*	Storace, 1950	Bahrdàr [Bahar Dar] sulle rive meridionali del Lago Tana	E
359		*Euchrysops nandensis*	(Neave, 1904)	Lake Tana	
360		*Hypolycaena ogadenensis*	Stempffer, 1946	Dagahbur, Ogaden	E
361		*Iolaus crawshayi maureli*	Dufrane, 1954	Harrar [Harar]	
362		*Iolaus piaggiae*	Oberthür, 1883	Kolla di Giagaguè-Agher	E
363		*Lachnocnema abyssinica*	Libert, 1996	Dire Daouna [Dawa]	
364		*Lepidochrysops abyssiniensis abyssiniensis*	(Strand, 1911)	Eli	E
365		*Lepidochrysops abyssiniensis oculus*	(Ungemach, 1932)	Ouama	E
366		*Lepidochrysops guichardi*	Gabriel, 1949	10 miles West of Addis Ababa	E
367		*Lepidochrysops lunulifer*	(Ungemach, 1932)	Didessa	E
368		*Lepidochrysops negus*	(Felder & Felder, 1865)	Africa septentrionali-orientalis: Bogo	
369		*Lepidochrysops pterou lilacina*	(Ungemach, 1932)	Didessa	E

	Family	Taxon	Author	Type Locality	
370	Lycaenidae	*Lepidochrysops subvariegata*	Talbot, 1935	Dirre Dawa	E
371		*Leptomyrina boschi*	Strand, 1911	Abyssinie [Ethiopia]n	E
372		*Lycaena phlaeas pseudophlaeas*	(Lucas, 1866)	Abyssinie [Ethiopia]	E
373		*Myrina silenus nzoiae*	Stoneham, 1937	Western Kenya to Ethiopia and Eritrea	
374		*Pentila pauli ras*	Talbot, 1935	S.W. Abyssinia [Ethiopia], Pokodi [Bokoji]	E
375		*Stugeta bowkeri ethiopica*	(Stempffer & Bennett, 1958)	Harrar [Harar]	E
376		*Tarucus ungemachi*	Stempffer, 1942	Rivière Baro Abyssinie [Ethiopia] occidentale	
377		*Thermoniphas colorata*	(Ungemach, 1932)	Youbdo	
378		*Tuxentius cretosus*	(Butler, 1876)	Atbara*	
379		*Tuxentius kaffana*	(Talbot, 1935)	Nado's Province, Yeki; Mocha District, Gamadura	E
380		*Uranothauma antinorii*	(Oberthür, 1883)	Torrente di Sciotalit	
381		*Uranothauma nubifer distinctesignatus*	(Strand, 1911)	[Ethiopia]	E
382		*Zintha hintza resplendens*	(Butler, 1876)	Atbara*	E
383	Metarbelidae	*Aethiopina semicirculata*	Gaede, 1929	Abyssinia [Ethiopia]	E
384		*Salagena fetlaworkae*	Rougeot, 1977	near Koffolé [Koffale]	E
385		*Teragra lemairei*	Rougeot, 1977	Dinsho Marches	E
386		*Teragra villiersi*	Rougeot, 1977	near Koffolé [Koffale]	E
387	Noctuidae	*Abrostola obliqua*	Dufay, 1958	Abyssinia [Ethiopia]	E
388		*Abrostola rougeoti*	Rougeot, 1977	near Koffolé [Koffale]	E
389		*Acontia albatrigona*	Hacker, Legrain & Fibiger, 2008	Arba Minch Region, Omo, Province Gemu, Gofa	
390		*Acontia amarei*	Hacker, Legrain & Fibiger, 2010	Gamu-Gofa Province, 10.5 km W of Weyto	E
391		*Acontia amhara*	Hacker, Legrain & Fibiger, 2008	Gamu-Gofa Province, 8 km N of Turmi	E
392		*Acontia proesei*	Hacker, Legrain & Fibiger, 2008	Valley of the river Tekezé, 30 km N of Gashena	E
393		*Acontia robertbecki*	Hacker, Legrain & Fibiger, 2010	Arba Minch Region, Gemu Gofa Province	E
394		*Acontia ruficincta*	Hampson, 1910	Atbara*	E
395		*Acontia secta*	Guenée, 1852	Abyssinia [Ethiopia]	
396		*Acontia uhlenhuthi*	Hacker, Legrain & Fibiger, 2008	Diré Daouá [Dire Dawa]	E
397		*Acontiola boursini*	(Berio, 1940)	Lekemti [Naqamte]	
398		*Acrapex abbayei*	Laporte, 1984	Dinsho Reserve	E
399		*Acrapex apexangula*	Laporte, 1984	near Koffolé [Koffale]	E
400		*Acrapex ausseili*	Laporte, 1984	Fisha Genet	E
401		*Acrapex franeyae*	Laporte, 1984	Dinsho Reserve	E
402		*Acrapex genrei*	Laporte, 1984	Dinsho Reserve	E
403		*Acrapex girardi*	Laporte, 1984	Dinsho Reserve	E
404		*Acrapex guiffrayorum*	Laporte, 1984	Dinsho Reserve	E
405		*Acrapex mastawatae*	Laporte, 1984	Arba Minch	E
406		*Acrapex matilei*	Laporte, 1984	Dinsho Reserve	E
407		*Acrapex satanas*	Laporte, 1984	Dinsho Reserve	E
408		*Acrapex soyema*	Le Ru, 2017	Gibe, Soyema Bridge	E
409		*Acrapex ulmii*	Laporte, 1991	Koffole [Koffale]	E
410		*Acrapex zaouditou*	Laporte, 1991	Koffole [Koffale]	E
411		*Aedia albirena*	(Hampson, 1926)	Taddecha Mullha	

	Family	Taxon	Author	Type Locality	
412	Noctuidae	*Aedia konsonata*	Hacker, 2016	Konso	E
413		*Aedia marmoreata*	Hacker, 2016	12 km W of Jinka	
414		*Aegocera ferrugo*	Jordan, 1926	Hora Daka	E
415		*Agrotis baleense*	Laporte, 1977	Dinsho, Bale Reserve	
416		*Agrotis cinchonina*	Guenée, 1852	Abyssinia [Ethiopia]	E
417		*Agrotis debivari*	(Berio, 1962)	Africa Orientale Italiana, Debivar	E
418		*Agrotis separata*	Guenée, 1852	Abyssinia [Ethiopia]	E
419		*Amazonides berioi*	(Laporte, 1984)	Lekemti [Naqamte]	E
420		*Amazonides berliozi*	Laporte, 1974	Dinsho Col	E
421		*Amazonides dubiomeodes*	Laporte, 1977	Kébré-Mengist [Kibre Mengist]	E
422		*Amazonides ezanai*	(Laporte, 1984)	Kébré-Mengist [Kibre Mengist]	E
423		*Amazonides fumigera*	Laporte, 1977	Dinsho Marshes	E
424		*Amazonides koffoleense*	Laporte, 1977	Koffolé [Koffale]	E
425		*Amazonides laheuderiae*	Laporte, 1984	Abba Hoye-Gara	E
426		*Amazonides pseudoberliozi*	Rougeot & Laporte, 1983	Simyen, Sankaber	E
427		*Amazonides putrefacta*	(Guenée, 1852)	Abyssinia [Ethiopia]	
428		*Amazonides ungemachi*	(Laporte, 1984)	Ioubdo, Birbir, Nole Kabe	E
429		*Amazonides zarajakobi*	Laporte, 1984	Dinsho Marshes	E
430		*Amphia hepialoides*	Guenée, 1852	Abyssinia [Ethiopia]antio	E
431		*Aporophoba subaustralis*	Berio, 1977	Addis Ababa	E
432		*Apospasta albirenalis*	Laporte, 1974	Mt Batu	E
433		*Apospasta diffusa*	Laporte, 1974	Dinsho Col	E
434		*Apospasta erici*	Laporte, 1984	Dinsho Reserve	E
435		*Apospasta incongrua*	Laporte, 1974	Dinsho Col	E
436		*Apospasta maryamae*	Laporte, 1974	Dinsho Marshes	E
437		*Apospasta niger*	Laporte, 1974	Dinsho Marshes	E
438		*Apospasta rougeoti*	Laporte, 1991	Boré Forest	
439		*Apospasta rufa*	Laporte, 1991	Choa [Shoa], Menageshah [Menegasha] Forest	E
440		*Apospasta sabulosa*	Fletcher, 1959	Simien, Lori	E
441		*Apospasta thomasi*	Laporte, 1991	Addis Ababa	E
442		*Ariathisa abyssinia*	(Guenée, 1852)	Abyssinia [Ethiopia]	
443		*Aspidifrontia ungemachi*	(Laporte, 1978)	Metti	E
444		*Athetis aeschrioides*	Berio, 1940	Adi-Abuni [in Tigray, Ethiopia]	
445		*Athetis carayoni*	Laporte, 1977	Dinsho col	E
446		*Athetis viettei*	Laporte, 1991	Choa [Shoa], Melka-Kontoure [Melka Konture]	E
447		*Axylia aregashae*	Laporte, 1984	near Kébré-Mengist [Kibre Mengist]	E
448		*Axylia bryi*	Laporte, 1984	Dinsho Marshes	E
449		*Axylia destefanii*	Berio, 1944	El-Dire	
450		*Axylia gabriellae*	Laporte, 1975	Boré Forest	E
451		*Axylia marthae*	Laporte, 1984	near Koffolé [Koffale]	E
452		*Axylia orbicularis*	Laporte, 1984	near Kébré-Mengist [Kibre Mengist]	E
453		*Axylia sanyetiensis*	Laporte, 1984	near Mt Batu	E
454		*Axylia vespertina*	Laporte, 1984	near Kébré-Mengist [Kibre Mengist]	E
455		*Batuana abbahoyegarana*	Rougeot, 1983	Abba Hoye-Gara, Wollo	E
456		*Batuana exspectata*	Laporte & Rougeot, 1981	Gojam, Mt Choke	E
457		*Batuana lobeliarum*	Laporte, 1976	near Dinsho	E
458		*Batuana rougeoti*	Laporte, 1976	near Mt Batu	E

	Family	Taxon	Author	Type Locality	
459	Noctuidae	*Berionycta beckroberti*	Kiss, 2017	15 km E of Yabello	E
460		*Berionycta behouneki*	Kiss, 2017	13 km W of Yabello	E
461		*Berionycta berioi*	Kiss, 2017	12 km NNE of Arba Minch	E
462		*Berionycta nigra*	Kiss, 2017	15 km E of Yabello	E
463		*Berionycta orbicularis*	Kiss, 2017	15 km E of Yabello	E
464		*Berionycta ponticamima*	Kiss, 2017	15 km E of Yabello	E
465		*Capillamentum gelleyi*	Laporte, 1984	Addis Ababa	E
466		*Caradrina atriluna*	Guenée, 1852	Abyssinia [Ethiopia]	
467		*Caradrina torpens*	Guenée, 1852	Abyssinia [Ethiopia]	E
468		*Carcharoda erlangeri*	Rothschild, 1924	Waute Merehan [Mreham]	E
469		*Cirrodes rosaceus*	Rothschild, 1924	Waute Merehan [Mreham]	E
470		*Claudaxylia dinshoense*	Laporte, 1984	Dinsho Reserve	E
471		*Compsotata corneliae*	Behounek & Beck, 2012	Bale Mountains, Province of Bale, Hangasso	E
472		*Conservula ludocaroli*	(Laporte, 1991)	Debre Zeit	E
473		*Conservula scriptura*	(Rougeot & Laporte, 1983)	Simyen, Sankaber	E
474		*Cucullia simoneaui*	Laporte, 1976	Bale Reserve, Dinsho	E
475		*Cucullia tedjicolora*	Laporte, 1977	Kébré-Mengist [Kibre Mengist]	E
476		*Eucladodes achrorophilus*	Laporte, 1976	Near Mt Batu	E
477		*Eucladodes baleensis*	Laporte, 1976	Bale Reserve	E
478		*Euplexia imperator*	Laporte, 1984	Dinsho Marshes	E
479		*Euplexia mercieri*	Laporte, 1984	Arussi, near Koffolé [Koffale]	E
480		*Euplexia pinoni*	Laporte, 1984	Kébré-Mengist [Kibre Mengist]	E
481		*Euplexia shoana*	Laporte, 1984	Shoa, near Hosana	E
482		*Euxoa dodolaense*	Laporte, 1984	Road to Dodola	E
483		*Euxoa montigenarum*	Rougeot & Laporte, 1983	Simyen, Sankaber	E
484		*Euxoa semyenensis*	Laporte, 1991	Sankaber	E
485		*Euxoa waliarum*	Rougeot & Laporte, 1983	Simyen, Sankaber	E
486		*Feliniopsis duponti*	Laporte, 1974	near Kebré-Mengist [Kibre Mengist]	
487		*Feliniopsis germainae*	Laporte, 1975	near Kebré-Mengist [Kibre Mengist]	E
488		*Feliniopsis insolita*	Hacker & Fibiger, 2007	Addis Ababa, Sholla	E
489		*Feliniopsis jinka*	Hacker, 2010	Gamu-Gofa Province, 10 km W of Jinka	
490		*Feraxinia jemjemensis*	(Laporte, 1984)	Kébré-Mengist [Kibre Mengist]	E
491		*Heliophobus africana*	Berio, 1977	Addis Ababa	E
492		*Heliothis saskai*	(Berio, 1975)	Addis Ababa	E
493		*Hemituerta mahdi*	(Pagenstecher, 1903)	Hanadscho [Dinsho district]	
494		*Heraclia viettei*	Kiriakoff, 1973	Nole Kaba	E
495		*Hermonassoides abyssinica*	(Berio, 1975)	Addis Ababa	E
496		*Hermonassoides dinshoensis*	(Laporte, 1977)	Dinsho Marshes	E
497		*Hermonassoides marmorata*	(Laporte, 1977)	Fisha Genet	E
498		*Hermonassoides mauricei*	(Laporte, 1975)	Koffale	
499		*Hermonassoides mendeboense*	(Laporte, 1984)	Dinsho	E
500		*Hermonassoides minosi*	(Laporte, 1991)	Managesha Forest	E
501		*Hermonassoides scipioni*	(Laporte, 1977)	Dinsho, Bale Reserve	E
502		*Hiccoda clarae*	Berio, 1947	Ogaden, Uarder [Warder]	E
503		*Hyperfrontia direae*	Berio, 1962	Dire-Daoua [Dire Dawa]	E
504		*Hyperfrontia limbata*	Berio, 1962	El-Dire	E
505		*Koffoleania michaellae*	Laporte, 1977	near Koffolé [Koffale]	E
506		*Leucania aedesiusi*	Rougeot & Laporte, 1983	Simyen, Sankaber	E
507		*Leucania argyrina*	Laporte, 1984	Bahar Dar	E

	Family	Taxon	Author	Type Locality	
508	Noctuidae	*Leucania claudicans*	Guenée, 1852	Abyssinia [Ethiopia]	E
509		*Leucania cyprium*	(Laporte, 1984)	Dinsho Marshes	E
510		*Leucania fasilidasi*	(Laporte, 1984)	Dinsho Marshes	E
511		*Leumicamia oreias*	(Fletcher, 1959)	Simien, above Lori	E
512		*Leumicamia palustris*	Laporte, 1976	Dinsho Marshes	E
513		*Leumicamia venustissima*	(Laporte, 1974)	Bale Reserve	E
514		*Lophotarsia girmai*	Laporte, 1975	Arba Minch	E
515		*Lophotarsia leucoplagoides*	(Berio, 1941)	El-Dire	E
516		*Lophotarsia theresae*	Beck & Behounek, 2013	Bale Mountains National Park, region Oromia/Sidamo, Province of Bale, 4 km W of Sura	E
517		*Maghadena ingridae*	Laporte, 1977	Dinsho Reserve, Balé	E
518		*Maliattha eburnea*	Hacker, 2016	Oroma Province, 6 km ESE of Jimma	
519		*Matopo berhanoui*	Laporte, 1984	Melka-Kontouré [Konture]	E
520		*Mentaxya bruneli*	Laporte, 1975	near Kebré-Mengist [Kibre Mengist]	E
521		*Mentaxya fouqueae*	Laporte, 1974	Boré Forest	
522		*Mentaxya inconstans*	Laporte, 1984	Dinsho Marshes	E
523		*Mentaxya lacteifrons*	Laporte, 1984	Kébré-Mengist [Kibre Mengist]	E
524		*Michelliana afroalpina*	Laporte, 1976	near Mt Batu	E
525		*Micraxylia antemedialis*	Laporte, 1975	near Kebré-Mengist [Kibre Mengist]	E
526		*Micraxylia hypericoides*	Berio, 1962	Oromo e Sidamo, Neghelli [Neghelle]	E
527		*Micraxylia lividoradiata*	(Berio, 1940)	Adi-Abuna [in Tigray, Ethiopia]	E
528		*Mythimna altiphila*	Hreblay & Legrain, 1996	Addis Abeba [Ababa]	
529		*Mythimna amlaki*	Laporte, 1984	Near Mt Batu	E
530		*Mythimna bisetulata*	(Berio, 1940)	Adi-Abuna [in Tigray, Ethiopia]	E
531		*Mythimna germanae*	Laporte, 1991	Melka Kontouré	E
532		*Neostichtis teruworkae*	Laporte, 1984	Near Hosana	E
533		*Nocthadena griseoviridis*	Laporte, 1976	Near Mt Batu	E
534		*Numeniastes selenis*	Fletcher, 1963	Harar	
535		*Nyodes biardi*	Laporte, 1984	Shashemane	E
536		*Ochropleura sidamona*	Laporte, 1977	Fisha-Genet	
537		*Odontestra richinii*	Berio, 1940	Adi-Abuna [in Tigray, Ethiopia]	E
538		*Odontestra variegata*	Berio, 1940	Adi-Abuna [in Tigray, Ethiopia]	
539		*Odontestra vitta*	Berio, 1975	Addis Ababa	E
540		*Oligia adactricula*	Guenée, 1852	Abyssinie [Ethiopia]	E
541		*Oligia arbaminchensis*	Laporte, 1991	Arba Minch	E
542		*Oligia genettae*	Laporte, 1991	Kebre-Mengist [Kibre Mengist]	E
543		*Omphalestra nellyae*	(Berio, 1939)	Adua [in Ethiopia]	E
544		*Ozarba alberti phaeoxantha*	Hacker, 2016	Dire Dawa	
545		*Ozarba didymochra*	Hacker, 2016	Gamu-Gofa Province, 8 km E of Weyto	E
546		*Ozarba fuscundosa*	Hacker, 2016	Oromia, 3 km NNE of Finchawa	
547		*Ozarba grisescens*	Berio, 1947	Harrar [Harar], Dire Daua [Dire Dawa]	
548		*Ozarba latizonata*	Hacker, 2016	Gamu-Gofa Province, 8 km E of Weyto	
549		*Ozarba naumanni*	Hacker, 2016	Gamo Gofa Province, Konso	E

	Family	Taxon	Author	Type Locality	
550	Noctuidae	*Ozarba permutata*	Hacker, 2016	20 km ESE of Sashemene, Wondo Genet	
551		*Ozarba rubrofusca*	Berio, 1947	Ogaden, Uarder [Werder]	E
552		*Ozarba tenuis*	Hacker, 2016	Province of Gamo Gofa, 8 km N of Turmi	E
553		*Ozarba uhlenhuthi*	Hacker, 2016	Dire Dawa	E
554		*Phyllophila corgatha*	Berio, 1984	Arba Minch	E
555		*Phyllophila richinii*	Berio, 1940	Adi-Abuna [in Tigray, Ethiopia]	E
556		*Pseudozarba nilotica*	Hacker, 2016	30 km SE of Bahir Dar, Tisisat above Blue Nile Falls	E
557		*Pusillathetis fiorii*	Berio, 1976	Uarder [Warder in Ogaden]	
558		*Ramesodes oblonga*	Berio, 1976	Adi Abuna [in Tigray, Ethiopia]	
559		*Rhodochlaena dinshoense*	Laporte, 1974	Dinsho Marshes	E
560		*Rougeotia abyssinica*	(Hampson, 1918)	Kutai Mecha	E
561		*Rougeotia aethiopica*	Laporte, 1974	Dinsho swamp	E
562		*Rougeotia ludovici*	Laporte, 1974	Bale Reserve	E
563		*Rougeotia ludovicoides*	Laporte, 1977	Dinsho Marshes	E
564		*Rougeotia obscura*	Laporte, 1974	Dinsho Col	E
565		*Rougeotia roseogrisea*	Laporte, 1974	Near Mt Batu	E
566		*Rougeotia rougeoti*	Laporte, 1984	Mt Batu Forest	E
567		*Schinia ennatae*	(Laporte, 1984)	Addis Ababa	E
568		*Schinia magdalenae*	(Laporte, 1976)	Bale Reserve, Dinsho	E
569		*Schinia ungemachi*	(Berio, 1945)	Oromo Sidamo, Uollega [Wollega]	E
570		*Schinia xanthiata*	(Berio, 1940)	Adi-Abuna [in Tigray, Ethiopia]	E
571		*Sciomesa boulardi*	(Laporte, 1984)	near Koffolé [Koffale]	E
572		*Sciomesa excelsa*	(Laporte, 1976)	Near Mt Batu	E
573		*Sciomesa franciscae*	Laporte, 1991	Choa, Hosana	E
574		*Sciomesa secata*	Berio, 1977	Addis Ababa	E
575		*Sesamia enanouae*	Laporte, 1991	Gojam, Bahr-Dar, marais du Nil Bleu	E
576		*Sesamia roumeti*	Laporte, 1991	Gojam, Bahr-Dar	E
577		*Solgaitiana petrosi*	Laporte, 1984	Kébré-Mengist [Kibre Mengist]	E
578		*Spodoptera excelsa*	Rougeot & Laporte, 1983	Simyen, Sankaber	E
579		*Subnoctua arbaminchensis*	Laporte, 1984	Arba Minch	E
580		*Thiacidas robertbecki*	Hacker & Zilli, 2007	Awassa, Awassa Lake, Bale Region	E
581		*Tholeropsis decimata*	Berio, 1977	Addis Ababa	E
582		*Tholeropsis uncinata*	Berio, 1977	Addis Ababa	E
583		*Thysanoplusia asapheia*	(Dufay, 1977)	near Koffolé [Koffale]	
584		*Thysanoplusia dolera*	Dufay, 1977	near Koffolé [Koffale]	E
585		*Timora flavocarnea*	Hampson, 1903	Abyssinia [Ethiopia]	
586		*Timora zavattarii*	Berio, 1944	El-Dire	E
587		*Tracheplexia annabellae*	Laporte, 1991	Menagesha Forest	E
588		*Tracheplexia colettae*	Laporte, 1991	Gemu-Gofa, Arba-Minch	E
589		*Tracheplexia leguerni*	Laporte, 1984	Fort Wosha	E
590		*Tracheplexia petryvesi*	Laporte, 1991	Menagesha Forest	E
591		*Tracheplexia richinii*	Berio, 1973	Adiu Abuna [in Tigray, Ethiopia]	
592		*Tycomarptes adami*	Laporte, 1974	Dinsho Col	E
593		*Tycomarptes aethiopica*	Laporte, 1974	Mt Batu	E
594		*Tycomarptes berioi*	Laporte, 1974	Boré Forest	E
595		*Tycomarptes bipuncta*	Laporte, 1974	Boré Forest	E
596		*Tycomarptes bipunctatoides*	Laporte, 1974	near Koffolé [Koffale]	E

