

# Another new species of *Pseudouroplectes* Lourenço, 1995 from Madagascar (Scorpiones, Buthidae)

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## Abstract

A new species of the endemic Malagasy genus *Pseudouroplectes* Lourenço, 1995 (family Buthidae) is described from spiny forests of the southwestern portion of the island. The holotype was obtained in the forests of Ifaty, north of Toliara. With the description of this species, the distributional pattern of this genus is confined to dry forest formations in the south and southwest. A key is proposed to the known species.

## Keywords

Scorpion, *Pseudouroplectes*, Madagascar, Toliara, new species

## Introduction

As already discussed by Lourenço and Goodman (2006), the species of genus *Pseudouroplectes*, which are soil-dwelling scorpions of the family Buthidae (Lourenço 2004), are rare. In Madagascar the best-studied soil scorpions are represented by members of the endemic family Microcharmidae (Lourenço et al. 2006). *Pseudouroplectes*

was originally described based on two females of *P. betschi* Lourenço, 1995, collected in the dry southwestern spiny bush formation at Andramanoetse Be, Plateau Mahafaly, Toliara Province (Lourenço 1995). Subsequently, a single specimen of another *Pseudouroplectes* species, *P. pidgeoni* Lourenço & Goodman, 1999, was collected in the extreme southeastern dry forests of the Parc National d'Andohahela (parcel 2), Toliara Province (Lourenço and Goodman 1999). This animal was collected in a soil litter sample from the spiny bush parcel of the reserve, within a few kilometers of the ecotone between dry and wet forest formations. Only several years later, additional material was obtained of the genus *Pseudouroplectes*. This led to the description of a third species, *Pseudouroplectes maculatus* Lourenço & Goodman, 2006. New specimens of *Pseudouroplectes* have been collected due to the efforts of Dr. Brian Fisher and colleagues