	Family	Taxon	Author	Type Locality	
597	Noctuidae	*Tycomarptes gelladarum*	Rougeot & Laporte, 1983	Simyen, Sankaber	E
598		*Tycomarptes inferior*	(Guenée, 1852)	Abyssinia [Ethiopia]	
599		*Tycomarptes journiaci*	Laporte, 1977	Near Mt Batu	E
600		*Tycomarptes limoni*	Laporte, 1974	near Koffolé [Koffale]	E
601		*Tycomarptes semyensis*	Rougeot & Laporte, 1983	Simyen, Sankaber	E
602		*Tycomarptes thibauti*	Laporte, 1974	Boré Forest	E
603		*Vietteania chojnackii*	(Laporte, 1984)	Dinsho Marshes	E
604	Nolidae	*Arcyophora zanderi*	Felder & Rogenhofer, 1875	Abyssinia [Ethiopia]	
605		*Bryophilopsis martinae*	Laporte, 1991	Gemu-Gofa, Konso	E
606		*Characoma adiabunensis*	Berio, 1940	Adi-Abuna [in Tigray, Ethiopia]	E
607		*Earias richinii*	Berio, 1940	Adi-Abuni [in Tigray, Ethiopia]	
608		*Eligma neumanni*	Rothschild, 1924	Blue Nile, Abera Koritscha, Uata Dera	E
609		*Escarpamenta damarana abyssinica*	Hacker, 2013	6 km E of Weyto, Weyto River	E
610		*Evonima littoralis abyssinica*	Hacker, 2012	Southern Province, Jinka, Mago National Park, 350 m SW of Headquarter,	E
611		*Gigantoceras villiersi*	Laporte, 1975	Arba Minch	E
612		*Meganola cerographa*	Hacker, 2012	Oromia District, 6.5 km N of Bonga	E
613		*Meganola coffeana*	Hacker, 2012	Oromia Province, 6.5 km NE of Shebe	
614		*Meganola ethiopica*	Hacker, 2012	Addis Ababa	E
615		*Meganola harenna*	Hacker, 2014	Harenna Forest, Karcha Camp Ground	E
616		*Meganola leucometabola*	Hacker, 2012	Oromia Province, 6.5 km N of Bonga	
617		*Meganola longisigna*	Hacker, 2012	Oromia Region, 1km W. of village Aluweya	
618		*Meganola lupii*	Hacker & Hausmann, 2012	Oromia Province, 13 km S. of Agere Maryam	E
619		*Meganola pachygrapha*	Hacker, 2012	Oromia Province, 6.5 km N of Bonga	
620		*Meganola poliovittata*	Hacker, 2012	Oromia Province, 6 km ESE of Jimma	E
621		*Meganola pyrrhomorpha*	Hacker, 2012	Oromia Province, 6.5 km N of Bonga	E
622		*Meganola simillima*	Hacker, 2012	Oromia District, 13 km S of Agere Maryam	E
623		*Meganola stadiensis*	Hacker, 2014	Harenna Forest, Karcha Camp Ground	E
624		*Meganola stigmatolalis*	Hacker, 2012	Southern Province, 23 km WSW of Welkite, Gibe River	
625		*Meganola unilineata*	Hacker, 2012	Southern Province, 11.2 km W of Bonga	E
626		*Neaxestis mesogonia*	Hampson, 1905	Atbara R.	
627		*Nola abyssinica*	Hacker, 2012	Oromia Province, 13 km S of Agere Maryam	
628		*Nola afrotaeniata*	Hacker, 2012	12 km W Jinka, border Mago National Park	
629		*Nola amhara*	Hacker, 2012	Addis Ababa	
630		*Nola angensteini*	Hacker, 2012	Afar Region, NE of Mile Serdo Wildlife Refuge, Tendaho	

	Family	Taxon	Author	Type Locality	
631	Nolidae	*Nola balealpina*	Hacker, 2012	Oromia Province, Bale Mountains National Park, Disho	E
632		*Nola calochromata*	Hacker, 2014	Harenna Forest, Harenna Forest Road	E
633		*Nola destituta*	Hacker, 2012	Oromia Province, 8 km W of Nazret	E
634		*Nola jarzabekae*	Hacker, 2012	Oromia Province, Abiyata-Shala-Hayak National Park	E
635		*Nola omphalota euroetes*	Hacker, 2012	Oromia Province, 6 km ESE of Jimma	
636		*Nola socotrensis vansoni*	Hacker, 2012	12 km W Jinka, border Mago NP	
637		*Nola sphaeromorpha*	Hacker, 2012	Oromia Province, 13 km S of Agere Maryam,	E
638		*Nolidia platygrapha*	Hacker, 2012	Amhara Region, W of Mirab, Gojam Zone, 15 km NW of Bahar Dar	E
639	Notodontidae	*Afroplitis quadratus*	(Viette, 1954)	River Baro	E
640		*Antheua birbirana*	Viette, 1954	middle course of Birbir, Youbdo	E
641		*Antheua gaedei*	Kiriakoff, 1962	Addis Ababa	E
642		*Antheua trivitta*	(Hampson, 1910)	Abyssinia [Ethiopia]	E
643		*Antistaura decorata*	Kiriakoff, 1965	Derdaua, North-East of Harrar	E
644		*Boscawenia nora*	(Pagenstecher, 1903)	Ganale	E
645		*Desmeocraera kiriakoffi*	Thiaucourt, 1977	near Kébré-Mengist [Kibre Mengist]	E
646		*Eutimia smithii*	Holland, 1897	Dombalok	E
647		*Polelassothys callista abyssinica*	Viette, 1954	Moy. Dedissa [Didessa]	E
648		*Psalisodes saalfeldi*	Kiriakoff, 1979	Al Abed	E
649		*Scalmicauda azebae*	Thiaucourt, 1977	near Kébré-Mengist [Kibre Mengist]	E
650		*Thaumetopoea apologetica abyssinica*	Strand, 1911	Addis Ababa	
651		*Tricholoba rougeoti*	Thiaucourt, 1977	Arba Minch	E
652	Nymphalidae	*Acraea aganice orientalis*	(Ungemach, 1932)	Bouré	
653		*Acraea alcinoe nado*	(Ungemach, 1932)	Bouré	E
654		*Acraea chilo chilo*	Godman, 1880	Kalamet, Sebka Valley	
655		*Acraea doubledayi*	Guérin-Méneville, 1849	Abyssinie [Ethiopia]	
656		*Acraea epaea homochroa*	(Rothschild & Jordan, 1905)	Banka, Malo	E
657		*Acraea kakana*	Eltringham, 1911	Adie Kaka, Kafa	E
658		*Acraea oscari*	Rothschild, 1902	Banka, Malo	E
659		*Acraea poggei ras*	(Ungemach, 1932)	Oullaga [Wollega]	E
660		*Acraea zetes sidamona*	Rothschild & Jordan, 1905	Alata, Sidamo	E
661		*Acraea zoumi*	Pierre, 1995	Ethiopia	E
662		*Amauris echeria steckeri*	Kheil, 1890	Abessynia	
663		*Amauris hecate stictica*	Rothschild & Jordan, 1903	Anderatscha	E
664		*Amauris niavius aethiops*	Rothschild & Jordan, 1903	Anderatscha	
665		*Amauris ochlea darius*	Rothschild & Jordan, 1903	Anderatscha	
666		*Antanartia abyssinica*	(C. & R. Felder, [1867])	Ethiopia	E
667		*Antanartia schaeneia diluta*	Rothschild & Jordan, 1903	Kaffa	E
668		*Argynnis hyperbius neumanni*	Rothschild, 1902	Kaffa	E
669		*Aterica galene incisa*	Rothschild & Jordan, 1903	between Kankati and Djibbe, Djimma [Jimma]	E

	Family	Taxon	Author	Type Locality	
670	Nymphalidae	*Bicyclus pavonis*	(Butler, 1876)	Abyssinia [Ethiopia]	
671		*Bicyclus safitza aethiops*	(Rothschild & Jordan, 1905)	Lake Abassi	E
672		*Charaxes etesipe abyssinicus*	Rothschild, 1900	Sciotalit, Sxioa [Shoa]	E
673		*Charaxes eurinome birbirica*	(Ungemach, 1932)	Youbdo	
674		*Charaxes figini*	van Someren, 1969	Eritaea, Setit, El Eghin [Ethiopia]	
675		*Charaxes galawadiwosi*	Plantrou & Rougeot, 1979	Arba-Minch	E
676		*Charaxes hansali hansali*	Van Someren, 1971	Africa septentrionali-orientalis: Bogos	
677		*Charaxes jahlusa ganalensis*	Carpenter, 1937	Salakle, Ganale river"	
678		*Charaxes junius junius*	Oberthür, 1883	Scioa [Shoa]	E
679		*Charaxes junius somalicus*	Rothschild, 1900	Harrar Highlands, Somaliland	
680		*Charaxes kirki daria*	Rothschild, 1903	Jabalo	E
681		*Charaxes lactetinctus ungemachi*	Le Cerf, 1927	Youbdo (Birir)	
682		*Charaxes larseni*	Rydon, 1982	Jambo area, Nanji Hill	E
683		*Charaxes numenes neumanni*	Rothschild, 1902	Wori to Gamitscha, Kaffa	E
684		*Charaxes pelias pagenstecheri*	Poulton, 1926	S Ethiopia	
685		*Charaxes phoebus*	Butler, 1866	Abyssinia [Ethiopia]	E
686		*Charaxes rectans*	Rothschild & Jordan, 1903	Upper Urga, Kollu, Schoa [Shoa]	
687		*Charaxes saturnus pagenstecheri*	Poulton, 1926	S. Abyssinia [Ethiopia]	E
688		*Charaxes sidamo*	Plantrou & Rougeot, 1979	Kébré-Mengist [Kibre Mengist]	E
689		*Charaxes tiridates marginatus*	Rothschild & Jordan, 1903	Scheko	E
690		*Eronia cleodora cleodora*	Hübner, [1823]	Ethiopia	
691		*Eronia leda*	(Boisduval, 1847)	Marako	
692		*Euphaedra caerulescens submarginalis*	Hecq, 1997	[Ethiopia?]	E
693		*Euphaedra castanoides deficiens*	Hecq, 1997	West, Didessa River	E
694		*Euphaedra medon abouna*	Ungemach, 1932	Youbdo	E
695		*Euphaedra neumanni*	Rothschild, 1902	Scheko [Sheko]	
696		*Euphaedra sarita abyssinica*	Rothschild, 1902	Kankati forest, Djimma	E
697		*Eurytela hiarbas abyssinica*	Rothschild & Jordan, 1903	Banka	E
698		*Euxanthe eurinome birbirica*	Ungemach, 1932	Youbdo	
699		*Hypolimnas salmacis platydema*	Rothschild & Jordan, 1903	Scheko	E
700		*Junonia terea fumata*	(Rothschild & Jordan, 1903)	Gillet Mountains	
701		*Lasiommata maderakal*	(Guérin-Méneville, 1849)	Abyssinie [Ethiopia]	
702		*Melitaea abyssinica*	Oberthür, 1909	Abyssinie [Ethiopia]	E
703		*Neptis nemetes obtusa*	Rothschild & Jordan, 1903	Scheko	E
704		*Phalanta eurytis microps*	(Rothschild & Jordan, 1903)	Walenso [Woliso], Gillet Mts	E
705		*Phalanta phalantha aethiopica*	(Rothschild & Jordan, 1903)	Gillet Mts	
706		*Pseudacraea boisduvalii sayonis*	Ungemach, 1932	Oumbi	E
707		*Pseudacraea eurytus mimoras*	Ungemach, 1932	Oumbi	E
708		*Pseudacraea lucretia walensensis*	(Sharpe, 1896)	Waenso [Woliso]	E
709		*Sevenia boisduvali kaffana*	(Rothschild & Jordan, 1903)	Godjeb to Bonga, Kaffa	E

	Family	Taxon	Author	Type Locality	
710	Nymphalidae	*Telchinia aurivillii schecana*	Rothschild & Jordan, 1905	Scheko [Sheiko]	E
711		*Telchinia bonasia banka*	Eltringham, 1912	Banka, Malo	
712		*Telchinia guichardi*	Gabriel, 1949	Lekempti	E
713		*Telchinia jodutta aethiops*	Rothschild & Jordan, 1905	Dereta Mts	E
714		*Telchinia necoda*	Hewitson, 1861	Abyssinia [Ethiopia]	E
715		*Telchinia peneleos gelonica*	(Rothschild & Jordan, 1905)	Upper Gelo River	E
716		*Telchinia perenna kaffana*	(Rothschild, 1902)	Kaffa	E
717		*Telchinia pharsalus rhodina*	Rothschild, 1902	Kaffa	E
718		*Telchinia rangatana maji*	Carpenter, 1935	Maji Province	E
719		*Telchinia safie antinorii*	(Oberthür, 1880)	Mahal-Uonz	E
720		*Telchinia safie safie*	(C. & R. Felder, 1865)	Abyssinia [Ethiopia] Meridionalis	E
721		*Telchinia ungemachi*	(Le Cerf, 1927)	Youbdo (Birbi)	E
722		*Tirumala formosa neumanni*	(Rothschild & Jordan, 1903)	Kaffa	E
723		*Vanessa abyssinica abyssinica*	Vane-Wright & Hughes, 2007	Ethiopia	
724		*Ypthima impura paupera*	Ungemach, 1932	Soubé-Boro	
725		*Ypthima simplicia*	Butler, 1876	Atbara*	
726	Papilionidae	*Graphium almansor birbiri*	(Ungemach, 1932)	Baro	E
727		*Graphium angolanus baronis*	(Ungemach, 1932)	Baro	
728		*Papilio arnoldiana*	Vane-Wright, 1995	S.W. Abyssinia [Ethiopia], Grine	E
729		*Papilio dardanus antinorii*	Oberthür, 1883	Abissinia, Feleklek and Sciotalit	E
730		*Papilio echerioides leucospilus*	Rothschild, 1902	Gara Mulata near Harar”	E
731		*Papilio echerioides oscari*	Rothschild, 1902	Kaffa and Djima [Jimma]	E
732		*Papilio microps*	Storace, 1951	Shoa, Abyssinia [Ethiopia] centrale	
733		*Papilio nireus pseudonireus*	Felder & Felder, 1865	Africa Septentrionali Oriental, Bogos	
734		*Papilio rex abyssinicana*	Vane-wright, 1995	S. W. Abyssinia [Ethiopia], Ganji River	E
735		*Papilio wilsoni*	Rothschild, 1926	Nubar Hills, Taldi	E
736	Pieridae	*Appias sylvia abyssinica*	Talbot, 1932	Joubda (Birbir)	E
737		*Belenois gidica abyssinica*	(Lucas, 1852)	Abyssinie [Ethiopia]	E
738		*Belenois gidica hypoxantha*	(Ungemach, 1932)	Gambela	E
739		*Belenois raffrayi*	(Oberthür, 1878)	Lac de Tzana [Lake Tana]	
740		*Belenois subeida hailo*	(Ungemach, 1932)	Nolé Kaba [in Wollega]	E
741		*Belenois thysa tricolor*	Talbot, 1943	Abyssinia [Ethiopia]	
742		*Belenois zochalia gada*	(Ungemach, 1932)	Nole-Kaba [in Wollega]	E
743		*Colias electo meneliki*	Berger, 1940	Gondar	
744		*Colias erate marnoana*	Rogenhofer, 1884	Ethiopia	
745		*Colotis antevippe zera*	(Lucas, 1852)	Abyssinie [Ethiopia]	
746		*Colotis celimene celimene*	(Lucas, 1852)	Abyssinie [Ethiopia]	
747		*Colotis danae eupompe*	(Klug, 1829)	in Arabia deserta, in Sinai monte, in Dongala et Habessinia	
748		*Colotis euippe exole*	(Reiche, 1850)	Abyssinie [Ethiopia]	
749		*Colotis hetaera aspasia*	(Ungemach, 1932)	Baro	
750		*Colotis phisadia ocellatus*	(Butler, 1886)	Somali-land [False locality]	E
751		*Colotis ungemachi*	(Le Cerf, 1922)	N Ethiopia	E
752		*Dixeia charina septentrionalis*	(Bernardi, 1958)	Djemdjem	E

	Family	Taxon	Author	Type Locality	
753	Pieridae	*Eronia leda pupillata*	Strand, 1911	Marako	E
754		*Euchloe belemia abyssinica*	Riley, 1928	Mt. Chillalo	E
755		*Eurema desjardinsii regularis*	(Butler, 1876)	Atbara*	
756		*Leptosia alcesta pseudonuptilla*	Bernardi, 1959	Haute-Orguessa	
757		*Mylothris erlangeri*	Pagenstecher, 1902	Gewidscha	E
758		*Mylothris mortoni balkis*	Ungemach, 1932	Alenga	E
759		*Mylothris mortoni mortoni*	Blachier, 1912	Kaffa, dans l'Abyssinie [Ethiopia] meridionale"	E
760		*Mylothris rueppellii*	(Koch, 1865)	Abessynica	
761		*Mylothris sagala swaynei*	Butler, 1899	Harar Highlands	E
762		*Mylothris yulei amhara*	Ungemach, 1932	Alenga	E
763		*Pieris brassicoides*	Guérin-Méneville, 1849	Abyssinie [Ethiopia]	
764		*Pontia daplidice aethiops*	(De Joannis & Verity, 1913)	Abyssinie [Ethiopia]	E
765	Plutellidae	*Lepocnemis metapelista*	Meyrick, 1932	Jem-Jem Forest	E
766		*Plutella dryoxyla*	Meyrick, 1932	Mt Chillálo	E
767		*Plutella oxylopha*	Meyrick, 1932	Mt Chillálo	E
768		*Plutella stichocentra*	Meyrick, 1932	Mt Chillálo	E
769	Psychidae	*Acanthopsyche chrysora*	Bourgogne, 1980	Arba Minch	E
770		*Oiketicoides aethiopica*	Bourgogne, 1991	Wollo, Lalibela	E
771		*Taleporia aethiopica*	Strand, 1911	Mahenge	E
772	Pterophoridae	*Cosmoclostis gorbunovi*	Ustjuzhanin & Kovtunovich, 2011	West Shewa, 2 km S of Ambo	E
773		*Hellinsia aethiopicus*	(Amsel, 1963)	Gembi	
774		*Hellinsia ambo*	Ustjuzhanin & Kovtunovich, 2011	West Shewa, 2 km S of Ambo	
775		*Hellinsia bigoti*	(Rougeot, 1983)	Simyen, Sankaber	E
776		*Hellinsia negus*	(Gibeaux, 1994)	Wondo-Genet	E
777		*Merrifieldia lonnvei*	Gielis, 2011	Amhara Region, S of Debub, Gondar zone, 8 km NW of Addis Zemen, Highway 3	E
778		*Paracapperia esuriens*	Meyrick, 1932	Jem Jem Forest	
779		*Platyptilia daemonica*	Meyrick, 1932	Jem Jem Forest	E
780		*Platyptilia gondarensis*	Gibeaux, 1994	Gondar Province	
781		*Platyptilia implacata*	Meyrick, 1932	Jem Jem Forest	E
782		*Pterophorus lindneri*	(Amsel, 1963)	Gore	E
783		*Stenoptilia aethiopica*	Gibeaux, 1994	Sidamo, Wondo-Genet	
784		*Stenoptilia amharae*	Gielis, 2011	Amhara Region, Semien North, Gondar zone, 17 km NEE of Debark, Simien Mts National Park	E
785		*Stenoptilia rougeoti*	Gibeaux, 1994	Bale, marais de Dinsho	E
786		*Stenoptilia tyropiesta*	Meyrick, 1932	Mt Chillálo	E
787	Pyralidae	*Aglossodes dureti*	(Rougeot, 1977)	Arba Minch	E
788		*Aglossodes navattae*	Rougeot, 1977	Arba Minch	E
789		*Bostra excelsa*	Rougeot, 1984	near Mt Batu	E
790		*Bostra pseudoexcelsa*	Rougeot, 1984	Arba Minch	E
791		*Dembea venulosella*	Ragonot, 1888	Abyssinia [Ethiopia]	
792		*Ematheudes pollex*	Shaffer, 1998	Kosogay Wagra	E
793		*Emmalocera erythrinella*	(Ragonot, 1888)	Abyssinia [Ethiopia]	
794		*Endotricha ellisoni*	Whalley, 1963	Harar	
795		*Harraria rufipicta*	Hampson, 1930	Harrar [Harar]	E
796		*Loryma albilinealis*	Hampson, 1917	Diré Daouá [Dire Dawa]	E

	Family	Taxon	Author	Type Locality	
797	Pyralidae	*Megarthridia christyi*	Rougeot, 1984	Arba Minch	E
798		*Nussia rougeoti*	Leraut, 2015	Koffolé [Koffale]	
799	Saturniidae	*Aurivillius cadioui*	Bouyer, 2008	100 kn E of Addis Ababa	E
800		*Bunaeopsis birbiri*	Bouvier, 1929	Joubdo (Birbir)	E
801		*Bunaeopsis oubie*	(Guérin-Méneville, 1849)	Abyssinia [Ethiopia]	
802		*Eosia digennaroi*	Bouyer, 2008	Bale, S of Omar	
803		*Epiphora antinorii*	(Oberthür, 1880)	Scioa [Shoa], Mahal Uonz [Awash River]	
804		*Epiphora bauhiniae atbarina*	(Butler, 1877)	Atbara*	
805		*Epiphora fourneri*	Rougeot, 1974	Road Koffolé-Arussi [Koffale-Arsi]	
806		*Gonimbrasia belina abayana*	Rougeot, 1977	Arba Minch	E
807		*Gonimbrasia belina felderi*	Rothschild, 1895	Bogos	E
808		*Gonimbrasia ellisoni*	Lemaire, 1962	Harar	E
809		*Gonimbrasia fletcheri*	Rougeot, 1960	Ethiopia	E
810		*Gonimbrasia fucata*	Rougeot, 1978	Ethiopia	E
811		*Goodia smithii*	(Holland, 1897)	East Africa [Ethiopia]	E
812		*Gynanisa arba*	Darge, 2008	Arba Minch	E
813		*Heniocha digennaroi*	Bouyer, 2008	Sidamo, Neguele Borana	E
814		*Holocerina digennariana*	Darge, 2008	Shashemene (Arsi)	E
815		*Ludia hansali*	Felder, 1874	Bogos	
816		*Ludia pupillata*	Strand, 1911	Antottos	E
817		*Micragone leonardi*	Bouyer, 2008	Sidamo, Dilla	E
818		*Nudaurelia fasciata*	Gaede, 1927	[Ethiopia]	E
819		*Nudaurelia ungemachti*	Bouvier, 1926	Djemdejm [Jem Jem]	E
820		*Pseudobunaea heyeri citrinarius*	Gaede, 1927	Harrar [Harar]	
821		*Pseudobunaea megana*	Darge, 2012	Sidamo Province, near Mega	E
822		*Urota melichari*	Bouyer, 2008	Sidamo Province, 15 km S of Negele	E
823	Scythrididae	*Scythris ethiopica*	Bengtsson, 2014	Lake Tana, Bahir Dar	E
824	Sesiidae	*Agriomelissa aethiopica*	(Le Cerf, 1917)	Abyssinia [Ethiopia]	E
825		*Jerbeia darkovi*	Gorbunov, 2018	Oromia, 21.8 km NW (289.5°) of Dembi Dolo	E
826		*Melittia abyssiniensis*	Hampson, 1919	Harar	E
827		*Melittia ambo*	Gorbunov, 2015	West Shewa, 3 km S of Ambo	E
828	Sphingidae	*Ceridia heuglini*	(Felder C. & Felder R., 1874)	Abyssinia [Ethiopia]	
829		*Ceridia quirini*	Sulak, Naumann & Witt, 2016	Oromia Region, road between Deritu and Dubuluk, near Deritu	E
830		*Chaerocina ellisoni*	Hayes, 1963	Harar	E
831		*Covelliana berioi*	Eitschberger & Melichar, 2016	near Debark Gondar	E
832		*Covelliana robertbecki*	Eitschberger & Melichar, 2016	Ethiopia Central, Oromia, southern Bale Mts, Harenna Forest	E
833		*Dovania dargei*	Pierre, 2000	Metu	E
834		*Dovania neumanni*	Jordan, 1926	SW Abyssinia [Ethiopia], Dhimma [Jimma]	E
835		*Falcatula tamsi*	Carcasson, 1968	Harrar [Harar]	E
836		*Leucophlebia neumanni*	Rothschild, 1902	Gelo River to Akobo River	
837		*Lophostethus dumolinii riedeli*	Eitschberger & Ströhle, 2011	Arba Minch	E

	Family	Taxon	Author	Type Locality	
838	Sphingidae	*Lophostethus negus*	Jordan, 1926	SW Abyssinia [Ethiopia], Kambatta	E
839		*Macropoliana chrismonika*	Eitschberger & Melichar, 2016	Ethiopia W, 12 km E of Bonga	E
840		*Macropoliana haileselassiei*	Eitschberger & Melichar, 2016	Sidamo Province, 20 km S of Angere Maryam	E
841		*Macropoliana kingstoni*	Eitschberger, 2016	Oromia Region, 25 km E of Bonga/Mera	E
842		*Macropoliana stroehlei*	Eitschberger, 2016	Near Dorze	E
843		*Nephele xylina*	Rothschild & Jordan, 1910	Abyssinia [Ethiopia]	
844		*Platysphinx dorsti*	Rougeot, 1977	Kébré-Mengist [Kibre Mengist]	E
845		*Praedora melichari*	Haxaire, 2011	Sidamo Province, near Bitata	E
846		*Pseudoclanis bianchii*	(Oberthür, 1883)	Scioa [Shoa]	E
847		*Rufoclanis numosae rostislavi*	Haxaire & Melichar, 2008	Gamo Gofa Province, Dagabule National Park	E
848		*Temnora arida*	Melichar & Řezáč & Ilčíková, 2016	Dorze, Guge Mts	
849		*Temnora robusta*	Melichar, Řezáč & Ilčíková, 2016	Kaffa Prov., 40 km SW Jima,	
850		*Theretra ankae*	Melichar & Řezáč, 2015	Asosa	E
851	Thyrididae	*Arniocera cyanoxantha*	(Mabille, 1893)	Abyssinia [Ethiopia]	
852		*Arniocera guttulosa*	Jordan, 1915	Harar	E
853		*Lamprochrysa amata*	(Druce, 1910)	Diré Daouá [Dire Dawa]	E
854	Tineidae	*Afrocelestis minuta*	(Gozmány, 1965)	Gamu-Gofa, Konso	
855		*Ateliotum convicta*	(Meyrick, 1932)	Jem Jem Forest	E
856		*Ceratophaga luridula*	(Meyrick, 1932)	Mt Chillálo, moorland	E
857		*Ceratophaga nephelotorna*	(Meyrick, 1932)	Jem-Jem Forest	E
858		*Criticonoma spinulosa*	Gozmány, 1965	Gamu-Gofa, Konso	E
859		*Crypsithyris stenovalva*	(Gozmány, 1965)	Gamu-Gofa, Konso	E
860		*Dryadaula glycinoma*	(Meyrick, 1932)	Jem-Jem Forest	E
861		*Ectabola pygmina*	(Gozmány, 1965)	Marako	
862		*Edosa torrifacta*	(Gozmány, 1965)	Harrar [Harar]	E
863		*Hapsifera gypsophaea*	Gozmány, 1965	Gamu-Gofa, Konso	E
864		*Hapsifera pachypsaltis*	Gozmány, 1965	Kaffa, Ghimira	
865		*Hapsifera richteri*	Gozmány, 1965	Ethiopia SW, Gamu-Gofa, Konso	E
866		*Leptozancla zelotica*	(Meyrick, 1932)	Jem-Jem Forest	E
867		*Monopis addenda*	Gozmány, 1965	Kaffa, Gembi [Gimbi]	
868		*Monopis leopardina*	Gozmány, 1965	Kaffa, Abaro	E
869		*Monopis triplacopa*	Meyrick, 1932	Jem-Jem Forest, 45 miles W. of Addis-Ababa,	E
870		*Perissomastix lucifer*	Gozmány, 1965	Muger Valley	E
871		*Scalmatica separata*	Gozmány, 1965	Konso, Gamu-Gofa	E
872		*Silosca mariae*	Gozmány, 1965	Djerrer Valley	
873		*Tinissa spaniastra*	Meyrick, 1932	Jem-Jem Forest, , 45 miles from Addis Ababa	
874	Tortricidae	*Acleris baleina*	Razowski & Trematerra, 2010	Bale Mountains, Sanetti Plateau	E
875		*Acleris harenna*	Razowski & Trematerra, 2010	Bale Mountains, Harenna Forest, Karcha Camp	E
876		*Ancylis colaccii*	Razowski & Trematerra, 2012	Wellega Zone, Didessa River	E
877		*Bubonoxena alatheta*	Razowski & Trematerra, 2010	Bale Mountains, Harenna Forest, Karcha Camp	E
878		*Choristoneura palladinoi*	Razowski & Trematerra, 2010	Bale Mountains, Harenna Forest	E
879		*Coccothera carolae*	Razowski & Trematerra, 2010	Bale Mountains, Harenna Forest	

	Family	Taxon	Author	Type Locality	
880	Tortricidae	*Coccothera triorbis*	Razowski & Trematerra, 2010	Bale Mountains, Harenna Forest	E
881		*Coniostola separata*	Razowski & Trematerra, 2010	Bale Mountains, Harenna Forest, Karcha Camp	E
882		*Cosmetra anepenthes*	(Razowski & Trematerra, 2010)	Bale Mountains, Harenna Forest, Karcha Camp	E
883		*Cosmetra latiloba*	(Razowski & Trematerra, 2010)	Bale Mountains, Harenna Forest, Karcha Camp	E
884		*Cydia calliglypta*	(Meyrick, 1932)	Jem-Jem Forest, edge of forest	E
885		*Cydia dinshoi*	Razowski & Trematerra, 2010	Bale Mountains, Dinsho Lodge	E
886		*Cydia lathetica*	Razowski & Trematerra, 2010	Bale Mountains, Dinsho Lodge	E
887		*Cydia tytthaspis*	Razowski & Trematerra, 2010	Bale Mountains, Harenna Forest, Karcha Camp	E
888		*Eccopsis aegidia*	(Meyrick, 1932)	Jem-Jem Forest	
889		*Eccopsis brunneopostica*	Razowski & Trematerra, 2010	Bale Mountains, Harenna Forest, Karcha Camp	E
890		*Eccopsis maschalista*	(Meyrick, 1932)	Jem-Jem Forest	E
891		*Eccopsis subincana*	Razowski & Trematerra, 2010	Bale Mountains, Harenna Forest	E
892		*Endothenia albapex*	(Razowski & Trematerra, 2010)	Bale Mountains, Harenna Forest	E
893		*Endothenia ethiopica*	Razowski & Trematerra, 2010	Bale Mountains, Harenna Forest, Karcha Camp	E
894		*Epichoristodes spilonoma*	(Meyrick, 1932)	Jem Jem Forest	
895		*Eucosma vulpecularis*	Meyrick, 1932	Jem-Jem Forest	E
896		*Eucosmocydia zegieana*	Razowski & Trematerra, 2018	Amhara, Zegie Peninsula	E
897		*Grapholita insperata*	Razowski & Trematerra, 2010	Bale Mountains, Dinsho Lodge	E
898		*Gypsonoma giorgiae*	Razowski & Trematerra, 2012	Ilubabor zone, Bedelle, Dabeda River	E
899		*Lozotaenia karchana*	Razowski & Trematerra, 2010	Bale Mountains, Harenna Forest, Karcha Camp	E
900		*Lozotaenia sciarrettae*	Razowski & Trematerra, 2010	Bale Mountains, Harenna Forest, Karcha Camp	E
901		*Megaherpystis oromiae*	Razowski & Trematerra, 2018	Oromia, Suba Forest	E
902		*Megaherpystis subae*	Razowski & Trematerra, 2018	Oromia, Suba Forest	E
903		*Megalota lygaria*	Razowski & Trematerra, 2010	Bale Mountains, Harenna Forest	E
904		*Metamesia physetopa*	(Meyrick, 1932)	Jem-Jem Forest and Mt Chillálo	
905		*Multiquaestia aequivoca*	Razowski & Trematerra, 2010	Bale Mountains, Harenna Forest	E
906		*Olethreutes didessae*	Razowski & Trematerra, 2012	Wellega zone, Didessa River	E
907		*Olethreutes polymorpha*	(Meyrick, 1932)	Jem-Jem Forest	E
908		*Parabactra addisalema*	Razowski & Trematerra, 2018	Oromia, Addis Alem, Ambo Park	E
909		*Paraeccopsis addis*	Aarvik, 2014	Addis Ababa	E
910		*Phtheochroa lonnvei*	Aarvik, 2010	Oromia Province, Bale zone, 43 km SW of Goba, Bale Mts National Park, Darwin Camp	E
911		*Plutographa xanthala*	Razowski & Trematerra, 2010	Bale Mountains, Dinsho Lodge	E
912		*Procrica dinshona*	Razowski & Trematerra, 2010	Bale Mountains, Dinsho Lodge	
913		*Procrica ophiograpta*	(Meyrick, 1932)	em-Jem Forest and Mt Chillálo	
914		*Procrica parisii*	Razowski & Trematerra, 2010	Bale Mountains, Dinsho Lodge	E
915		*Russograptis albulata*	Razowski & Trematerra, 2010	Bale Mountains, Harenna Forest	E
916		*Thaumatographa amarana*	Razowski & Trematerra, 2018	Amhara, Zegie Peninsula	E
917		*Thaumatovalva spinai*	Razowski & Trematerra, 2010	Omo Valley, Dowro Zone, Tarcha	
918		*Tortrix diametrica*	Meyrick, 1932	Jem-Jem Forest	E
919		*Trachybyrsis chionochlaena*	Meyrick, 1932	Mt Chillálo	E

	Family	Taxon	Author	Type Locality	
920	Uraniidae	*Arussiana herbuloti*	Rougeot, 1977	near Koffolé [Koffale]	
921	Yponomeutidae	*Yponomeuta ocypora*	(Meyrick, 1932)	Jem-Jem Forest	E
922		*Yponomeuta ioni*	Agassiz, 2019		E
923		*Yponomeuta ocypora*	Meyrick, 1932		
924		*Yponomeuta oromiensis*	Agazzia, 2019		E
925	Zygaenidae	*Alteramenelikia jordani*	(Alberti, 1954)	Abyssinia [Ethiopia]	
926		*Astyloneura bicoloria*	Röber, 1929	Abyssinia [Ethiopia]	E
927		*Epiorna abessynica*	(Koch, 1865)	Abyssinia [Ethiopia]	
928		*Saliunca anhyalina*	Alberti, 1957	Abyssinia [Ethiopia]	E
929		*Saliunca homochroa*	(Holland, 1897)	Darde River	

Kenya, which for several aspects can be considered similar to Ethiopia, but probably it has been better investigated. So far, from Kenya approximately 4,815 lepidopteran taxa were reported, belonging to 63 families (Sáfián et al. 2009; De Prins and De Prins 2019). The currently known number of species in Kenya is almost twice that of Ethiopia, and 15 families are not recorded at all in the latter country. Is it really due to difference in faunal richness between the two coutries or because of the different level of investigation? A better idea can come from the differences observed within the single families. When considering most groups of the 'Microlepidoptera', very few investigations were made in Ethiopia and the difference in species numbers between the two countries is huge. Considering only the most species-rich families of Microlepidoptera, the percentage of species present in Ethiopia, compared to the species numbers in Kenya, is 10% for Scytrididae, 13% for Gelechiidae, 17% for Thyrididae, 31% for Tortricidae, 34% for Pyralidae, 45% for Crambidae, 46% of Pterophoridae, up to 76% for Tineidae. However, if we look at the 'larger moths' (Macroheterocera) and butterflies, which are better investigated in both countries, the difference is decreasing from 40% for Saturniidae, 41% for Geometridae, 50% for Lycaenidae, 53% for Sphingidae, 55% for Erebidae up to 77% for Papilionidae, 79% for Noctuidae, 91% for Nymphalidae, peaking to 132% in Pieridae, where Ethiopia shows a higher number of species than Kenya.

Although the two countries certainly exhibit faunistic differences, due to biogeographic or climatic factors, it seems clear that the Ethiopian fauna is seriously understudied in many groups. By analysing comprehensive revisions of single genera or families accompanied by major collection campaigns in Ethiopia, we can have an idea of the potential biodiversity the country inhabits.

The geometrid genus *Prasinocima* Warren, 1897 was subject of an extensive review focused on Ethiopian species, based on an investigation carried out in 100 collection localities in the country for more than 15 years, which included an integrative taxonomic analysis based on morphology and DNA barcodes (Hausmann et al. 2016). As a result of this contribution, the species number was raised from eight previously known Ethiopian species to 40, of which 19 were new to science. After the publication, another seven new species for the Ethiopian fauna were described. Authors of the same article estimated the number of Ethiopian geometrids to exceed 700 species once the unidentified material in their hands is examined, which may suggest a more realistic total species number in excess of 1,000 for the whole country.

Another contribution came from the revision that Hacker carried out on the subfamily Nolinae (Nolidae; Hacker et al. 2012; Hacker 2014), where many of the published data concerned sub-Saharan Africa. For Ethiopia, only three species were previously reported. After Hacker's monograph, the number was raised to 61 species, with 27 newly described taxa from Ethiopia. For Kenya, he raised the figure from 12 to 73, a number not far from that of Ethiopia.

Although these are two examples of taxonomically particularly difficult groups, we can assume similar multiplicators for the so called 'Microlepidoptera' resulting in an estimate for the entire order of Lepidoptera in Ethiopia which may exceed 10,000 species, of which a number of species new for science. This estimate is based on, and in concordance with the usual ratio of geometrid species number versus lepidopteran species number of roughly 1:10, and on the usual ratio of the Rhopalocera (400+ species in Ethiopia) versus lepidopteran species number of roughly 1:20, as it results from large museum material (e.g. ZSM) and from various fauna inventories (e.g. Bavaria: Haslberger and Segerer 2016; Europe: Karsholt and Razowski 1996; North America: Hodges et al. 1983). For the moth fauna of Africa, 38,988 species group names of them are listed by Afromoths (2019), of which 5510 (14%) are geometrids. The total number, however, does not include Rhopalocera names, with 4405 species (Williams 2018) and Microlepidoptera taxonomy is underrepresented, hence also here the "10%-rule" for the Geometridae ratio seems to apply, at least roughly.

Data from DNA barcoding

In the framework of the international Barcode of Life initiative, DNA barcodes (658bp 5' COI gene fragment, cf. Hebert et al. 2003) have been assembled for Ethiopian Lepidoptera since 2006 with the aim to establish a national DNA reference library for integrated taxonomic studies. So far, 3160 DNA barcodes have been generated from Ethiopian Lepidoptera (including many Ethiopian type specimens), belonging to 1012 genetic clusters (Barcode Index Numbers, 'BINs') which are a good proxy for real species numbers (Ratnasingham and Hebert 2013; Hausmann et al. 2013). Most DNA barcodes could be assembled in the Geometridae (2290 barcodes, 571 BINs), Noctuidae (314 barcodes, 165 BINs) and Erebidae (246 barcodes, 143 BINs). Species coverage is particulary good in the smaller families such as the Saturniidae (121 barcodes, 36 BINs) and Sphingidae (70 barcodes, 24 BINs), while it is still being very poor in the 'Microlepidoptera'. All images and most metadata and molecular data are accessible in the public database BOLD (Ratnasingham and Hebert 2007).

Actual constraints and future perspectives of research on Lepidoptera Diversity of Ethiopia

Butterflies and moths are a major component of biodiversity playing a crucial role in the ecosystem as primary consumers, essential part of food-chains and pollinators. However, humans are exerting unprecedented pressures on all of the earth's ecosystems, and such pressures may affect all species (Sanchez-Bayo and Wyckhuyes 2019). Nature conservation strategies have focused most of their attention on the "charismatic megafauna", i.e., on mammals, birds, and other vertebrates. The vast majority of invertebrate species – although accounting for more than 80% of the animal species - are too poorly known to allow an assessment of how they are affected by human activities, and what might be done to mitigate the damage that humans cause. In most cases, the best way that can be done is to conserve their habitats so that most inhabiting species will continue to thrive.

The greatest threats to butterflies and moths are habitat fragmentation and destruction, intensification of agricultural practice with over-use of pesticides and herbicides; climate change mainly affecting endemic species adapted to mountainous habitats, whereas scientific collecting is absolutely negligible (Hausmann 2001; Sanchez-Bayo and Wyckhuyes 2019). In general, human activity is enormously threatening the global diversity of life on the planet. Rough estimates suggest that we are currently undergoing not only unprecedented, but also accelerating rates of species extinction (UNEP 2006; Sanchez-Bayo and Wyckhuyes 2019).

In the same manner, Ethiopia is experiencing major biodiversity loss, mainly related to extensive destruction of habitats, deforestation, land degradation, intensive agricultural expansion, climate change, excessive pesticide and herbicide use, introduction of exotic plant species, among others (EBI 2015; Tesfu et al. 2018). The loss of primary or native forest areas, due to clearcutting and conversion into agroforests, farmland or settlements, are currently the major threat to the Ethiopian biodiversity in general and Lepidoptera in particular.

Despite Ethiopia being known for its rich heritage of biological diversity and many diverse ecosystems, the conservation of its habitats have received scant attention. The system of protected areas so far established includes 21 national parks, four sanctuaries, eight wildlife reserves, 20 controlled hunting areas, six open hunting areas, six community conservation areas and 58 national forest priority areas (Young 2012), covering 14% of the country (EBI 2015). However, most of its biodiversity, including Lepidoptera, is still unexplored because of significant lack of national research capacity. Hence, in parallel to conservation programs and sustainable utilisation of biological resources, efforts for the preparation of a comprehensive bio-inventory should receive highest priority. Such an instrument must be considered an essential baseline for policy makers, planners, donors and researchers working on biodiversity conservation in Ethiopia.

In order to upsurge biodiversity knowledge, capacity building in the area at various levels is needed. Lack of well organised natural history museums, specialists, and scientific societies providing support and fostering citizen science, international research networks and projects are among the identified gaps. Currently, most of the type specimens and reference collections are deposited outside the country of origin. In this context, the Nagoya Protocol (UNSG 2010), although intending to strengthen nations to conserve their genetic resources, to some extent could lead to the opposite effect by hampering international collaboration. Joint protocols and agreements between national actors (research institutes, governing agencies, universities, NGO's) and international research bodies should be promoted in a collaborative way, favoring shared, non-commercial biodiversity research. Close collaboration with museums and universities possessing reference collections and skills, designing and organising projects are required to teach and train a generation of highly competent scientists and managers so that collections of Ethiopian insects could be built and properly managed. In absence of these minimum requirements, establishing a national entomological museum/collection could be ineffective in promoting the study and conservation of local biodiversity resources.

References

Agassiz D (2019) The Yponomeutidae of the Afrotropical region (Lepidoptera: Yponomeutoidea). Zootaxa 4600(1): 1–69. https://doi.org/10.11646/zootaxa.4600.1.1

Beccaloni G, Scoble M, Kitching I, Simonsen T, Robinson G, Pitkin B, Hine A, Lyal C (2003) The Global Lepidoptera Names Index LepIndex. http://www.nhm.ac.uk/ourscience/data/lepindex/lepindex/ [accessed 25 March 2019]

Berio E (1937) Eteroceri africani a arentemente nuovi. Annali del Museo Civico di Storia Naturale di Genova 59: 370–393.

Berio E (1939a) Lepidoptera. In: Missione biologica nel paese dei Borana. Raccolte Zoologiche 9–15.

Berio E (1939b) Contributi alla conoscenza dei lepidotteri eteroceri dell'Eritrea I. Lista delle specie condescrizioni delle nuove entità raccolte negli anni 1934 al 1937 dal sig. Francesco Vaccaro. Memoriedella Società Entomologica Italiana 17: 47–62. [pls 1, 2]

Berio E (1939c) Contributi alla conoscenza dei lepidotteri eteroceri dell' Eritrea II. Eteroceri raccolti dal cap. Antonio Richini e famiglia nella zona di Adua. Bollettino della Società entomologica italiana 71(8): 164–165.

Berio E (1940a) Diagnosi di eteroceri africani. Memorie della Società Entomologica Italiana 19: 125–128.

Berio E (1940b) Contributo alla conoscenza dei lepidotteri eteroceri dell'Eritrea VI. Eteroceri raccoltidal cap. Richini ad Adi-Abuna (Adua) nel Marzo 1940. Bollettino della Società entomologica italiana 72(10): 161–165.

Berio E (1943) Descrizione dell'armatura genitale di alcune *Hypotacha* e diagnosi di una nuove specie (Lepidoptera: Noctuidae). Annali del Museo Civico di Storia Naturale di Genova 62: 25–29.

Berio E (1944) Missione biologica Sagan-Omo diretta dal Prof. E. Zavattari. Lepidoptera Agaristidae e Noctuidae Memorie della Società Entomologica Italiana 23: 74–79.

Berio E (1945) Reperti di nuove Noctuidae dell'Africa orientale. Memorie della Società Entomologica Italiana 24: 81–83.

Berio E (1947) Diagnosi di alcune Erastriinae africane (Lepidoptera: Noctuidae). Memorie della Società Entomologica Italiana 26: 12–15.

Berio E (1954) Diagnosi di nuove Catocaline africane (Lepidoptera: Noctuidae). Bollettino della Società entomologica italiana 84(3–4): 55–58.

Berio E (1962) Descrizione di nuove Noctuidae africane (Euxoinae). Annali del Museo Civico di Storia Naturale di Genova 73: 196–208.

Berio E (1973) Nuove specie e genere di Noctuidae Africane e Asiatiche e note sinonimichi. Parte II. Annali del Museo Civico di Storia Naturale di Genova 79: 126 –171.

Berio E (1975) Nuove genere e nuove specie di Noctuidae Africane (Lepidoptera). Annali del Museo Civico di Storia Naturale di Genova 80(1974): 217–225.

Berio E (1976) Nuovi generi e specie di Noctuidae dell'Africa equatoriale (Lepidoptera). Annali del Museo Civico di Storia Naturale di Genova 81: 96–123.

Berio E (1977) Diagnosi di nuovi taxa di Noctuidae del globo (Lepidoptera). Annali del Museo Civico di Storia Naturale Giacomo Doria 81: 321–339.

Biodiversity Institute of Ontario (2006) All Leps Barcode of Life Project. http://www.lepbarcoding.org/ [accessed 28 April 2018]

Brandao S, Lyra L, Freitas L (2009) Barcoding Lepidoptera: Current Situation and Perspectives on the Usefulness of a Contentious Technique. Neotropical Entomology 38(4): 44–451. https://doi.org/10.1590/S1519-566X2009000400001

Burgess N, D'Amico Hales J, Underwood E, Dinerstein E, Olson D, Itoua I, Schipper J, Ricketts T, Newman K (2004) Terrestrial Ecoregions of Africa and Madagascar. Island Press, Washington, 497 pp.

Clausnitzer V (2014) NABU's Biodiversity Assessment at the Kafa Biosphere Reserve, Ethiopia, 162 pp.

Clausnitzer V, Dijkstra KD (2005) The dragonflies (Odonata) of Ethiopia, with notes on the status of its endemic species and the description of a new one. Entomologische Zeitschrift 115: 117–130.

Debauche HR (1937) Entomological expedition to Abyssinia 1926–27: Lepidoptera, Geometridae. Annals and Magazine of Natural History (10)20: 320–344. [pls 7, 8] https://doi.org/10.1080/00222933708655348

De Prins J, De Prins W (2019) Afromoths, online database of Afrotropical moth species (Lepidoptera). http://www.afromoths.net/ [accessed 25 March 2019]

Ethiopian Biodiversity Institute (EBI) (2015) National Biodiversity Strategy and Action Plan of Ethiopia (NBSAP). Rela Printing Press, Addis Ababa, 120 pp.

Eitschberger U, Melichar T (2016) Revision und Neugliederung aller Arten, die momentan in der Gattung *Macropoliana* auct. (nec Carcasson, 1968) vereint, zusammengefaßt sind. Neue. Entomologische Nachrichten 71: 1–639.

Eitschberger U, Ströhle M (2011) Der Artkomplex von *Lophostethus dumolinii* (Angas, [1849]) im vergleich mit *Lophostethus negus* Jordan, 1926 Neue Entomologische Nachrichten 67: 121–255.

Goff R (2008) African moths. http://www.africanmoths.com [accessed 25 March, 2019]

Gordon F, Carillet J (2003) Ethiopia and Eritrea. Lonely Planet, Melbourne, 368 pp.

Guénée MA (1852–1857) Histoire naturelle des Insectes. V–X. Species général des Lépidoptères. Librairie encyclopédique de Roret, Paris.

Guérin-Méneville FE (1849) Ordre des lepidopteres. Famille des diurnes. In: Lefebrvre T (Ed.) Voyage en Abyssinie. Zoologie 6(4): 364–386.

Hacker HH (2011) Neue *Metachrostis* Hübner (1829) Arten aus dem Yemen und aus Afrika (Lepidoptera, Noctuidae, Eublemminae). Esperiana 16: 213–231. [pls 28–30]

Hacker HH (2013) Additions to several revisions of Noctuid genera revised from 2001 to 2011, with descriptions of nine new species and three new subspecies from Africa, Arabian Peninsula and Iran, with faunistic notes (Noctuioidea). Esperiana 18: 199–220. [pls 13, 14]

Hacker HH (2014) Revision of the tribe Nolini of Africa and the Western Palaearctic Region (Lepidoptera, Noctuoidea, Noctuidae, Nolinae) Supplement 1. Esperiana 19: 121–179.

Hacker HH (2016) Systematic and illustrated catalogue of the Macroheterocera and Cossoidea Leach, [1815], Zygaenoidea Latreille 1809, Thyridoidea Herrich-Schäffer 1846 and Hyblaeoidea Hampson, 1903 of the Arabian Peninsula, with a survey of their distribution (Lepidoptera). Esperiana 20(1): 1–742; (2): 1–430.

Hacker HH (2019) Biogeography; Bolebiinae (Lepidoptera, Noctuodea, Erebidae) – Moths of Africa. Systematic and illustrated Catalogue of the Heterocera of Africa, Volume 1. Esperiana. Bad Staffelsein, Germany, 816 pp.

Hacker HH, Fibiger M (2007) Review of the African species of the genus *Feliniopsis* Roepke, 1938 (*Eutamsia* Fletcher, 1961) (Lepidoptera: Noctuidae). Esperiana Memoir 3: 59–178. [pls 10–20]

Hacker HH, Mey W (2010) Beiträge zur Taxonomie, Systematik und Faunistik von Noctuidae (Noctuoidea), hauptsächlich aus dem Museum für Naturkunde Berlin. Esperiana Memoir 5: 457–468.

Hacker HH, Zilli A (2007) Revisional notes on the genus *Thiacides* Walker, 1855, with descriptions of Thiacidinae subfam. nov. and eleven species (Lepidoptera: Noctuidae). Esperiana Memoir 3: 179–246. [pls 21–30]

Hacker HH, Legrain A, Fibiger M (2008) Revision of the genus *Acontia* Ochsenheimer, 1816 and the tribus Acontiini Guenée, 1841 (Old World) (Lepidoptera: Noctuidae: Acontiinae). Esperiana 14: 7–533. [pls 1–38]

Hacker HH, Schreier HP, Goater B (2012) Revision of the tribe Nolini of Africa and the Western Palaearctic Region (Lepidoptera, Noctuoidea, Noctuidae, Nolinae). Esperiana 17: 1–612.

Hampson GF (1896) On the classification of the Schoenobiinae and Crambinae, two subfamilies of Moths of the family Pyralidae. Proceedings of the Zoological Society of London 1895(4): 897–974.

Hampson GF (1898) Catalogue of the Lepidoptera Phalaenae in the collection of the British Museum. Syntomidae The Trustee of the British museum (Natural History)1: i–xxi, 1–538. [pls 1–17] https://doi.org/10.5962/bhl.title.52217

Hampson GF (1899) A revision of the moths of the subfamily *Pyraustinae* and family *Pyralidae*, part 1. Proceedings of the Zoological Society of London 1898(4): 590–761. [pls 49–50]

Hampson GF (1905) Descriptions of new genera and species of Syntomidæ, Arctiadæ, Agaristidæ, and Noctuidæ. The Annals and Magazine of Natural History (7th series) 15(89): 425–453. https://doi.org/10.1080/03745480509442831

Hampson GF (1909) Descriptions of new genera and species of Syntomidæ, Arctiadæ, Agaristidæ and Noctuidæ. Annals and Magazine of Natural History (8) 4(22): 344–388. https://doi.org/10.1080/00222930908692682

Hampson GF (1910) Descriptions of new African moths. The Annals and Magazine of Natural History (8th series) 6(31): 116–141. https://doi.org/10.1080/00222931008692829

Hampson GF (1916) Descriptions of new species of the family Arctiadæ in the British Museum. Novitates Zoologicae 23(2): 230–240.

Hampson GF (1913) Catalogue of the Lepidoptera Phalaenae in the collection of the British Museum (Nat. Hist.). XII. Noctuidae. The Trustees of the British Museum (N.A.T.H.ST.), London 12: 1–626.

Hampson GF (1918) Descriptions of new Pyralidae in the subfamily Pyraustinae (cont.). The Annals and Magazine of Natural History (9th series) 2 (9): 181–196; (11): 393–407. https://doi.org/10.1080/00222931808673777

Hampson GF (1919) Descriptions of new Pyralidae of the subfamilies Crambinae and Siginae. The Annals and Magazine of Natural History (9) 4 (20): 53–68; (21): 137–154; (23): 305–326. https://doi.org/10.1080/00222931908673884

Hampson GF (1926) Descriptions of new genera and species of Lepidoptera Phalaenae of the subfamily Noctuinae (Noctuidae) in the British Museum (Natural History): 1–641.

Hampson GF (1930) New genera and species of Phycitinae (Lepidoptera, Pyralidae) The Annals and Magazine of Natural History (10th series) 5: 50–80. https://doi.org/10.1080/00222933008673106

Haslberger A, Segerer AH (2016) Systematische, revidierte und kommentierte Checkliste der Schmetterlinge Bayerns (Insecta: Lepidoptera). Mitteilungen der Münchner Entomologischen Gesellschaft Supplement 106: 1–336.

Hausmann A (2001) Introduction. Archiearinae, Orthostixinae, Desmobathrinae, Alsophilinae, Geometrinae. In: Hausmann A (Ed.) The Geometrid Moths of Europe 1. Apollo Books, Stenstrup, 282 pp.

Hausmann A, Parisi F, Sciarretta A (2014) The geometrid moths of Ethiopia I: tribes Pseudoterpnini and Comibaenini (Lepidoptera: Geometridae, Geometrinae). Zootaxa 3768(4): 460–468. https://doi.org/10.11646/zootaxa.3768.4.4

Hausmann A, Parisi F, Sciarretta A (2016) The Geometrinae of Ethiopia II: Tribus Hemistolini, genus *Prasinocyma* (Lepidoptera: Geometridae, Geometrinae). Zootaxa 4065(1): 1–63. https://doi.org/10.11646/zootaxa.4065.1.1

Hausmann A, Godfray HCJ, Huemer P, Mutanen M, Rougerie R, van Nieukerken EJ, Ratnasingham S, Hebert PDN (2013) Genetic patterns in European geometrid moths revealed by the Barcode Index Number (BIN) system. PLoS ONE. https://doi.org/10.1371/annotation/8c15cfdf-7bfe-4da1-a8c8-76d5d465f7b2

Haxaire J, Melichar T (2008) Un nouveau Sphingidae d'Ethiopie: *Rufoclanis numosae rostislavi* ssp. n. (Lepidoptera Sphingidae). The European Entomologist 1(3–4): 111–115.

Hebert PD, Cywinska A, Ball SL, deWaard JR (2003) Biological identifications through DNA barcodes, Proceedings Royal Society London B Biological Sciences 270: 313–321. https://doi.org/10.1098/rspb.2002.2218

Herbulot C (1983) Missions de MPC Rougeot en Ethiopie et en République de Djibouti. Lepidoptera Geometridae 2. Bulletin mensuel de la Société linnéenne de Lyon 52(1): 10–21. https://doi.org/10.3406/linly.1983.10567

Herbulot C (1993) Deux nouveaux *Prasinocyma* d'Ethiopie (Lepidoptera: Geometridae). Bulletin de la Société entomologique de Mulhouse 23(2): 50.

Herbulot C (2002) Huit nouveaux Geometridae d'Amérique du Sud, d'Afrique centrale et orientale et d'Asie du Sud-est (Lepidoptera). Lambillionea 102(4): 451–458.

Hodges RW, Dominick T, Davis DR, Ferguson DC, Franclemont JG, Munroe EG, Powell JA (1983) Check list of the Lepidoptera of America North of Mexico. E.W. Classey Ltd. and the Wedge Entomological Research Foundation, London, 284 pp.

ICZN [International Commission on Zoological Nomenclature] (1999) International Code of Zoological Nomenclature. Fourth Edition. The International Trust for Zoological Nomenclature, London, 106 pp.

Karsholt O, Razowski J (1996) The Lepidoptera of Europe. A Distributional Checklist. Apollo Books, Stenstrup, 380 pp.

Kravchenko VD, Ronkay L, Speidel W, Witt T, Fibiger M, Rybalov L, Mohammed D, Habte T, Junnila A, Müller GC (2007) Contribution to the Noctuidae fauna of Ethiopia. Atalanta 38(3/4): 385–39.

Kristensen N, Scoble M, Karsholt O (2007) Lepidoptera phylogeny and systematics: the state of inventorying moth and butterfly diversity. Zootaxa 1668: 699–747.

Laporte B (1974) Diagnoses de nouveaux genres et de plusieurs espèces inédites de Noctuidae trifides (Lépidoptères) d'Ethiopie. Bulletin mensuel de la Société linnéenne de Lyon 43(6): 216–224; (7): 246–251. [pls 1, 2]

Laporte B (1975) Diagnoses de 17 nouvelles espèces de Noctuidae d'Ethiopie et du Kenya (Lépidoptères). Bulletin mensuel de la Société linnéenne de Lyon 44(8): 277–287. https://doi.org/10.3406/linly.1975.10206

Laporte B (1976) Diagnoses de nouveaux genres et de plusiers espèces inédites de Noctuidae trifinae (Lépidoptères) d'Ethiopie (3e note). Bulletin mensuel de la Société linnéenne de Lyon 45(3): 131–136. https://doi.org/10.3406/linly.1976.10243

Laporte B (1978) Nouvelles espèces de noctuelles trifides africaines (Lepidoptera: Noctuidae) Bulletin de la Société entomologique de France 83: 62–65.

Laporte B, Rougeot PC (1981) Description d'une nouvelle espèce de *Batuana* (Lepidoptera: Noctuidae, Trifidae) d'Ethiopie. Bulletin mensuel de la Société linnéenne de Lyon 50(4): 126–127.

Lucas H (1852) Description de nouvelles espèces de Lepidopteres appartenant aux collections entomologiques de Musee de Paris Revue et. Magasin de Zoologie Pure et Appliquee 4: 324–345; 422–432.

Melichar T, Řezáč M (2015) A new species of the genus *Theretra* Hübner, [1819] (Lepidoptera, Sphingidae) from Ethiopia. The European Entomologist 7(2): 40–47.

Melichar T, Řezáč M, Milčíková A (2016) Descriptions of three new taxa in the *Temnora pylas* (Cramer, 1779) species group (Lepidoptera, Sphingidae), with notes on several other taxa. The European Entomologist 8(3): 105–131.

Meyrick E (1932) Entomological Expedition to Abyssinia, 1926–7. Microlepidoptera. Transactions of the Entomological Society of London 80(1): 107–120. https://doi.org/10.1111/j.1365-2311.1932.tb00085.x

Mittermeier RA, Turner, WR, Larsen FW, Brooks TM, Gascon C (2011) Global Biodiversity Conservation: The Critical Role of Hotspots. Biodiversity Hotspots 3–22. https://doi.org/10.1007/978–3–642–20992–5_1

Natural History Museum (2014) The Global Lepidoptera Names Index. http://www.nhm.ac.uk/our-science/data/lepindex [accessed 25 Mar 2019]

Navarro R (2007) LepiMap. http://lepimap.adu.org.za [accessed on 10 April 2019]

Nazari V, Larsen TB, Lees DC, Brattstro O, Bouyer T, Van de Poel G, Hebert PDN (2011) Phylogenetic systematics of *Colotis* and associated genera (Lepidoptera: Pieridae): evolutionary and taxonomic implications. Journal of Zoological Systematics and Evolutionary Research 49(3): 204–215. https://doi.org/10.1111/j.1439-0469.2011.00620.x

Nieukerken, EJ van, Kaila L, Kitching IJ, Kristensen NP, Lees DC, Mine, J, Mitter C, Mutanen M, Regier JC, Simonsen TJ, Wahlberg N, Yen SH, Zahiri R, Adamski D, Baixeras J, Bartsch D, Bengtsson BÅ, Brown JW, Bucheli SR, Davis DR, De Prins J, De Prins W, Epstein ME, Gentili-Poole P, Gielis C, Hättenschwiler P, Hausmann A, Holloway JD, Kallies A, Karsholt O, Kawahara AY, Koster SJC, Kozlov MV, Lafontaine JD, Lamas G, Landry JF, Lee S, Nuss M, Park KT, Penz C, Rota J, Schmidt BC, Schintlmeister A, Sohn JC, Solis MA, Tarmann GM, Warren AD, Weller S, Yakovlev RV, Zolotuhin VV, Zwick A (2011) Order Lepidoptera Linnaeus, 1758. In: Zhang Z (Ed.) Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness. Zootaxa 3148: 212–221. https://doi.org/10.11646/zootaxa.3148.1.41

Plantrou J, Rougeot PC (1979) Mission P.C. Rougeot en Ethiopie, I et II – 1978. *Charaxes* inedits du Sud ethiopien. (Lepidoptera: Nymphalidae). Bulletin de la Société Entomologique de France 139:138–142.

Ratnasingham S, Hebert PDN (2007) BOLD: The Barcode of Life Data System. https://doi.org/10.1111/j.1471-8286.2007.01678.x [accessed 15 March 2019]

Ratnasingham S, Hebert PDN (2013) A DNA-based registry for all animal species: The Barcode Index Number (BIN) System. PLOS ONE 8 (8): e66213. https://doi.org/10.1371/journal.pone.0066213

Razowski J, Trematerra P (2010) Tortricidae (Lepidoptera) from Ethiopia. Journal of Entomological and Acarological Research 42(2): 47–79. https://doi.org/10.4081/jear.2010.47

Razowski J, Trematerra P (2012) Tortricidae (Lepidoptera) from Ethiopia 2. Journal of Entomological and Acarological Research 44: 37–40. https://doi.org/10.4081/jear.2012.e8

Razowski J, Trematerra P, Colacci M (2018) Tortricidae (Lepidoptera) from Ethiopia 3. SHILAP Revista de Lepidopterologia 46(181): 91–104.

Reiche L (1850) Entomologie. In: Ferrets PVA, Galinier JG (1847–1850) Voyage en Abyssinie dans les provinces du Tigre, du Samen et de l'Ahmarra, Paulin Libraire Éditeur, Paris, 258–471.

Rothschild W (1902) Some new African Lepidoptera discovered by Oscar Neumann. Novitates Zoologicae 9: 595–598.

Rothschild W (1926) On some African Papilios, with descriptions of new forms. Annals and Magazine of Natural History (9)17; 113 (112–114). https://doi.org/10.1080/00222932608633378

Rothschild W, Jordan K (1900) A monograph of *Charaxes* and the allied prionopterous genera. Novitates Zoologicae 7: 287–524. https://doi.org/10.5962/bhl.part.17460

Rothschild W, Jordan K (1903) Lepidoptera collected by Oscar Neumann in North-East Africa. Novitates Zoologicae 10: 491–542.

Rothschild W, Jordan K (1905) Lepidoptera collected by Oscar Neumann in North-East Africa (continuation). Novitates Zoologicae 12: 175–191. https://doi.org/10.5962/bhl.part.24270

Rougeot PC (1974) Sur deux nouvelles espèces d'Attacides d'Afrique orientale (Lepidoptera: Attacidae). Bulletin de la Société entomologique de France 78(1973); (11–12): 334–336.

Rougeot PC (1975) Diagnoses de trois nouvelles espèces de lépidoptères hétérocères d'Afrique. orientale, Lambillionea 75(9–10): 68–71.

Rougeot PC (1977) Missions entomologiques en Ethiopie 1973–1975. Fascicule 1. Mémoires du Muséum national d'Histoire naturelle (A) 105: 1–150, pls 1–20.

Rougeot PC (1984) Missions entomologiques en Ethiopie 1976–1982. Fascicule II. Mémoires du Muséum national d'Histoire naturelle (A) 128: 1–93, pls 1–18.

Rougeot PC, Laporte B (1983) Lépidoptères du Haut-Simyen (Ethiopie du Nord). Bulletin mensuel de la Société linnéenne de Lyon 52(7): 219–232. https://doi.org/10.3406/linly.1983.10597

Rougeot PC, Bourgogne J, Laporte B (1991) Les Lépidoptères Hétérocères d'Afrique orientale. Annales de la Société entomologique de France (NS) 27(4): 407–463.

Sáfián S, Collins SC, Kormos B, Siklosi A (2009) Checklist of the butterflies (Papilionoidea and Hesperoidea) of Ethiopia. African Butterfly Database. https://www.abdb-africa.org/ [Accessed 1 March 2019]

Sanchez-Bayo F, Wyckhuyes KA (2019) Worldwide decline of the entomofauna: a review of its drivers, Biological Conservation 232: 8–27. https://doi.org/10.1016/j.biocon.2019.01.020

Sciarretta A, Hausmann A, Parisi F (2014) Recent advances in the knowledge of Geometrid moths of Ethiopia. P. 259 In: Hausmann A (Ed.) Proceedings of the eighth Forum Herbulot 2014. How to accelerate the inventory of biodiversity (Schlettau, 30 June – 4 July 2014) Spixiana 37(2).

Stoch F (2003) Checklist of the Italian fauna online. http://www.faunaitalia.it/checklist/introduction.html [accessed 15 March 2019]

Tesfu F, Weldemariam T, Asersie A (2018) Impact of human activities on biosphere reserve. A case study from Yayu Biosphere Reserve, Southwest Ethiopia. International Journal of Biodiversity Conservation 10(7): 319–326. https://doi.org/10.5897/IJBC2016.1005

United Nations Environment Programme (UNEP) (2006) 2005 Annual Evaluation Report, 70 pp. https://www.unenvironment.org/resources/evaluation-synthesis-reports/unep-annual-evaluation-report-2005 [accessed 16 April 2019]

UNSG [United Nations, Secretary-General] (2010) Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity, 29 October 2010. https://treaties.un.org/doc/Treaties/2010/11/20101127%2002-08%20PM/XXVII-8-b-Corr-Original.pdf [accessed 16 April 2019]

Wikipedia (2011) List of Lepidoptera of Metropolitan France. https://en.wikipedia.org/wiki/List_of_Lepidoptera_of_Metropolitan_France [Accessed 15 March 2019]

Williams MC (2018) Afrotropical butterflies and skippers. A digital encyclopaedia. https://www.metamorphosis.org.za/?p=articles&s=atb [accessed 28 February 2019]

Young J (2012) Ethiopian protected areas. A 'Snapshot'. A reference guide for future strategic planning and project funding. Ethiopian Wild Life Authority, Addis Ababa, 46 pp.

ZooKeys 882: 127–157 (2019)
doi: 10.3897/zookeys.882.38449
http://zookeys.pensoft.net

CHECKLIST

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

An update to the inventory of shore-fishes from the Parque Nacional Sistema Arrecifal Veracruzano, Veracruz, México

D. Ross Robertson[1], Horacio Pérez-España[2], Omar Domínguez-Domínguez[3], Carlos J. Estapé[4], Allison Morgan Estapé[4]

1 *Smithsonian Tropical Research Institute, Balboa, Republic of Panama* **2** *Instituto de Ciencias Marinas y Pesquerías, Universidad Veracruzana, Hidalgo 617, Col. Río Jamapa, C.P. 94290, Boca del Río, Veracruz, México* **3** *Laboratorio de Biología Acuática "Javier Alvarado Díaz". Facultad de Biología, Universidad Michoacana de San Nicolás de Hidalgo. C.P. 58290. Morelia, Michoacán, México* **4** *150 Nautilus Drive Islamorada, Florida 33036, USA*

Corresponding author: *D. Ross Robertson* (robertsondr@si.edu)

Academic editor: *Kyle Piller* | Received 22 July 2019 | Accepted 12 September 2019 | Published 23 October 2019

http://zoobank.org/C947D30F-3030-4A60-88EB-EB9AEBEF27FF

Citation: Robertson DR, Pérez-España H, Domínguez-Domínguez O, Estapé CJ, Estapé AM (2019) An update to the inventory of shore-fishes from the Parque Nacional Sistema Arrecifal Veracruzano, Veracruz, México. ZooKeys 882: 127–157. https://doi.org/10.3897/zookeys.882.38449

Abstract

Data on marine and brackish-water fishes recorded in the area of the Parque Nacional Sistema Arrecifal Veracruzano in the southwest Gulf of Mexico were extracted from online aggregators of georeferenced location records, the recent ichthyological literature reviewed, and collections and observations made to provide a more complete faunal inventory for that park. Those actions added 95 species to a comprehensive inventory published in 2013, and brought the total to 472 species, an increase of 22%. Seventy-four percent of the additions came from online aggregators of georeferenced species records, which clearly demonstrates the value of reviewing and incorporating such data into species inventories. However, different aggregators recorded different sets of species, and some of their data were linked to outdated taxonomy or included identification errors. Hence individual records from multiple aggregators need to be obtained and reviewed for such issues when using such data to compile and revise faunal inventories. Existing lists also need to be carefully reviewed to ensure that errors are not perpetuated during updates.

Keywords

Georeferenced aggregator records, literature review, nomenclature, observations, photography vouchers

Introduction

The Parque Nacional Sistema Arrecifal Veracruzano (**PNSAV**), which has an area of 522 km^2, encompasses approximately 50 coral reefs with a combined area of 70.2 km^2, only half of which are emergent, along a 50 km stretch of the coastline immediately adjacent to Veracruz city (~450,000 inhabitants), on the southwest coast of the Gulf of Mexico (**GoMx**). These reefs, which are situated in a shallow area of the continental shelf in which the water is < 50m deep, include some along the shoreline and others as much as 21 km offshore. This area was established as a national Marine Protected Area (**MPA**) in 1992, with modifications and additions in 2000 and 2012. As part of the management effort involved in the declaration of that MPA Del Moral-Flores et al. (2013) spent five years working up a comprehensive check-list of the fish fauna of that area, was based on a review of 13 previous publications, as well as their own collections and observations. That list included 387 species of shore-fishes (marine and brackish water fishes) known from the PNSAV. There have been only two subsequent publications that provide further documentation of the PNSAV's fish fauna, by Ayala-Rodríguez et al. (2016), and Tello-Musi et al. (2018). The present paper builds on that work by incorporating more recently available data from several sources and reviewing information in those previous publications to provide an update to that inventory.

Materials and methods

The additions to, name changes and deletions of questionable records of some species listed from the PNSAV that are presented here are based on a review of those previous papers and incorporation of information from two additional sources: georeferenced records of species present in the PNSAV obtained from the digital databases of four major online aggregators that contain biogeographic information on fishes in the Gulf of Mexico, and our own collections and observations in the PNSAV. We reviewed and assessed the validity of the names used and questionable records of various species listed by Del Moral-Flores et al. (2013) and similarly reviewed the list of species arising from a subsequent study by Ayala-Rodríguez et al. (2016). Tello-Musi et al. (2018) provided further information on one species.

In recent years various efforts have led to large databases on the distributions of species becoming available through online museum databases, and from online aggregators that collate and distribute data from museums and a broad range of additional science sources. We took advantage of this trend by obtaining georeferenced records for species of fishes present in the area of the PNSAV from six major aggregators:

i) the Mexican National Commission for the Use and Conservation of Biodiversity (**CONABIO:** http://www.conabio.gob.mx/informacion/gis/) a national aggregator that collects data from Mexican science sources, and three aggregators that obtain data from a wider range of international sources;

ii) Integrated Digitized Biocollections (**iDigBio:** https://portal.idigbio.org/portal/search), an NSF sponsored effort run by the University of Florida that provides digital data from US collections;
iii) the Global Biodiversity Information Facility (**GBIF:** https://www.gbif.org/), which draws data from 45,000+ datasets on a broad range of organisms from a wide range sources scattered in most major areas of the globe;
iv) **Fishnet2** (http://www.fishnet2.net/), which aggregates data from ~75 museum databases in North America (mainly), Europe, Asia and Australia;
v) the Ocean Biogeographic Information System (**OBIS:** https://obis.org/), a clearing house for data that aggregates museum and local-aggregator data on various aspects of the biology of marine organisms, including their geographic distributions, is hosted in Belgium, and has 13 regional nodes scattered around the world, including the USA; and
vi) **FishBase** (http://www.fishbase.org), an international aggregator supervised by a consortium of nine non-USA international institutions that takes data on fishes in general from a broad range of sources.

These aggregators often recycle some data amongst themselves. To obtain data on occurrences of fishes from the PNSAV we searched each of those databases for georeferenced species records within a quadrat with latitudinal and longitudinal limits that closely bounded the PNSAV, with latitudes from 19.04° to 19.26°N, and longitudes from -95.75° to -96.18° W. Individual georeferenced records can be obtained from each aggregator. Since water depths within almost all of the PNSAV, particularly around the reefs, do not exceed 50m (Liaño-Carrera et al. 2019) we included in our results only those species known to occur at depths between 0–50 m in other parts of their geographic ranges. We excluded records of species of poeciliids, characids and cichlids as those are primarily or exclusively freshwater taxa. The records obtained from those aggregators were reviewed, to check for inconsistencies between putative occurrences and the known geographic ranges of species, which are not uncommon (e.g., see Robertson 2008), and to ensure included occurrences relate to updated taxonomic nomenclature, based on that in Eschmeyer's Catalog of Fishes (Fricke et al. 2019). The PNSAV lies within the known geographic ranges of all species included in this update whose records in that MPA came from the aggregators.

Omar Domínguez-Domínguez (ODD) led a collecting expedition to the PNSAV in 2015 as part of a study of connectivity among reef fish populations throughout different reef areas in the Mexican tropical west Atlantic. That effort focused on both readily visible and small, cryptic fishes hiding in the reef matrix. For the latter the anesthetic clove oil was used to make collections (e.g., see Robertson et al. 2019). Voucher specimens of all small cryptic species collected by ODD were preserved in ethanol and have been deposited in the Colección de Peces de la Universidad Michoacana de San Nicolás de Hidalgo (curator MC Xavier Madrigal, xmguridi@yahoo.com).

Horacio Pérez-España (HP-E), based at the Universidad Veracruzana in Veracruz City, has spent decades studying reef fishes in the PNSAV. During a week in May 2019 D Ross Robertson (DRR), Carlos J Estapé (CJE), and Allison Morgan Estapé (AME) made scuba and snorkeling dives at a variety of inner and outer reefs in the northern and southern parts of the PNSAV. That activity led to the observations of species not on any previously published lists, or in online databases, and photographic records of various species.

Results

Changes to nomenclature used by Del Moral-Flores et al. (2013)

Dasyatis americana Hildebrand & Schroeder, 1928 and ***D. sabina*** (Lesueur, 1824) to ***Hypanus americanus*** and ***H. sabinus.*** Both species have been reassigned to the genus *Hypanus* by Last et al. (2016).

Gymnura micrura (Bloch & Schneider, 1801) to ***G. lessae***. Yokota and Carvalho 2017. Yokota and Carvalho (2017) split *G. micrura* into two species, and named the population from the Gulf of Mexico and Atlantic USA *G. lessae*, leaving *G. micrura* restricted to the coast of South America.

Manta birostris (Walbaum, 1792) to ***Mobula birostris.*** *Manta* was synonymized with *Mobula* by Last et al. (2016).

Antennarius striatus (Shaw, 1794) to ***A. scaber***. (Cuvier, 1817). *A striatus* was thought to represent a single pantropical species. However, the west Atlantic population was recently recognized as *A. scaber* (see Arnold and Pietsch 2012; Smith-Vaniz and Jelks 2014).

Haemulon chrysargeum Gunther, 1859) to ***Brachygenys chrysargeum*** (Gunther, 1859). Tavera et al. (2018) reassigned this species to the newly created genus *Brachygenys*.

Pomadasys crocro (Cuvier, 1830) to ***Rhonciscus crocro*** (Cuvier, 1830). Tavera et al. (2018) reassigned this species to the newly created genus *Rhonciscus*.

Bairdiella ronchus (Cuvier, 1830) to ***Bairdiella veraecrucis*** Jordan & Dickerson, 1908. Marceniuk et al. (2019) revised the genus and resurrected *B. veraecrucis* for the Gulf of Mexico population. *Bairdiella ronchus* is restricted to South America.

Kyphosus incisor (Cuvier, 1831) to ***Kyphosus vaigiensis*** (Quoy & Gaimard, 1825). Knudsen and Clements (2013) synonymized *K. incisor* with *K. vaigiensis*.

Stegastes variabilis (Castelnau, 1855) to ***Stegastes xanthurus*** (Poey, 1860). While the name *S. variabilis* was long applied to both Brazilian and Greater Caribbean populations of what was thought to be a single species, *S. variabilis* is now considered to be a Brazilian endemic, while the Greater Caribbean population is *S. xanthurus* (Smith-Vaniz and Jelks 2014)

Labrisomus kalisherae (Jordan, 1904) to ***Gobioclinus kalisherae*** (Jordan, 1904) Lin and Hastings (2013) revised the genus *Labrisomus* and split it into three, with *G. kalisherae* placed in Gobioclinus.

Emblemariopsis* sp**. to ***Emblemariopsis diaphana Longley, 1927. Photographs of this species (Figure 1) show it to be *E. diaphana*.

Gnatholepis cauerensis (Bleeker, 1853) to ***Gnatholepis thompsoni*** Jordan, 1904. The species *G cauerensis* is restricted to the Indo-Pacific and St Helena in the Atlantic.

Figure 1. *Emblemariopsis diaphana* at PNSAV **A** male **B** female or immature male. Photographs CJE & AME.

Gnatholepis thompsoni, which is closely related to *G cauerensis*, is found on both sides of the Atlantic, including throughout the Greater Caribbean (Rocha et al. 2005; Van Tassell 2011)

Questionable records from Del Moral-Flores et al. (2013)

Del Moral-Flores et al. (2013) listed 387 species in 206 genera and 92 families, including 21 elasmobranchs and 366 bony fishes in the PNSAV. We excluded ten species from this list that were not replaced by other names, due to likely identification errors, which would reduce the number listed by that paper to 377 species.

Narcine* sp.** to ***Narcine bancrofti (Griffith & Smith, 1834). *Narcine bancrofti*, which is included in the Del Moral-Flores et al. (2013) list, is the only member of this genus currently recognized from the Gulf of Mexico and Caribbean. *Narcine* sp. may have been used due to longstanding confusion arising from misidentification of *N. bancrofti* as *N. brasiliensis* (now known to be a Brazilian endemic, see Rosa et al. 2007) or to the fact that coloration of *N. bancrofti* varies considerably. We excluded this record during the update.

Alosa sapidissima (Wilson, 1811) is a temperate species with a native range in eastern North America from Canada to the central east coast of Florida (Natureserve and Daniels 2019). There are only two members of the genus with established populations in the GoMx, both of which are endemic to the northern Gulf. *Alosa alabamae* Jordan & Evermann, 1896, is restricted to the northeast section of the gulf (Natureserve 2010). *Alosa chrysochloris* (Rafinesque, 1820) ranges more widely, as far south as the Texas/ México border (Robertson and Caruso 2018), and is the most likely candidate for any *Alosa* found in in the southwest GoMx. Adults of *Alosa* spp. are marine, but spawn in rivers, and juveniles can be found in estuaries (Natureserve and Daniels 2019; Limburg 1996, O'Connell et al. 2004). Castro-Aguirre et al. (1999) did not record any members of this genus in estuaries on lagoons of México, which would be expected if they lived in Mexico and spawned there in rivers. The only aggregator records of any *Alosa* species in México are a few in GBIF (and Fishnet2 and FishBase) of *A. pseudoharengus* (Wilson, 1811) in Campeche, southern Veracruz state (not the PNSAV) and off the northeast tip of the Yucatan peninsula. While those Yucatan records represent misidentified *Harengula jaguana* Poey, 1865, the other records are of an *Alosa* species of uncertain identity, possibly *A. chrysochloris*, but not *A. pseudoharengus* (Hector Espinoza Pérez pers. comm. September 2019). Given that *Harengula jaguana* has been confused with *Alosa* elsewhere and is listed as present in the PNSAV by Del Moral-Flores et al. (2013), we suggest that the record of *Alosa sapidissima* at the PNSAV should be viewed as *incertae sedis*. We excluded it during the update.

Hypoplectrus puella (Cuvier, 1828) to ***H. floridae*** Victor, 2012. González-Gándara et al. (2012, 2013) recorded *H. nigricans* (Poey, 1830) (a look-alike congener of the Veracruz endemic *H. atlahua* Tavera & Acero P., 2013), *H. puella* (a a look-alike congener of the species described from Florida, *H. floridae*), and *H. unicolor* (Walbaum, 1792) (a look-alike congener of the Veracruz endemic *H. castroaguirre* Del Moral-Flores et al. 2012) from reefs around Tuxpan, 250 km north of the PNSAV.

Among those species Del Moral-Flores et al. (2013) listed only *H. atlahua*, *H. castroaguirre* and *H. puella* from the PNSAV. Subsequently *H. floridae* was noted from one of the Tuxpan reefs by González-Gándara (2014) and in the PNSAV by Tello-Musi et al. (2018). Given that their look-alike congeners are present in Veracruz it seems unlikely that any *H. nigricans*, *H. puella*, and *H. unicolor* also are present. Hence, just as the records of Avalos et al. (2008) of *H. nigricans* and *H. unicolor* in the PNSAV were replaced by *H. atlahua* and *H. castroaguirre*, respectively, in Del Moral-Flores et al. (2013) the *H. puella* record of Del Moral-Flores et al. (2013) from the PNSAV most likely refers to *H. floridae*. For comparison, images of *H. floridae* from the PNSAV and Florida, and of *H. puella* from the Caribbean are presented in Figure 2.

Cynoscion jamaicensis (Vaillant & Bocourt, 1883). This species is largely restricted to South America and extends no further north than Honduras on the continental shoreline (Fredou and Villwock de Miranda 2015). This record most likely represents a misidentification of one of the three species of *Cynoscion* that have been found in the PNSAV, but were not included in the Del Moral-Flores et al. (2013) list (see Table 1). Castro-Aguirre et al. (1999) did not record it from México. This record was excluded during the update.

Stegastes fuscus (Cuvier, 1830) to ***Stegastes adustus*** (Troschel, 1865). While the specific name *fuscus* was long applied to the Caribbean dusky damselfish as *Pomacentrus fuscus* under the assumption that there is a single west Atlantic species, *S. fuscus* is a Brazilian species not known to be present in the Greater Caribbean (Carter and Kaufman 2003). As *S. adustus* is in the list of Del Moral-Flores et al. (2013) we excluded this record during the update.

Stegastes pictus (Castelnau, 1855) to ***Stegastes partitus*** (Poey,1868). *Stegastes pictus* is a Brazilian species (Carter and Kaufman 2003), juveniles of which resemble some individuals of the variably colored *S. partitus*. No other Greater Caribbean *Stegastes* species has a color pattern resembling that of *S. pictus*. The only records of *S. pictus* in the Greater Caribbean are of a few vagrants on the lesser Antilles in the southeast corner of the Caribbean, where vagrants of other species of Brazilian endemics also are known to occur. We note that *S. partitus* is in the Del Moral-Flores et al. (2013) list, and we excluded the *S. pictus* record from the update.

Halichoeres pictus (Poey, 1860) and ***Halichoeres socialis*** Randall & Lobel, 2003 to ***Halichoeres burekae*** Weaver & Rocha, 2007. The terminal phase male of *H. burekae* resembles that phase of both *H. pictus* and *H. socialis*, and the initial phases of *H. socialis* and *H. burekae* also are very similarly colored. Those three species form a clade within the new world *Halichoeres* species, in which *H. burekae* and *H. socialis* are sisters (Wainwright et al. 2018). *Halichoeres pictus* is a conspicuous species widely distributed on reefs throughout most of the Greater Caribbean, while *H. socialis* is a Belize endemic. *Halichoeres burekae* is abundant on reefs throughout the southwest Gulf of Mexico (Aguilar-Perera and Tuz-Sulub 2009; Robertson et al. 2016a, b). The southwest gulf records of *H. pictus* and *H. socialis* predate the description date for *H. burekae* and most likely refer to that species, as there are

Table 1. Additional species of marine and brackish water fishes from the Parque Nacional Sistema Arrecifal Veracruzano not recorded by Del Moral-Flores et al. (2013). Sources: 1 CONABIO; 2 iDigBio; 3 Santander-Mosalvo et al. 2016; 4 Observations by DRR, CJE & AME; 5 Collections by ODD; 6 Ayala-Rodríguez et al. (2016); 7 GBIF; 8 Fishnet2; 9 Robertson et al. (2016a); 10 Avalos et al. (2008); 11 FishBase; 12 OBIS. Key: H = habitat; SB = soft-bottom/ estuarine, P = pelagic, R = reef, BP = benthopelagic. Distribution: WA = West Atlantic; GC = Greater Caribbean; GoMx =Gulf of Mexico; NWA = Northest Atlantic; information on global ranges and West Atlantic latitudinal ranges from https://biogeodb.stri.si.edu/caribbean/en/pages and https://www.iucnredlist.org/search

Family	Species	H	Distribution	Source
Triakidae	*Mustelus canis* (Mitchill, 1815)	SB	WA (Canada to Uruguay)	7
Potamotrygonidae	*Styracura schmardae* (Werner, 1904)	SB	GC (GoMx to Guyana)	7
Mobulidae	*Mobula hypostoma* (Bancroft, 1831)	SB	WA (E USA to Argentina)	7
	Mobula spp.	P	GC (North Carolina to South Caribbean)	4
Muraenidae	*Gymnothorax ocellatus* Agassiz, 1831	SB	WA (Cuba to Brazil)	2,8
Ophichthidae	*Ahlia egmontis* (Jordan, 1884)	SB	WA (South Carolina to Brazil)	2,7,8,11,12
	Bascanichthys bascanium (Jordan, 1884)	SB	GC (Georgia to South Caribbean)	2,8
	Bascanichthys scuticaris (Goode & Bean, 1880)	SB	GC (Nth Carolina to GoMx)	7,11,12
	Echiophis intertinctus (Richardson, 1848)	SB	WA (North Carolina to Brazil)	7
	Ethadophis akkistikos McCosker & Bohlke, 1984	SB	GC (GoMx to Suriname)	2,8
	Gordiichthys randalli McCosker & Böhlke, 1984	SB	GC (GoMx to South Caribbean)	2,8
	Ophichthus cruentifer (Goode & Bean, 1896)	SB	NWA (Maine to Suriname)	6
Congridae	*Rhynchoconger flavus* (Goode & Bean, 1896)	SB	WA (GoMx to Brazil)	2,8
	Uroconger syringinus Ginsburg, 1954	SB	Transatlantic (Florida to Suriname)	2,8
Engraulidae	*Anchoa cubana* (Poey, 1868)	P	WA (Nth Carolina to Brazil)	2,7,8
	Anchoa lamprotaenia Hildebrand, 1943	P	GC (GoMx to Guyana)	1,7,11,12
	Anchoa mitchilli (Valenciennes, 1848)	P	NWA (Maine to GoMx)	1,2,6,7
	Anchoviella perfasciata (Poey, 1860)	P	GC (Nth Carolina to Orinoco River)	2,7,8
	Cetengraulis edentulus (Cuvier, 1829)	P	WA (GoMx to Brazil)	1,2,7,8,11,12
Clupeidae	*Brevoortia gunteri* Hildebrand, 1948	P	GC (Endemic to GoMx)	2,7,8
	Dorosoma petenense (Günther, 1867)	P	GC (GoMx to Guatemala)	2,7
	Opisthonema oglinum (Lesueur, 1818)	P	WA (Maine to Brazil)	1,6,7
Ariidae	*Cathorops aguadulce* (Meek, 1904)	SB	GC (Endemic to GoMx)	7,8
Batrachoididae	*Opsanus beta* (Goode & Bean, 1880)	SB	GC (E Florida to Belize)	1,2,7,11,12
Ogcocephalidae	*Dibranchus atlanticus* Peters, 1876	SB	WA (Canada to Brazil)	2,7,8
Mugilidae	*Dajaus monticola* (Bancroft, 1834)	SB	GC (North Carolina to Orinoco River)	7,8,12
	Mugil trichodon Poey, 1875	SB	GC (Bermuda to South Caribbean)	2,7
Atherinopsidae	*Membras martinica* (Valenciennes, 1835)	P	NWA (New York to GoMx)	6
	Menidia beryllina (Cope, 1867)	P	NWA (Massachusetts to GoMx)	6
Exocoetidae	*Cheilopogon cyanopterus* (Valenciennes, 1847)	P	W Atlantic & Indo-West Pacific (40°N to 40°S)	6
	Exocoetus volitans Linnaeus, 1758	P	Circumtropical (35°N to 30°S)	6
	Hirundichthys rondeletii (Valenciennes, 1847)	P	Circumtropical (Nova Scotia to South Caribbean)	2,8,12
Hemiramphidae	*Oxyporhamphus similis* Bruun, 1935	P	Transatlantic (40°N to 20°S)	6
Belonidae	*Strongylura marina* (Walbaum, 1792)	P	WA (Massachusetts to Brazil)	2,6,7,8
	Tylosurus acus acus (Lacepéde, 1803)	P	WA (Massachusetts to Brazil)	2,7,8
Syngnathidae	*Microphis lineatus* (Kaup, 1856)	SB	WA (N USA to Brazil)	7,8,11,12
	Syngnathus louisianae Günther, 1870	SB	NWA (New Jersey to GoMx)	2,7,8
	Syngnathus scovelli (Evermann & Kendall, 1896)	SB	WA (NE Florida to Brazil)	7
Dactylopteridae	*Dactylopterus volitans* (Linnaeus, 1758)	SB	Transatlantic (Massachusetts to Argentina)	6
Scorpaenidae	*Pterois volitans* (Linnaeus, 1758)	R	Indo-West Pacific; invasive	1,3,5,7
	Scorpaena brasiliensis Cuvier, 1829	R	WA (Georgia to Brazil)	2,7,8
Triglidae	*Prionotus rubio* Jordan, 1886	SB	GC (North Carolina to Guyana)	2,7,8

Family	Species	H	Distribution	Source
Triglidae	*Prionotus tribulus* Cuvier, 1829	SB	NWA (New York to GoMx)	1,7
Centropomidae	*Centropomus mexicanus* Bocourt, 1868	SB	WA (SE Florida to Brazil)	2,7
	Centropomus pectinatus Poey, 1860	SB	WA (Florida to Brazil)	2,7
	Centropomus poeyi Chávez, 1961	SB	GC (SW GoMx to Belize)	2,7,8,12
Serranidae	*Hemanthias leptus* (Ginsburg, 1952)	R	GC (North Carolina to Suriname)	1,7
	Hypoplectrus gemma Goode & Bean, 1882	R	GC (SE Florida to SW GoMx)	10
Apogonidae	*Apogon aurolineatus* (Mowbray, 1927)	R	GC (Georgia to South Caribbean)	6
Coryphaenidae	*Coryphaena equiselis* Linnaeus, 1758	P	Circumtropical (Nova Scotia to Brazil)	6
Gerreidae	*Eucinostomus jonesii* (Gunther,1879)	SB	WA (Bermuda to Brazil)	2,7,8
	Eugerres brasilianus (Cuvier, 1830)	SB	WA (Cuba to Brazil)	2,7,8
Haemulidae	*Haemulon boschmae* (Metzelaar, 1919)	R	GC (SW GoMx to Guyana)	4
	Haemulon vittatum (Poey, 1860)	R	WA (North Carolina to Brazil)	7
Sparidae	*Calamus nodosus* Randall & Caldwell, 1966	SB	GC (North Carolina to GoMx)	4
Polynemidae	*Polydactylus virginicus* (Linnaeus, 1758)	SB	WA (North Carolina to Brazil)	2,7,8
Sciaenidae	*Cynoscion arenarius* Ginsburg, 1930	SB	GC (Endemic to GoMx)	2,7,8
	Cynoscion nebulosus (Cuvier, 1830)	SB	NWA (New York to GoMx)	6
	Cynoscion nothus (Holbrook, 1848)	SB	NWA (Chesapeake Bay to GoMx)	1,2,7,8,11,12
	Larimus fasciatus Holbrook,1855	SB	NWA (Massachusetts to GoMx)	2,7,8
	Menticirrhus americanus (Linnaeus, 1758)	SB	WA (Massachusetts to Argentina)	1,2,7,8,11,12
	Menticirrhus littoralis (Holbrook, 1847)	SB	WA (Massachusetts to Brazil)	2,7,8
	Menticirrhus saxatilis (Bloch & Schneider, 1801)	SB	NWA (Maine to GoMx)	2,7,8
	Umbrina coroides Cuvier, 1830	SB	WA (Chesapeake Bay to Brazil)	1,2,7,8
Kyphosidae	*Kyphosus cinerascens* (Forsskal, 1775)	R	Indo-Pacific & trans-Atlantic (Bahamas to Brazil)	4
Pomacentridae	*Neopomacentrus cyanomos* (Bleeker, 1856)	R	Indo-West Pacific; alien	9
Tripterygiidae	*Enneanectes boehlkei* Rosenblatt, 1960	R	GC (Florida to South Caribbean)	5
Blenniidae	*Entomacrodus nigricans* Gill, 1859	R	GC (Bermuda to South Caribbean)	4
	Hypsoblennius hentz (Lesueur, 1825)	R	NWA (Nova Scotia to Caribbean Mexico)	6
	Lupinoblennius vinctus (Poey, 1867)	SB	GC (Cuba to South Caribbean)	12
Labrisomidae	*Gobioclinus gobio* (Valenciennes, 1836)	R	GC (Florida to South Caribbean)	2,5,7
	Gobioclinus guppyi (Norman, 1922)	R	GC (Florida to South Caribbean)	5
	Paraclinus nigripinnis (Steindachner, 1867)	R	GC (Florida to South Caribbean)	2,7,8
	Starksia ocellata (Steindachner, 1876)	R	GC (North Carolina to NW Caribbean)	5
Chaenopsidae	*Stathmonotus hemphillii* Bean, 1885	R	GC (Bahamas to Central Caribbean)	5
Eleotridae	*Dormitator maculatus* (Bloch, 1792)	SB	WA (North Carolina to Brazil)	7
	Gobiomorus dormitor Lacepede, 1800	SB	Transatlantic (Bermuda to Brazil)	7,8,11,12
Gobiidae	*Bathygobius mystacium* Ginsburg, 1947	R	GC (Florida to South Caribbean)	2,7
	Ctenogobius boleosoma (Jordan & Gilbert, 1882)	SB	WA (Chesapeake Bay to Brazil)	1,2,7,8,11,12
	Ctenogobius claytonii (Meek, 1902)	SB	GC (Endemic to GoMx)	2,7
	Evorthodus lyricus (Girard, 1858)	SB	WA (Chesapeake Bay to Brazil)	1,2,7,8,11,12
	Gobioides broussonnetii Lacepede, 1800	SB	WA (Georgia to Brazil)	2,7
	Gobionellus oceanicus (Pallas, 1770)	SB	NWA (Virginia to Suriname)	2,7
	Nes longus (Nichols, 1914)	R	GC (Bermuda to South Caribbean)	4
Microdesmidae	*Microdesmus carri* Gilbert, 1966	SB	GC (GoMx to South Caribbean)	1,2,7,8,11,12
Trichiuridae	*Trichiurus lepturus* Linnaeus, 1758	BP	Transatlantic & Indo-West Pacific;	2,7,8
Xiphiidae	*Xiphias gladius* Linnaeus, 1758	P	Circumtropical (Canada to Argentina)	11
Stromateidae	*Peprilus paru* (Linnaeus, 1758)	BP	WA (Chesapeake Bay to Argentina)	1,7
Paralichthyidae	*Citharichthys abbotti* Dawson, 1969	SB	GC (GoMx to Honduras)	1,7,11,12
	Citharichthys macrops Dresel, 1885	SB	WA (Chesapeake Bay to Brazil)	1,2,7,8
	Etropus crossotus Jordan & Gilbert, 1882	SB	E Pacific & W Atlantic (Virginia to Brazil)	2,7,8
Achiridae	*Achirus lineatus* (Linnaeus, 1758)	SB	WA (South Carolina to Argentina)	1,2,6,7,8,11, 12
	Trinectes maculatus (Bloch & Schneider, 1801)	SB	NWA (Massachusetts to GoMx)	2,7,8
Monacanthidae	*Stephanolepis setifer* (Bennett, 1831)	R	WA (North Carolina to Brazil)	6
Tetraodontidae	*Canthigaster jamestyleri* Moura & Castro, 2002	R	GC (North Carolina to South Caribbean)	4

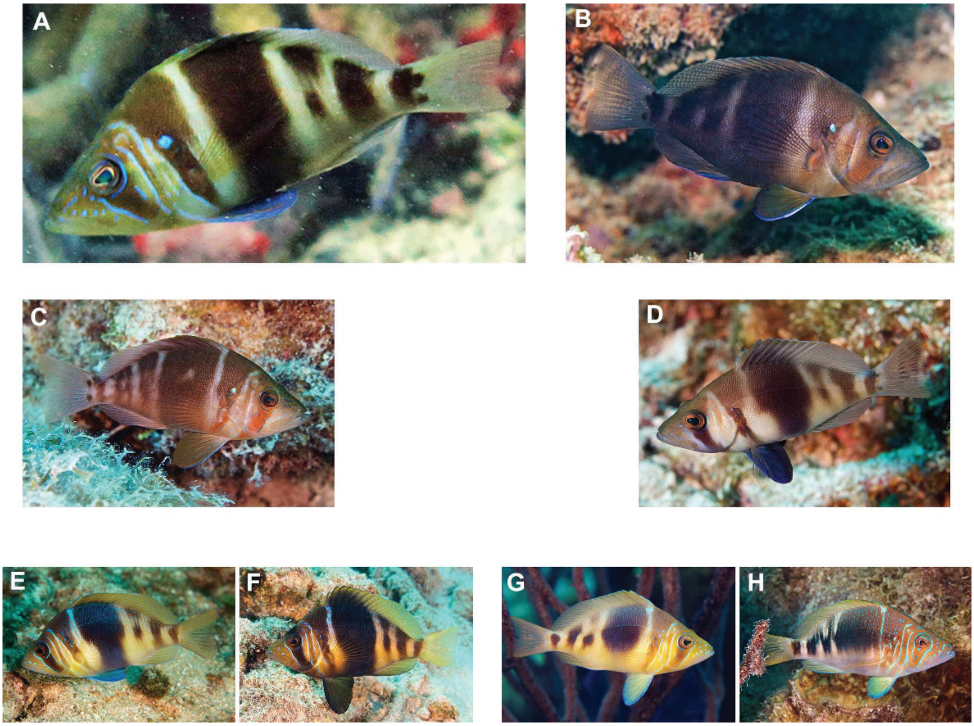


Figure 2. *Hypoplectrus floridae* and *Hypoplectrus puella*. **A, B** *H. floridae* from PNSAV **C, D** *H. floridae* from southeast Florida **E–H** *H. puella* **E** Roatan **F** Bonaire **G** Bonaire **H** Southeast Florida. Photographs A HP-E, B-H CJE & AME.

no verified recent records of either of these two species in the southwest Gulf of Mexico since *H. burekae* was described. *Halichoeres burekae* is a common inhabitant of PNSAV reefs (our observations) that is in the Del Moral-Flores et al. (2013) list. We excluded these two records during the update.

Ophioblennius atlanticus (Valenciennes, 1836). The name *O. atlanticus* was originally applied to the populations in both the west and east Atlantic. However, the Greater Caribbean population is now recognized as *O. macclurei* (Silvester, 1915), and *O. atlanticus* refers to the east Atlantic population only (Collette et al. 2003). As the Del Moral-Flores et al. (2013) list includes *O. macclurei* as well as *O. atlanticus* the record of *O. atlanticus* was excluded during the update.

Eleotris pisonis (Gmelin, 1789) to ***Eleotris amblyopsis*** (Cope, 1871). Pezold and Cage (2002) revised the genus and found that *E. pisonis* is restricted to eastern South America. *Eleotris amblyopsis* has been collected in the study area (see Table 1). We excluded this record when constructing the update. It should also be noted that *Eleotris perniger* (Cope, 1871) which ranges from Veracruz south to Brazil (Pezold et al. 2015) also has aggregator records very near the PNSAV and probably occurs within it.

Elacatinus evelynae (Böhlke & Robins, 1968) to ***Elacatinus prochilos*** (Böhlke & Robins, 1968), which is on the Del Moral-Flores et al. (2013) list. *Elacatinus evelynae*, which has a color pattern very similar to that of *E. prochilos*, is restricted to the Bahamas, Antilles and central Caribbean. It is not known from the northwest Caribbean. *Elacatinus prochilos* does occur along the coast of the northwest Caribbean from Honduras to northeast Yucatan and hence is the more likely of the two species to be present at Veracruz. There are no records of either species from the reefs of Campeche bank. We excluded this record from the update

Tigrigobius dilepis (Robins & Böhlke, 1964) and ***Tigrigobius saucrus*** (Robins, 1960) to ***Tigrigobius redimiculus*** (Taylor & Akins, 2007). Records of *T. dilepis* and *T. saucrus* in the PNSAV precede the date of the relatively recent description of *T. redimiculus*, which was based on specimens from the PNSAV. These three species have similarly structured color patterns, with the dark marks on the head and body ranging from brown in *T. saucrus* to red in *T. dilepis* to a brown body with a red head in *T. redimiculus* (Figure 3). *Tigrigobius redimiculus* is endemic to the southwest Gulf of Mexico, where it ranges from reefs of Veracruz state to Alacranes reef on the central Campeche Bank. The older Veracruz record is the only one for *T. dilepis* anywhere in the GoMx, while *T. saucrus* has confirmed records in the GoMx only at the Florida Keys and northern Cuba. No other species of goby in the wider Caribbean as similar to *T. redimiculus* as are *T. dilepis* or *T. saucrus* is known from the Gulf of Mexico. *Tigrigobius redimiculus* was common on massive coral heads in very shallow water on all reefs visited, but no *T. dilepis* or *T. saucrus* (Figure 3) were observed, despite searches for them by DRR, CJE and AME in May 2019. We excluded these two records from the update.

Questionable additional records from Ayala-Rodríguez et al. (2016)

The study of fishes in the PNSAV by Ayala-Rodriguez et al. (2016) was focused primarily on larval fishes. However, they also added 16 species, based on records of adults, that were not included by Del Moral-Flores et al. (2013), including two deep-water species (*Bregmaceros cantori* (Milliken & Houde, 1984) and *Tetragonurus atlanticus* (Lowe, 1839)) we do not include here, and three questionable records that we discuss below.

Menidia menidia (Linnaeus, 1766). The generally recognized geographic range of this species is limited to the east coast of North America, from central Florida to Newfoundland (Carpenter and Munroe 2015). This record likely relates to a congener, e.g., *M. peninsulae*, which was not recorded in the PNSAV by either Ayala-Rodríguez et al. (2016) or Del Moral-Flores et al. (2013), and the known range of which extends along the northern coast of the GoMx and south along the western coast to at least Tamiahua, 275 km from Veracruz city in the northern part

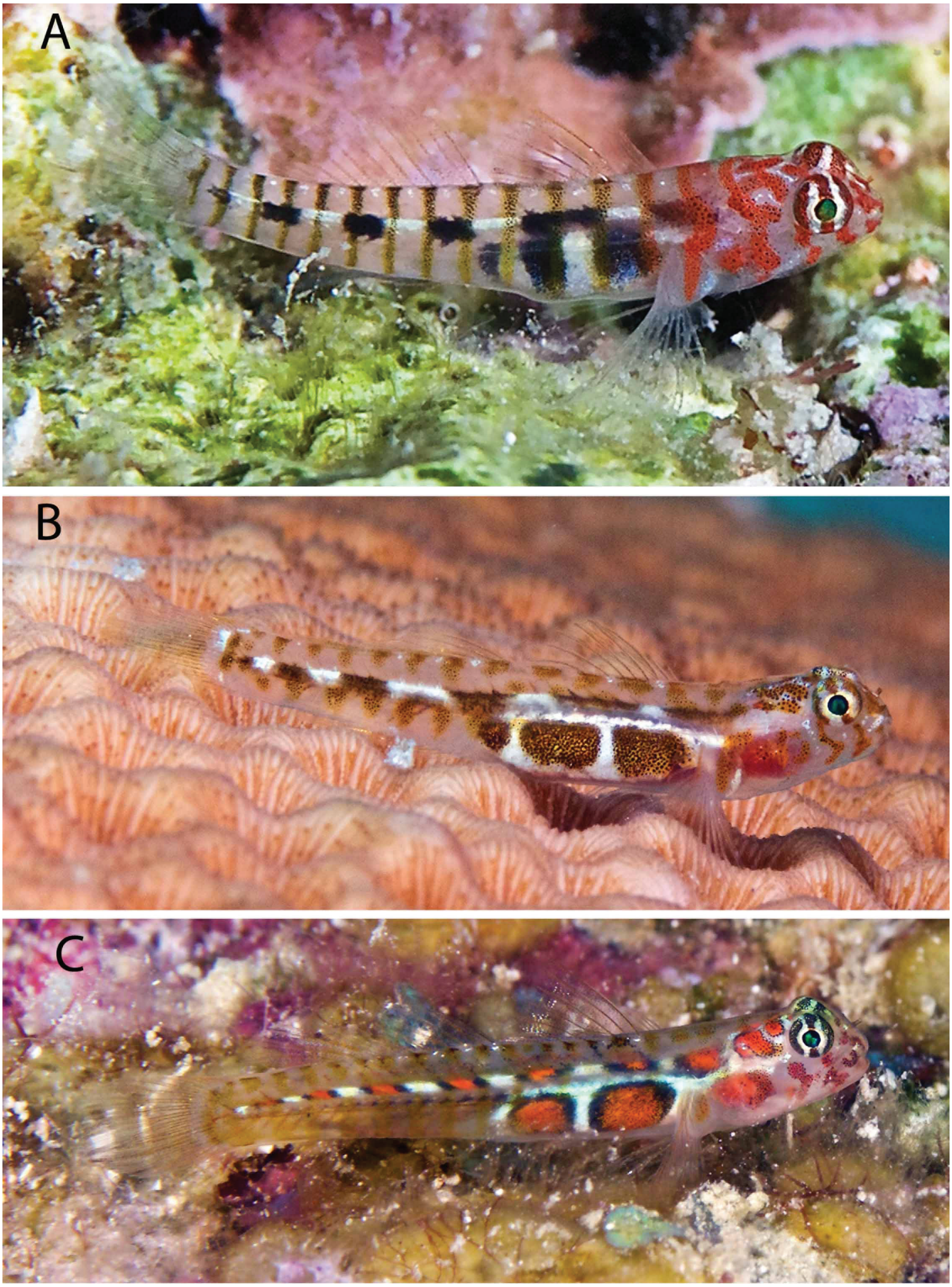


Figure 3. Three *Tigrigobius* species. **A** *T. redimiculus* from PNSAV **B** *T. saucrus* from Roatan **C** *T. dilepis* from Grand Cayman. Photographs CJE & AME.

of Veracruz state (Castro-Aguirre et al. 1999; Chao et al. 2015 a; Raz-Guzmán et al. 2018). The update does not include this record.

Cynoscion regalis (Bloch & Schneider, 1801). The generally recognized geographic range of this species is the east coast of North America from Nova Scotia to southeast Florida, with occasional individuals on the southwest coast of Florida (Chao, 2003). *Cynoscion nebulosus* (Cuvier, 1830), which Ayala-Rodriguez et al. (2016) also recorded in the PNSAV, is a look-alike sister species that is sometimes misidentified as *C. regalis* (Chao, 2003). The known range of *C. nebulosus* extends from New York south throughout the Gulf of Mexico (except Cuba) (Chao et al. 2015b). Raz-Guzmán et al. (2018) recorded this species, but not *C. regalis*, in northern Veracruz state. Similarly, Castro-Aguirre et al. (1999) recorded *C. nebulosus* but not *C. regalis* from México. This record was not included in the update.

Membras vagrans (Goode & Bean, 1879); type locality Pensacola, Florida. Ayala-Rodriguez et al. (2016) and Raz-Guzmán et al. (2018) listed both *M. martinica* (Valenciennes, 1835) and *M. vagrans* at the PNSAV and at Tamiahua lagoon, 275 km north of the PNSAV, respectively. Castro-Aguirre et al. (1999, p. 191) treated *M. vagrans* as valid and provided a dichotomous key that separated *M vagrans* and *M. martinica* on the basis of non-overlapping numbers of anal fin rays: 14–18 for *M. vagrans* and 19–22 for *M martinica*. However, the geographic range of *M. vagrans* is overlapped completely by that of *M. martinica*, Miller (2006, p. 201) listed *M. vagrans* as a synonym of *M. martinica*, both McEachran and Fechhelm (1998, p. 886) and Robins et al. (2018, p. 185) did not include *M. vagrans* and gave anal fin ray counts for *M. martinica* of 14–21, completely overlapping the range given by Castro-Aguirre et al. (1999) for *M. vagrans*. In addition, Chernoff (1986) did not include *M. vagrans* in his revision of the Menidine silversides, and Chernoff (2003) did not include it in the FAO guide to the fishes of the northwest Atlantic. Hence it seems best at present to regard *M. vagrans* as a synonym of *M. martinica*. We did not include this record in the update.

Additional species from the aggregators and recent literature

We found records of 95 additional species not listed by Del Moral-Flores et al. (2013) that are known to occur in depths shallower than 50 m elsewhere in their geographic ranges. Those, which include two elasmobranchs, are from 73 genera and 41 families (Table 1), with eight of those families and 42 of those genera not recorded by Del Moral-Flores et al. (2013). Seventy-one (74.7%) of the additional records came from the six aggregators. While those aggregators produced the great majority of additional records only seven species (9.9% of those in aggregator databases) were recorded in all six aggregator databases. In addition, 10 (14.1%) of those 71 species were recorded from only one aggregator, eight from GBIF and one each from FishBase and OBIS.

GBIF provided the greatest number of additional aggregator records, 61 species, but missed 14.1% of species recorded by one or more of the other aggregators. CONABIO recorded 18 additional species, iDigBio 49 species, Fishnet2 42 species, FishBase 15 species, and OBIS 18 species. Given this degree of variability in numbers and identity of species recorded by different aggregators it is evident that records need to be obtained from multiple aggregators to assemble comprehensive checklists. Further, two aggregators that draw data from the same sources do not necessarily provide the same set of georeferenced records for the same species: that table shows concurrence of additional species records among those extracted from iDigBio and Fishnet2 in only 37 (69.8%) of 53 cases in which either source provided a record, with five cases of species for which records extracted directly from Fishnet2 were not present in iDigBio. In contrast, GBIF, which also receives Fishnet2 data, did record all species recorded by Fishnet2.

The additional species records also include 25 species not in the aggregator databases: 12 of those recorded by Ayala-Rodríguez et al. (2016), one by Avalos et al. (2008), four collected by ODD and students in 2015 (in addition to 81 species they collected that are on the Del Moral-Flores et al. (2013) list), and seven species observed (plus one previously unnamed species on the Del Moral-Flores et al. (2013) list subsequently identified), and in three cases photographed, by DRR, CJE and AME during one week of diving and snorkeling in May 2019. Additional records also include two invasive Indo-Pacific species: *Pterois volitans* (Linnaeus, 1758), known from the PNSAV since the beginning of 2012 (Santander-Monsalvo et al. 2012), and *Neopomacentrus cyanomos* (Bleeker,1856) (see Figure 4), which was first recorded in the PNSAV by Horacio Pérez-España (HP-E) in early 2014 (see Robertson et al. 2016b). In addition, one species recorded by Tello-Musi et al. (2018) (*Hypoplectrus floridae*) effectively replaced one of the species (*H. puella*) on Del Moral-Flores (2016) list.

The additional species added since Del Moral-Flores et al. (2013) and discussed here include species with a range of biogeographic distributions, 32 Greater Caribbean endemics (including four GoMx endemics), 13 Northwest Atlantic endemics (found in and to the north of the Greater Caribbean), 33 West Atlantic endemics found in both the Greater Caribbean and Brazil, four transatlantic species, seven circumtropical species, and two aliens from the Indo-Pacific.

Additional species and endemics observed by the authors during May 2019

Mobula aff. birostris (the Caribbean manta; see Stevens et al. 2018). A large individual of this unnamed species, which has a distinctively different color pattern to that of *M. birostris* (Walbaum, 1792) (see Stevens et al. 2018), the only other morphologically similar species in the wider Caribbean, was closely observed by CJE, AME and DRR as it circled overhead during one dive; unfortunately poor visibility then did not allow for an adequate photograph. *Haemulon boschmae* (Metzelaar, 1919) was photographed by the wreck Riva Palacio (Figure 5), *Calamus nodusus* Randall & Caldwell, 1966 was photo-

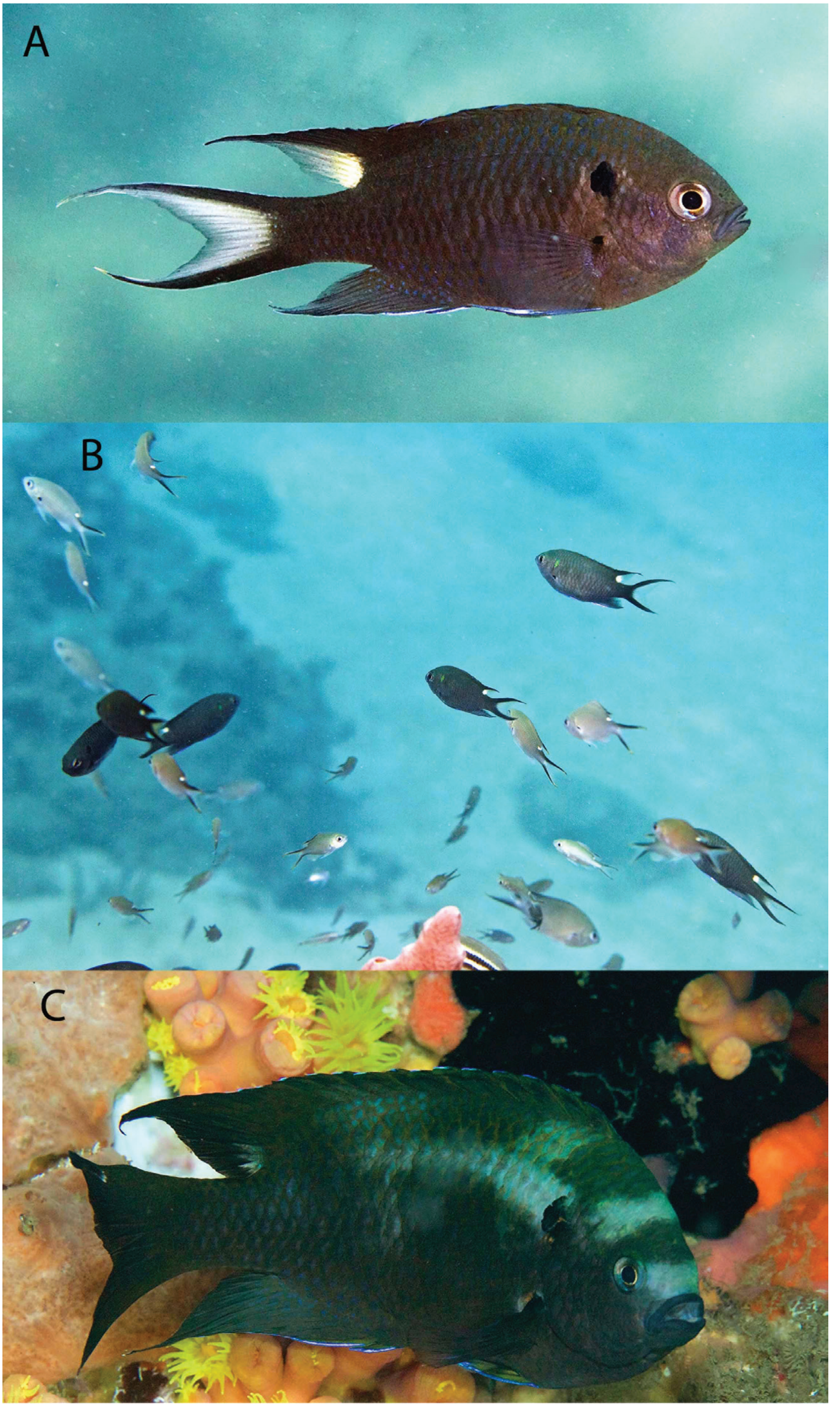


Figure 4. *Neopomacentrus cyanomos* in the PNSAV **A** adult **B** an aggregation of large juveniles and small adults with juveniles of *Chromis multilineata* **C** large male with nuptial colors. Photographs CJE & AME.

Figure 5. *Haemulon boschmae* in the PNSAV. Photograph CJE & AME.

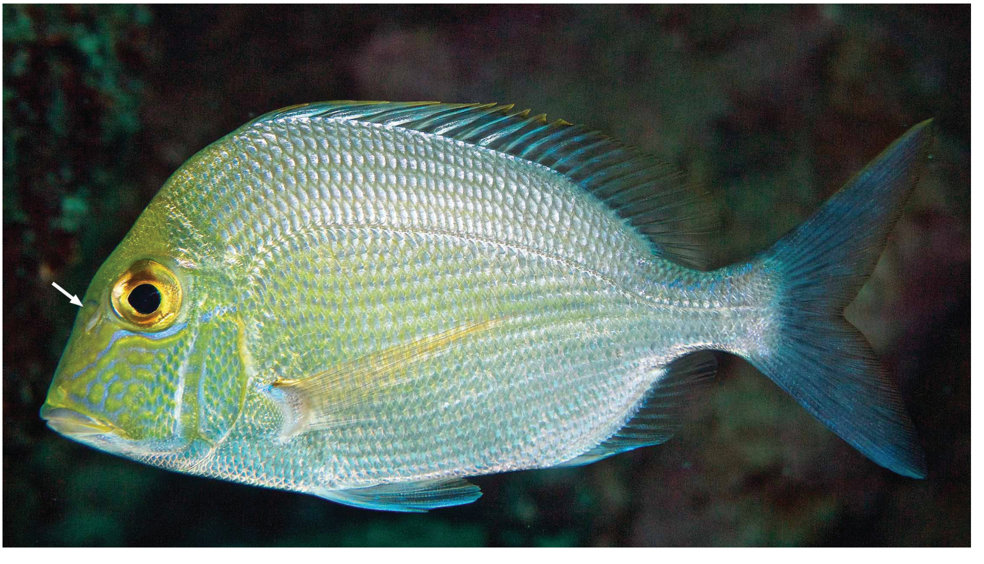


Figure 6. *Calamus nodosus* subadult in the PNSAV. Note the nodule (indicated by arrow) characteristic of this species on side of snout before eye. Photograph CJE & AME.

Figure 7. *Canthigaster jamestyleri* in the PNSAV. Photograph CJE & AME.

graphed on De Enmedio reef (Figure 6); DRR, CJE and AME observed, and CJE photographed *Canthigaster jamestyleri* Moura & Castro, 2002 on Anegada reef (Figure 7), including one aggregation of 5 adults, in relatively shallow water for this species (14–20 m depth). H P-E had noticed this species previously on PNSAV reefs, present in some years, not in others. We repeatedly observed schools of *Kyphosus* spp. containing young adults of *Kyphosus cinerascens* (Forsskål, 1775) on several reefs which, due to its distinctly elevated dorsal and anal fins (see Knudsen and Clements 2013), is easy to distinguish from other members of the genus. DRR observed *Entomacrodus nigricans* Gill, 1859 living in barnacles in 0.5 m depth water, its typical habitat, at the base of a lighthouse on each of two emergent reefs. CJE photographed *Emblemariopsis diaphana* Longley, 1927 (Figure 1) at Isla Verde, and Blanca reefs, *Emblemaria pandionis* Evermann & Marsh, 1900 (Figure 8) on Enmedio reef, and *Coryphopterus punctipectophorus* Springer, 1960 (Figure 9) on Anegada reef. DRR observed several pairs of *Nes longus* (Nichols, 1914), perched at the mouths of snapping-shrimp burrows in which they live, on a sand bottom with abundant live *Strombus pugilis* Linnaeus, 1758, ca. 25 m away from the base of Enmedio reef at 15 m depth. *Elacatinus jarocho* Taylor & Akins, 2007 (Figure 10), and *Halichoeres burekae* (Figure 11) both endemic to the southwest GoMx and on the Del Moral-Flores et al. (2013) list, were common and present on all reefs visited.

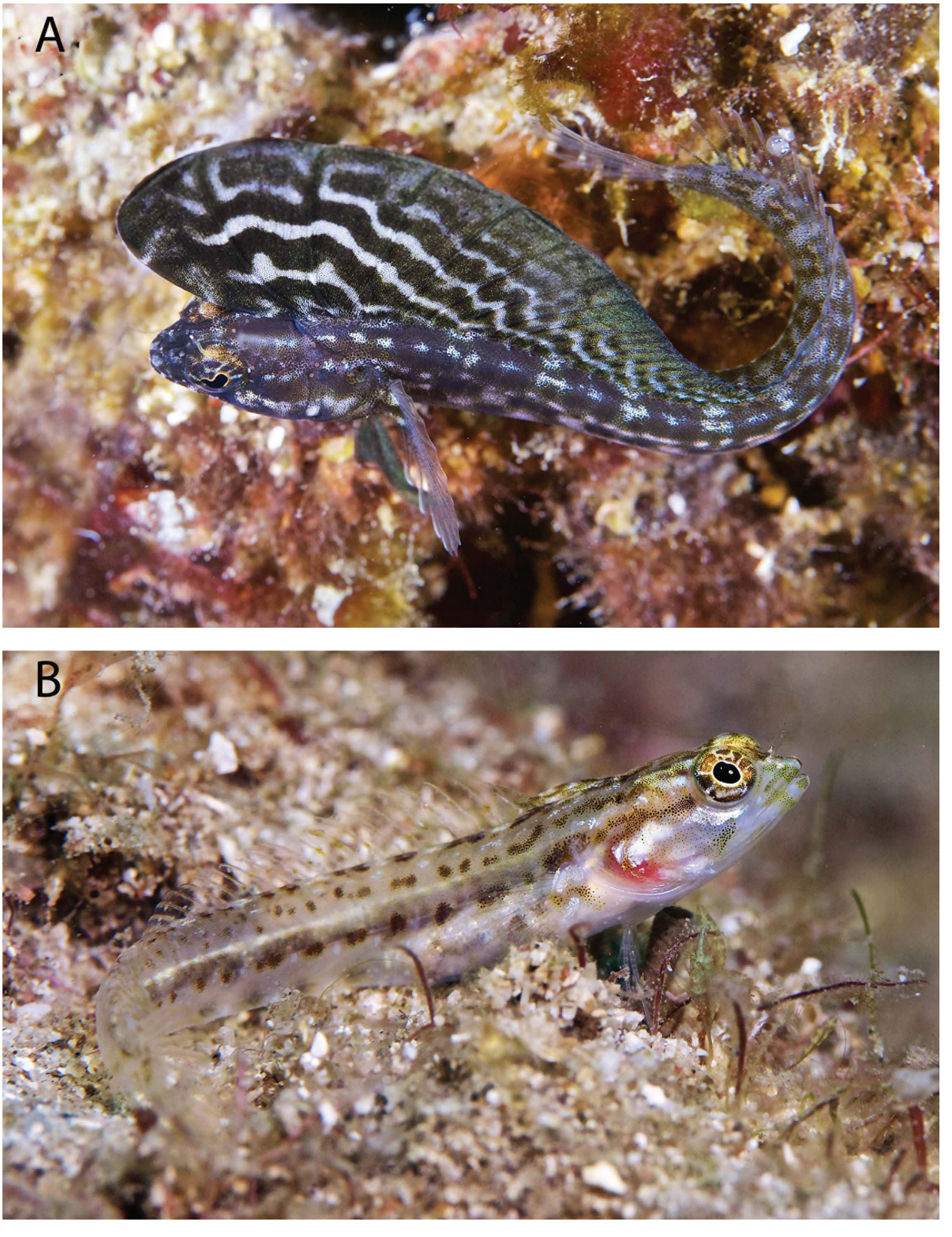


Figure 8. *Emblemaria pandionis* in the PNSAV **A** male **B** female or uncolored male. Photographs CJE & AME.

Figure 9. *Coryphopterus punctipectophorus* in the PNSAV. Photograph CJE & AME.

Figure 10. *Elacatinus jarocho* in the PNSAV. Photograph CJE & AME.

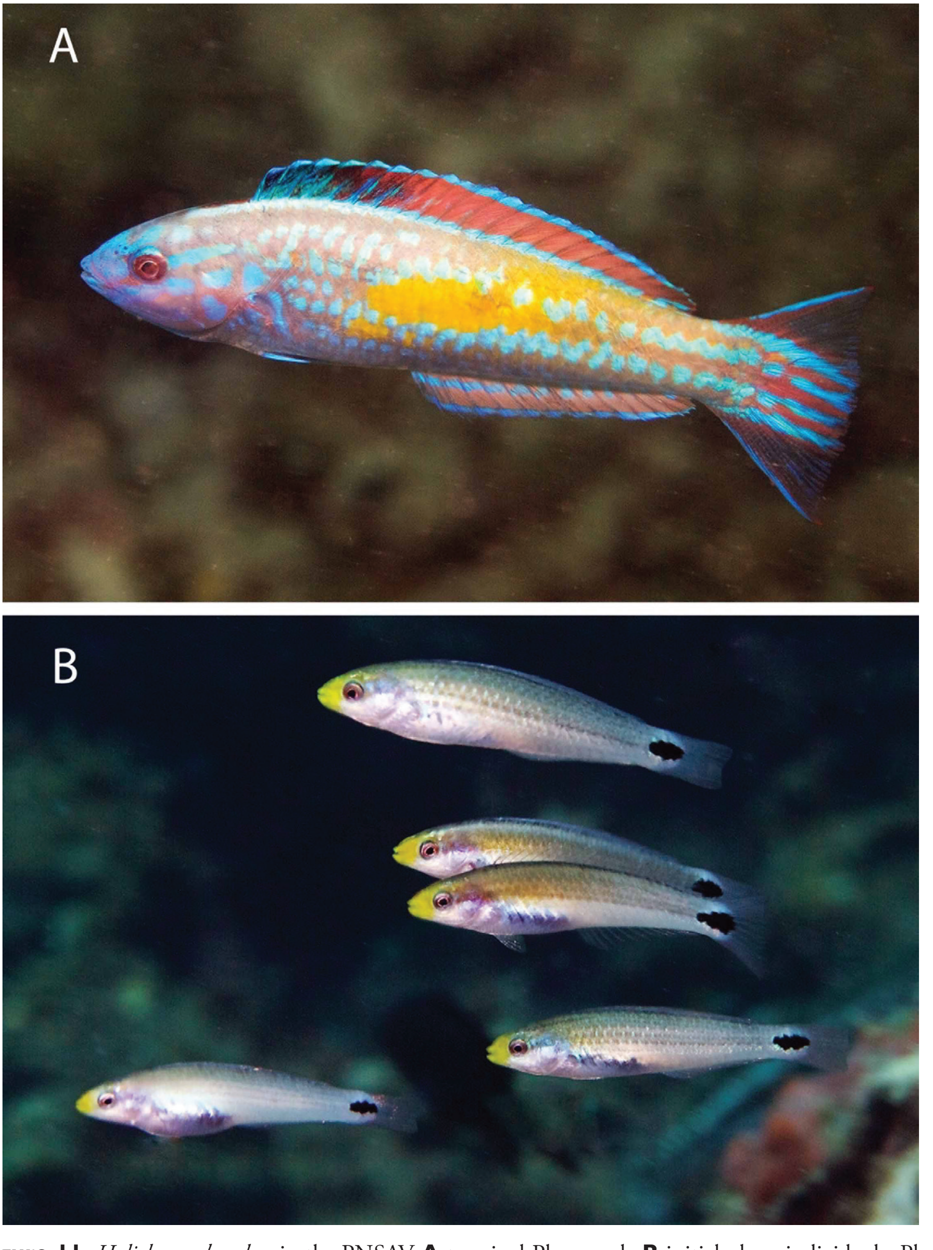


Figure 11. *Halichoeres burekae* in the PNSAV **A** terminal Phase male **B** initial phase individuals. Photographs CJE & AME.

Variation in coloration of two species of *Hypoplectrus* endemic to the southwest Gulf of Mexico

Two species of *Hypoplectrus* that are endemic to the southwest GoMx were recently described, both of which are present in the PNSAV. The descriptions were based on few specimens and did not adequately cover the range of variation in live coloration we

Figure 12. Adults of *Hypoplectrus atlahua* **A–C** are of the same individual taken a few minutes apart **D, E** are of another single individual taken a few minutes apart **H** note heavy marking of blue lines on head and thin vertical blue lines on body **F** at Tuxpan, the remainder in the PNSAV. Photographs: **F** by HP-E with natural light; the remainder by CJE & AME with electronic flash.

have observed, and photographed, in both species at the PNSAV. As color patterns are important taxonomic aids for identifying *Hypoplectrus* species and often vary within as well as between species we present additional information on variation in both species.

Hypoplectrus atlahua. The type locality of this species is offshore from Tuxpan, 250 km north along the coast from the PNSAV. The photographs presented here represent the first published of the live coloration of this species, as the original description included only photos of freshly killed specimens. Here we present a selection to show variation in the coloration of adults and describe some of that variation. We also present images and describe the juvenile color pattern, which is quite different to that of adults. We observed a full range of color patterns from that of small juveniles grading to that of the largest adults. Large adults of *H. atlahua* have uniform dark brownish black head, body and fins, the head usually being paler than the body (Figure 12G, I). The eyes are brown, and there is a prominent blue spot at the upper corner of the operculum, varying amounts of blue lines on the face (sometimes virtually absent: Figure 13), and a prominent blue front margin to the pelvic fins (Figure 12, and see Tavera and Acero 2013). Individuals of many other species of *Hypoplectrus* often have a blue spot at the upper corner of the operculum but smaller and more weakly colored than in *H. atlahua*. There is often an indistinct darker triangular bar

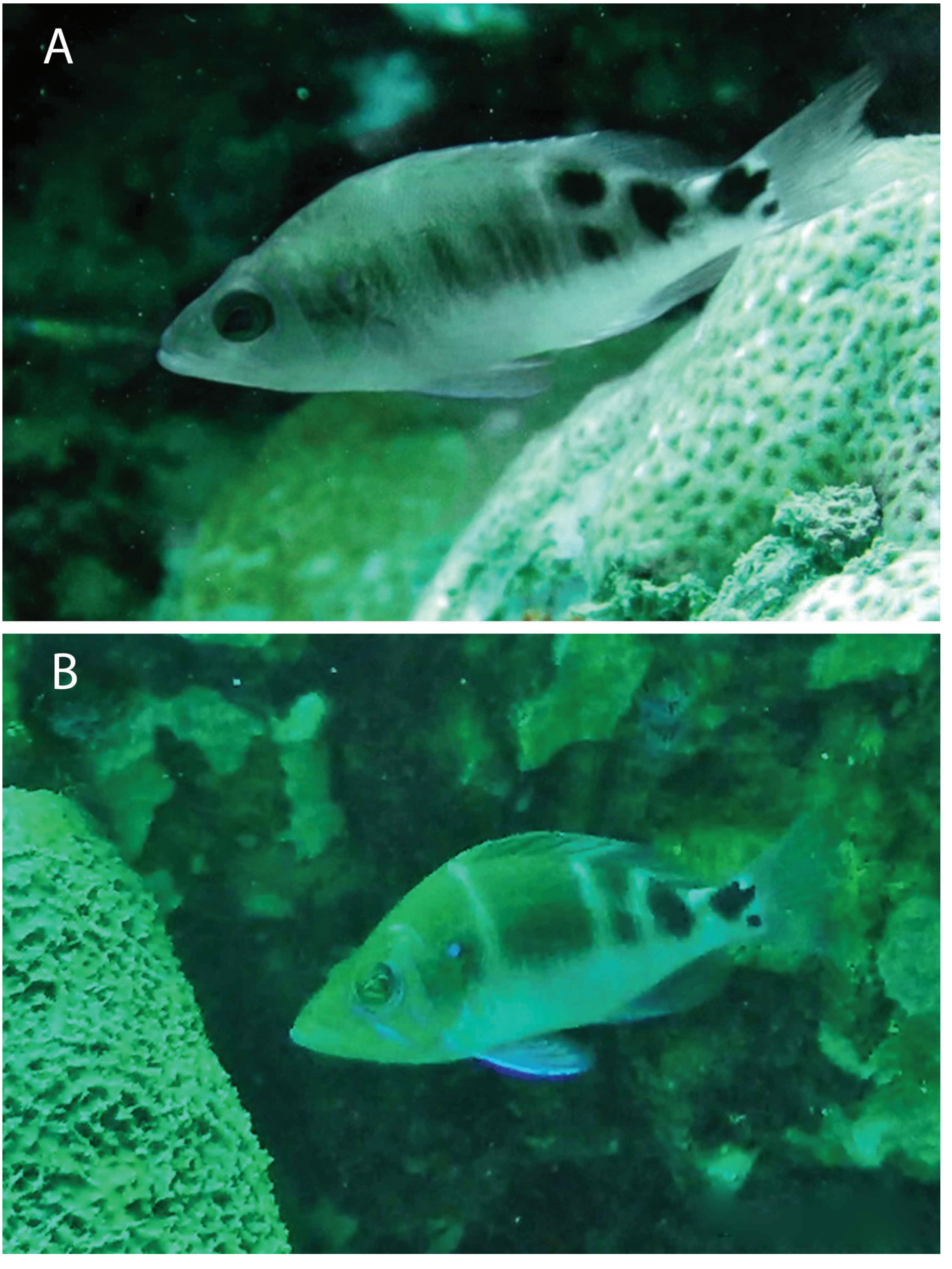


Figure 13. Juveniles of *Hypoplectrus atlahua* **A** at PNSAV **B** at Arrecife Lobos, Tuxpan. Photographs **A** Mariana Rivera-Higueras **B** DRR. Both photographs taken with natural light.

extending down and back from the eye to the lower rear corner of the operculum and the body can have indistinct dark bars (Figure 12F). The body sometimes has 15–20 faint vertical blue lines extending between the dorsal and ventral body profiles (Figure

Figure 14. Adults of *Hypoplectrus castroaguirrei* and its Caribbean look-alike congener *H. unicolor*. **A–E** *H. castroaguirrei* in the PNSAV **F** *H. unicolor* at Roatan. Photographs CJE & AME.

12H). Adults can change color between uniform blackish brown to mid-brown with indistinct dark blotches on the rear of the body (see Figure 12A-C, all of one fish), or they may change between a dark, indistinct barred pattern and more uniform dark pattern (see Figure 12D, E, both of another single fish).

Hypoplectrus atlahua juveniles (Figure 13) are differently colored: juveniles sometimes have pale bodies with five dark bars on the upper body, the anterior two brown, the rear three blackish, the third bar broken into two blotches, the last bar on the end of the caudal peduncle with two black spots adhering to its rear border, each of those spots with a bright white spot above it. Alternatively they sometimes have a grey-brown body, with a darker area along the side of the head and mid-flank, and a series of black blotches at the rear of the body, a vertical pair under the anterior soft dorsal, a single blotch under the rear of the soft dorsal, a large blotch before a pair of small round spots on the end of the caudal peduncle and base of the caudal fin, with whitish areas before and behind the top of the large caudal-base blotch. The fins are translucent. As fish grow, they get a progressively darker body and fins and the rear black blotches become less distinct.

Hypoplectrus castroaguirrei (Figure 14) Del Moral-Flores et al. (2011) described this species as being pale yellow, with fine blue lines on the head and chest, and blue spots on the top of the head; indistinct brown bars on the body, an oblique black bar from the top of eye down to the lower edge of the preopercle, a black blotch before the eye, both of those black marks finely edged with blue; a black blotch on the caudal peduncle; caudal, anal and pelvic fins yellow, the anal and pelvic fins with a thin blue border; the dorsal fin yellow with oblique blue lines. The type locality of this species is the PNSAV. There are very few photographs of live fish in the field available for this species (see Del Moral-Flores et al. 2011). Here we present and describe a selection taken on the reefs of the PNSAV, to provide an indication of the greater variation in this species coloration than was indicated in the original description. The ground color of the body of adults varies from pale yellowish white through mid-yellow to yellow with a brown tone over the upper body, to pale yellowish with indistinct brown bars on the upper body. The fins are yellow, and all except the caudal fin have a thin blue border. The dorsal fin, especially the soft part, is covered with many fine blue spots arranged in oblique lines, which sometimes coalesce into short, thin continuous stripes. The caudal peduncle bears a black blotch that varies considerably in size and shape, ranging from a small black blotch on the center of the upper caudal peduncle to a large, irregularly shaped blotch that covers most of the peduncle and extends forward on the rear of the body and onto the rear base of the soft dorsal fin, and sometimes is split into two separate blotches. The eye is black, surrounded by up to three black marks, including a triangular bar one angled back and down below the eye that is invariably present but varies in its length, a rounded blotch before the eye (present or absent), and a small rounded blotch above the top rear corner of the eye (present or absent). Those blotches are finely outlined with blue, there are varying amounts of blue lines on the snout, cheeks, operculum, nape, and breast, and varying arrangements of blue spots on the top of the head. The entire body of some individuals is covered with a series of ~15–20 thin vertical blue lines extending between the top and bottom profiles (Figure 14B). We have no photographs of small juveniles of this species.

Discussion

Taking into account the reductions in the number of species recorded by Del Moral-Flores et al. (2013) and the data we present here brings the total of shore-fishes currently known in the PNSAV to 474 species, an increase of 22.5% over the total listed by Del Moral-Flores et al. (2013). These additional records also increased the number of genera of fishes in the PNSAV by 45, to 251 and the number of families by eight, to 100. Del Moral-Flores et al. (2013) used several statistical techniques to estimate the total size of that MPA fish fauna and arrived at a range of 415 to 455 species. While the highest of those estimates is close to (4.2% lower than) the adjusted currently known total number based on the data added here, the ability of experienced field observers to add seven species during one week's snorkeling and SCUBA diving in depths of < 30 m on PNSAV reefs indicates that even 474 may represent a significant underestimate. Recently, additional shallow reefs have been discovered in and nearby to the north of PNSAV (Liaño-Carrera et al. 2019), which demonstrates the need for further studies of reefs not only of the PNSAV but elsewhere in the southwest GoMx.

Among the 95 additional species most live away from reefs, with 55.8% on and in soft bottom habitats and another 22.1% in pelagic or benthopelagic non-reef habitats. Only 22.1% of those species are demersal (or benthopelagic) forms that live on reefs and nine of those 21 species are small, cryptic fishes living within the interstices of reefs. Thus only 12 or 12.6% of the additional species represent relatively conspicuous reef fishes. Del Moral-Flores et al. (2013) efforts, in contrast were focused largely on reef fishes, mainly non-cryptic species. Populations of tropical reef-fishes and other shore-fishes do fluctuate, and rarer species may be seen at one time and not another (e.g., see comments above about *Canthigaster jamestyleri*). The update of a 50-year-old inventory of fishes on a Florida reef increased the total number of species by 21% (Starck et al. 2017), likely due to faunal changes as well as the availability of better information from sources similar to those we used here. Changes in abundances of different species likely contributed to lack of some records in the Del Moral-Flores et al. (2013) list. Furthermore, growth and increased industrial development of the city of Veracruz also may have produced changes to near-shore environments leading to changes in populations of different fish species in the PNSAV.

The Veracruz record for only seven of the additional 95 species, including four observed or collected by us, represents a significant range expansion: *Hypoplectrus gemma* Goode & Bean, 1882by 440 km (recorded on reefs of the western edge of Campeche Bank by Robertson et al. 2019); *Apogon aurolineatus* (Mowbray, 1927) by 575 km (recorded at Cayo Arenas, Campeche Bank by Robertson et al. 2019); *Kyphosus cinerascens* (Forsskål, 1775) by 440 km (recorded at Cayo Arcas on Campeche Bank by Robertson et al. 2016a); *Stathmonotus hemphilii* Bean, 1885 by 440 km (recorded at Cayo Arcas by Robertson et al. 2019); and *Canthigaster jamestyleri* Moura & Castro, 2002 by 445 km (recorded at Triángulo Este reef on Campeche Bank by Robertson et al. 2019). There is little georeferenced information available on the range of the Caribbean manta, *Mobula* cf. *birostris*, with the nearest existing records to Veracruz being at the eastern tip of the Yucatan peninsula and the Flower Garden Banks, off Texas, both ~1000 km from Veracruz. Among the aggregator-additions only one record, that of *Lupinoblennius vinctus* (Poey, 1867), represents a significant range extension, ~575 km from the west coast of the Yucatan peninsula. The fact that Veracruz is within the continental-shoreline section of the known range of all the remaining 71 additional aggregator species, almost all of which have up-to-date range maps published by https://www.iucnredlist.org, provides reason to accept those records. Judicious use of such data to update species location-lists, as we have done here, is not unusual (e.g., see Starck et al. 2017). However, while there is no reason to suspect the validity of those aggregator records we used here we cannot exclude the possibility that some are erroneous without extensive work by competent taxonomists checking specimens at a variety of museums. While such activity would be ideal it is simply not practicable in an age of shrinking resources available for basic taxonomic research at museums.

***Hypoplectrus* species in the PNSAV:** The only confirmed all-black hamlet in Veracruz state is *H.atlahua*. *Hypoplectrus nigricans* (Poey, 1852) is the Black Hamlet from the Caribbean, Florida and Bahamas. There are minor morphometric, meristic and color differences between the two species. However, those two species belong to geographically distinct, well differentiated genetic lineages, with *H. atlahua* a member of a GoMx clade that includes *H. floridae* and *H. castroaguirre*, and *H. nigricans* (from Belize at least) belonging to a Caribbean clade (Tavera and Acero 2013). It should also be noted that *H. nigricans* from west Campeche bank reefs have a different color pattern to that of *H. atlahua* (see Robertson et al. 2016a). Adults of *H. nigricans* from the Caribbean and Florida are variable in color and some have patterns very similar to that of adult *H. atlahua*, but typically lack the strong development of fine blue lines on the head that is seen in many *H.atlahua*. What juveniles of *H. nigricans* look like from those areas is unclear. The type locality for *H. nigricans* is Havana, on the north coast of Cuba, and which clade that population belongs to (GoMx or Caribbean) and how its color relates to that of *H. atlahua* and Caribbean *H. nigricans* remains to be determined. Large adults of *H. atlahua* in some cases have coloration remarkably similarly to that of some large adults of *H. nigricans* from the Caribbean, as can be seen in Figure 15. The only difference in such cases is the larger size of the blue spot at the top corner of the operculum, and stronger blue anterior border of the pelvic fins in *H. atlahua*.

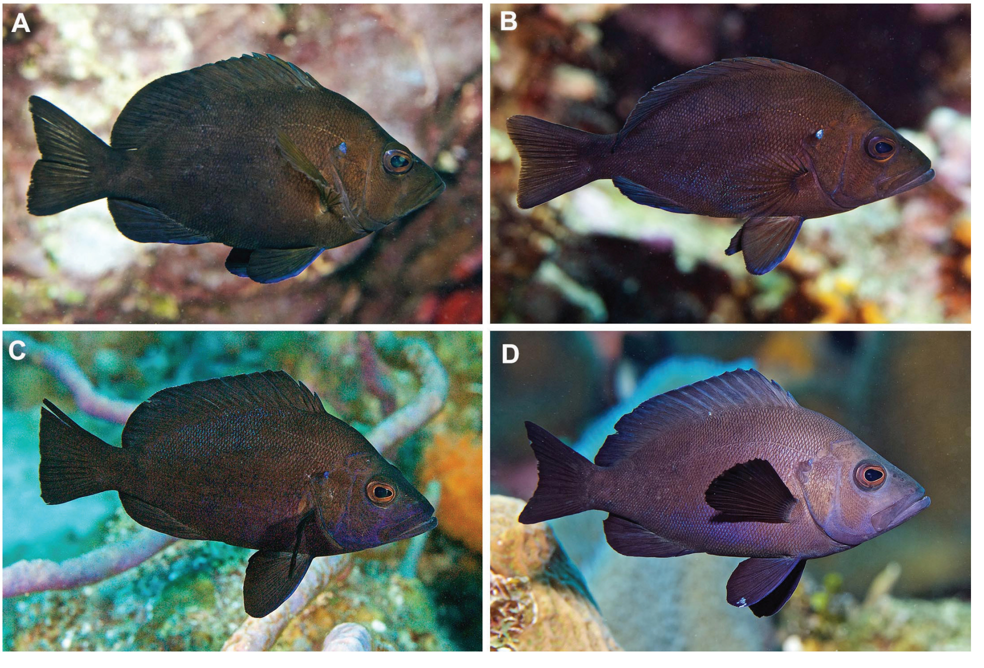


Figure 15. Adults of *Hypoplectrus atlahua* and its Caribbean look-alike congener *H. nigricans*. **A, B** *H. atlahua* in the PNSAV **C, D** *H. nigricans* at Grand Cayman and Roatan, respectively. Photographs CJE & AME.

Since those two allopatric, look-alike species belong to independent genetic lineages (Tavera and Acero 2013) these similarities likely are due to convergent evolution.

Tavera and Acero's (2013) genetic analyses indicate that *H. castroaguirrei* also belongs, with *H. floridae* and *H. atlahua*, to a GoMx lineage that is well differentiated from the Caribbean lineage. As well as *H. nigricans* the Caribbean lineage includes *H. unicolor*, the name used, due to similarity in coloration, for *H. castroaguirrei* before it was recently described. Thus, as with *H. atlahua* having a color pattern that possibly evolved convergently with that of *H. nigricans*, the coloration of *H. castroaguirrei* may represent the result of independent convergent evolution by allopatric, look-alike species to a pattern that strongly resembles that of *H. unicolor*. The only consistent difference in the coloration of those two species is the presence of the strong black bar through the eye angled down towards the lower preopercle in *H. castroaguirrei* that is not seen in *H. unicolor*.

It should also be noted that Del Moral-Flores et al. (2013) listed five other species of *Hypoplectrus* as present in the PNSAV: *H. aberrans* Poey, 1868, *H. chlorurus* (Cuvier, 1828), *H. gumigutta* (Poey, 1851), *H. guttavarius* (Poey, 1852), and *H. indigo* (Poey, 1851). DRR, CJE and AME did not observe any of these in May 2019 and we are not aware of any photographs of them from PNSAV that could be reviewed. Many species in this genus exhibit individual variation in coloration (see images in Robertson and Van Tassell 2015). The color patterns of some individuals of *H. aberrans*, *H. gumigutta* and *H. guttavarius*, all of which do or can have large areas of yellow on the body, resemble the coloration of some individuals of *H. castroaguirre*, which, as can be seen in Figure 14, varies in color. Similarly, the coloration of *H. aberrans* resembles that of a *H. atlahua* with a pale tail, and the coloration of *H. indigo* resembles that of *H. floridae* with the addition of heavy blue overtones. Revision of images of live individuals of those five species taken in the PNSAV would be useful for clarifying exactly how many species of this genus actually occur in the PNSAV.

Conclusions

Comprehensive inventories of local to regional fish faunas require not only literature reviews augmented by field observations and collections by inventory authors, but also careful and comprehensive review of information available in the databases of online aggregators. Those aggregators draw data from a variety of sources and provide information from museums that catalog specimens obtained since the beginning of research on fishes. Much of the aggregator material only became available recently and the amount of legacy information the aggregators provide continues to increase. Review of such material, and our own observations and collections, increased by 22% the known fish fauna of a large MPA next to a city with a substantial population and a university that has sponsored research on those fishes over the past several decades. This demonstrates the value of such aggregator material. However, different aggregators provide different information and multiple aggregators need to be consulted to obtain the fullest picture of their information. Aggregators do not themselves correct errors in material emanating from the primary sources of their information, which invariably contain uncorrected errors. Limitations in the quality of aggregator information due to misidentifications, outdated taxonomy and nomenclature, and errors in georeferencing of species records must be taken into consideration when using such data. In addition, the content of older lists needs to be carefully reviewed when updating faunal lists, to help ensure that old errors do not continue to be perpetuated, and that updates do not consist solely of additions to faunas.

Acknowledgements

Ernesto Peña extracted and organized the georeferenced species records in the PNSAV from the aggregator databases and updated the nomenclature of those records. Diving support to DRR, CJE and AME at Veracruz in May 2019 was provided by Manuel Victoria Muguira of Dorado Buceo in Veracruz city; we thank Angélica Vazquez for assistance with diving logistics. Yareli Margarita López Arroyo, Francisco Martínez Servin, Edgar Adrián Acevedo Álvarez and Francisco Loera Padilla assisted OD-D with field collections and identification of specimens collected and euthanized as required by a permit from the Secretaría de Agricultura y Desarollo Rural (SAGARPA PPF/DGOPA-262/17).

References

Aguilar-Perera A, Tuz-Sulub A (2009) Occurrence of the Mardi Gras wrasse, *Halichoeres burekae* (Teleostei: Labridae) in the Alacranes Reef, off northern Yucatán Peninsula. Zootaxa 2298: 64–68. https://doi.org/10.11646/zootaxa.2298.1.5

Arnold RJ, Pietsch TW (2012) Evolutionary history of frogfishes (Teleostei: Lophiiformes: Antennariidae): a molecular approach. Molecular Phylogenetics and Evolution 62: 117–129. https://doi.org/10.1016/j.ympev.2011.09.012

Avalos MAR, Jordan LKB, Walker BK, Gilliam DS, Hinojosa EC, Speiler RE (2008) Fish and Coral Reef Communities of the Parque Nacional Sistema Arrecifal Veracruzano (Veracruz Coral Reef System National Park) Veracruz, México: Preliminary Results. Proceedings of the 60th Gulf and Caribbean Fisheries Institute November 5–9, 2007 Punta Cana, 427–435.

Ayala-Rodríguez GA, Ordóñez-López U, Meiners C, Marín-Hernández M (2016) Listado taxonómico, aspectos ecológicos y biogeográficos de las larvas de peces del Sistema Arrecifal Veracruzano, Suroeste del Golfo de México (junio 2011-junio 2013). Revista de Biología Marina y Oceanografía 51: 255–264. https://doi.org/10.4067/S0718-19572016000200004

Carpenter KE, Munroe T (2015) *Menidia menidia*. The IUCN Red List of Threatened Species 2015: e.T16441575A16510092. https://doi.org/10.2305/IUCN.UK.2015-4.RLTS.T16441575A16510092.en

Carter JA, Kaufman L (2003) Pomacentridae. In: Carpenter KE (Ed.) The living marine resources of the Western Central Atlantic. Volume 3: Bony fishes part 2 (Opistognathidae to Molidae). FAO species identification guide for fishery purposes and American Society of Ichthyologist and Herpetologists Special Publication No. 5. FAO, Rome. 3: 1694–1700.

Castro-Aguirre JL, Espinosa-Pérez H, Schmitter-Soto JJ (1999) Ictiofauna estuarino-lagunar y vicaria de México. Noriega-Limusa, IPN, Mexico City, 711 pp.

Chao L, Vega-Cendejas M, Jelks H, Tolan J, Espinosa-Pérez H (2015a) *Menidia peninsulae*. The IUCN Red List of Threatened Species 2015: e.T155207A70180472.

Chao L, Espinosa-Pérez H, Barbieri L (2015b) *Cynoscion nebulosus*. The IUCN Red List of Threatened Species 2015: e.T193266A49237289. https://doi.org/10.2305/IUCN.UK.2015-2.RLTS.T193266A49237289.en

Chao L (2003) Sciaenidae. In: Carpenter KE (Ed.) The living marine resources of the Western Central Atlantic. Volume 3: Bony fishes part 2 (Opistognathidae to Molidae). FAO species identification guide for fishery purposes and American Society of Ichthyologist and Herpetologists Special Publication No. 5. FAO, Rome. 3: 1583–1653.

Chernoff B (1986) Phylogenetic relationships and reclassification of Menidiinae silverside fishes with emphasis on the tribe Membradini. Proceedings of the Academy of Natural Sciences of Philadelphia, 138: 189–249.

Chernoff B (2003) Atherinidae and Atherinopsidae. In: Carpenter KE (Ed.) The living marine resources of the Western Central Atlantic. Volume 3: Bony fishes part 2 (Opistognathidae to Molidae). FAO species identification guide for fishery purposes and American Society of Ichthyologist and Herpetologists Special Publication No. 5. FAO, Rome. 2: 1086–1103.

Collette BB, Williams JT, Thacker CE, Smith MJ (2003) Shore fishes of Navassa Island, West Indies: a case study on the need for rotenone sampling in reef fish biodiversity studies. Aqua, Journal of Ichthyology and Aquatic Biology 6: 89–131.

Del Moral-Flores LF, Tello-Musi JL, Martínez-Pérez JA (2012) Descripción de una nueva especie del género *Hypoplectrus* (Actinopterigy (sic)): Serranidae del Sistema Arrecifal Veracruzano, suroeste de Golfo de México. Revista de Zoología, Universidad Nacional Autónoma de México 22: 1–10.

Del Moral-Flores L, Tello-Musi J, Reyes-Bonilla H, Pérez-España H, Martínez-Pérez J, Horta-Puga G, Velazco-Mendoza L, Álvarez del Castillo-Cárdenas P (2013) Lista sistemática y afinidades zoogeográficas de la ictiofauna del Sistema Arrecifal Veracruzano, México. Revista Mexicana de Biodiversidad 84: 825–846.

Fredou FL, Villwock de Miranda L (2015) *Cynoscion jamaicensis*. The IUCN Red List of Threatened Species 2015: e.T47147457A49237421. https://doi.org/10.2305/IUCN.UK.2015-2.RLTS.T47147457A49237421.en

Fricke R, Eschmeyer WN, Van der Laan R (Eds) (2019) Eschmeyer's Catalog Of Fishes: Genera, Species, References. http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp [Accessed June 2019]

González-Gándara C (2014) Peces de Arrecife Blake, Veracruz, México: Inventario, distribución y afinidades zoogeográficas. Ecosistemas y Recursos Agropecuarios 2: 87–97.

González-Gándara C, de la Cruz FV, Salas Pérez, Domínguez Barradas C (2012) Lista de los peces de Tuxpan, Veracruz, México. Revista Científica UDO Agrícola 12: 675–689.

González-Gándara C, Lozano Vilano M de L, de la Cruz FV, Domínguez Barradas C (2013) Peces del sistema arrecifal Lobos-Tuxpan, Veracruz, México. Universidad y Ciencia 28: 191–208.

Knudsen SW, Clements KD (2013) Revision of the family Kyphosidae (Teleostei: Perciformes). Zootaxa 3751: 1–101. https://doi.org/10.11646/zootaxa.3751.1.1

Last PR, Naylor GJP, Manjaji-Matsumoto BM (2016) A revised classification of the family Dasyatidae (Chondrichthyes: Myliobatiformes) based on new morphological and molecular insights. Zootaxa 4139: 345–368. https://doi.org/10.11646/zootaxa.4139.3.2

Liaño-Carrera F, Camarena-Luhrs T, Gómez-Barrero A, Martos-Fernández FJ, Ramírez-Macías JI, Salas-Monreal D (2019) New coral reef structures in a tropical coral reef system. Latin American Journal of Aquatic Research 47: 270–281.https://doi.org/10.3856/vol47-issue2-fulltext-7

Limburg KF (1996) Modelling the ecological constraints on growth and movement of juvenile American Shad (*Alossa sapidissima*) in the Hudson River estuary. Estuaries 19: 794–813. https://doi.org/10.2307/1352298

Lin H-C, Hastings PA (2013) Phylogeny and biogeography of a shallow water fish clade (Teleostei: Blenniiformes). BMC Evolutionary Biology 13: 1–18. https://doi.org/10.1186/1471-2148-13-210

Marceniuk AP, Molina EG, Caires RA, Rotundo MM, Wosiacki WB, Oliveira C (2019) Revision of *Bairdiella* (Sciaenidae: Perciformes) from the western South Atlantic, with insights into its diversity and biogeography. Neotropical Ichthyology 17: e180024: 1–18. https://doi.org/10.1590/1982-0224-20180024

McEachran JD, Fechhelm JD (1998) Fishes of the Gulf of Mexico. Volume 1: Myxiniformes to Gasterosteiformes. University of Texas Press, Austin, 1112 pp.

Miller RR (2006) Freshwater Fishes of México. University of Chicago Press, Chicago, 490 pp.

NatureServe (G. Hammerson) (2010). *Alosa alabamae*. The IUCN Red List of Threatened Species 2010: e.T908A13094078. https://doi.org/10.2305/IUCN.UK.2010-3.RLTS.T908A13094078.en

NatureServe, Daniels A (2019) *Alosa sapidissima*. The IUCN Red List of Threatened Species 2019: e.T191206A82664336. https://doi.org/10.2305/IUCN.UK.2019-2.RLTS.T191206A82664336.en

O'Connell M, Cashner R, Schieble C (2004) Fish assemblage stability over fifty years in the Lake Pontchartrain estuary; comparisons among habitats using Canonical Correspondence Analysis. Estuaries 27: 807–817. https://doi.org/10.1007/BF02912042

Pezold FL, Cage B (2002) A review of the spinycheek sleepers, genus *Eleotris* (Teleostei: Eleotridae), of the Western Hemisphere, with comparisons to the west African species. Tulane Studies in Zoology and Botany 31: 19–63.

Pezold F, van Tassell J, Aiken KA, Tornabene L, Bouchereau J-L (2015) *Eleotris perniger*. The IUCN Red List of Threatened Species 2015: e.T185990A1799642. https://doi.org/10.2305/IUCN.UK.2015-2.RLTS.T185990A1799642.en

Randall JE, Lobel PS (2003) *Halichoeres socialis*: a new labrid fish from Belize. Copeia 2003: 124–130. https://doi.org/10.1643/0045-8511(2003)003[0124:HSANLF]2.0.CO;2

Raz-Guzmán A, Huidobro L, Padilla V (2018) An updated checklist and characterization of the ichthyofauna (Elasmobranchii and Actinopterygii) of the laguna de Tamianhua, Veracruz, México. Acta Ichthyologica et Piscatoria 48: 341–362. https://doi.org/10.3750/AIEP/02451

Robertson DR (2008) Global biogeographic databases on marine fishes: caveat emptor. Diversity and Distributions. 14: 891–892. https://doi.org/10.1111/j.1472-4642.2008.00519.x

Robertson DR, Caruso J (2018) *Alosa chrysochloris* (errata version, 2019). The IUCN Red List of Threatened Species 2018: e.T196673A143863055. https://doi.org/10.2305/IUCN.UK.2018-2.RLTS.T196673A143863055.en

Robertson DR, Pérez-España H, Nuñez Lara E, Puc Itza F, Simoes N (2016a) The fishes of Cayo Arcas (Campeche Bank, Gulf of Mexico): an updated checklist. ZooKeys 640: 139–155. https://doi.org/10.3897/zookeys.640.10862

Robertson DR, Simoes N, Gutiérrez Rodríguez C, Piñeros VJ, Pérez-España H (2016b) An Indo-Pacific damselfish widely established in the southwest Gulf of Mexico: prospects for a wider, adverse invasion. Journal of the Ocean Science Foundation 19: 1–17. https://doi.org/10.5281/zenodo.44898

Robertson DR, Domínguez-Domínguez O, Lopez Arollo YM, Moreno Mendoza R, Simoes N (2019) Reef-associated fishes from the offshore reefs of western Campeche Bank, Mexico, with a discussion of mangroves and seagrass beds as nursery habitats. ZooKeys 843: 71–115. https://doi.org/10.3897/zookeys.843.33873

Robertson DR, Van Tassell J (2015) Shorefishes of the Greater Caribbean: online information system. Version 1.0 Smithsonian Tropical Research Institute, Balboa, Panamá. https://biogeodb.stri.si.edu/caribbean/en/pages

Robins RH, Page LM, Williams JD, Randall ZS, Sheehy GE (2018) Fishes in the Fresh Waters of Florida: an Identification Guide and Atlas. University of Florida Press, Gainesville, 468 pp.

Rocha LA, Robertson DR, Rocha CR, van Tassell JL, Craig MT, Bowen BW (2005) Recent invasion of the tropical Atlantic by an Indo-Pacific coral reef fish. Molecular Ecology 14: 3921–3928. https://doi.org/10.1111/j.1365-294X.2005.02698.x

Rosa RS, Furtado M (2007) *Narcine brasiliensis*. The IUCN Red List of Threatened Species 2007: e.T63157A12602819. https://doi.org/10.2305/IUCN.UK.2007.RLTS.T63157A12602819.en

Santander-Monsalvo J, López-Huerta I, Aguilar-Perera A, Tuz-Sulub A (2012) First record of the red lionfish (*Pterois volitans* [Linnaeus, 1758]) off the coast of Veracruz, México. BioInvasions Records 1: 121–124. https://doi.org/10.3391/bir.2012.1.2.07

Smith-Vaniz W, Jelks HL (2014) Marine and inland fishes of St. Croix, U. S. Virgin Islands: an annotated checklist. Zootaxa 3803: 1–120. https://doi.org/10.11646/zootaxa.3803.1.1

Starck WA, Estapé CJ, Morgan Estapé A (2017) The fishes of Alligator Reef and environs in the Florida Keys: a half-century update. Journal of the Ocean Science Foundation 7: 74–117. https://doi.org/10.5281/zenodo.851651

Stevens GFD, Dando M, Notabartolo di Sciara G (2018) Guide to Manta and Devil Rays of the World. Princeton University Press, Princeton, 144 pp.

Tavera J, Acero P A (2013) Description of a new species of Hypoplectrus (Perciformes: Serranidae) from the southern Gulf of Mexico. Aqua 19: 1–21.

Tavera J, Acero PA, Wainwright PC (2018) Multilocus phylogeny, divergence times, and a major role for the benthic-to-pelagic axis in the diversification of grunts (Haemulidae). Molecular Phylogenetics & Evolution 121: 212–223. https://doi.org/10.1016/j.ympev.2017.12.032

Tello-Musi JL, Chávez-Arteaga M, Cruz-López FdeJ, Martínez-Pérez JA (2018) Adenda a la lista sistemática y afinidades zoogeográficas de la ictiofauna del Sistema Arrecifal Veracruzano, México. Revista de Zoológia 29: 81–83.

Van Tassell JL (2011) Gobiiformes of the Americas. In: Patzner RA, Van Tassell JL, Kovacic M, Kapoor GG (Eds) The Biology of Gobies. CRC Press, Boca Raton, 139–176. https://doi.org/10.1201/b11397-14

Wainwright PP, Santini F, Bellwood D, Robertson DR, Rocha L, Alfaro M (2018) Phylogenetics and geography of speciation in new world Halichoeres wrasses. Molecular Phylogenetics and Evolution 121: 35–45. https://doi.org/10.1016/j.ympev.2017.12.028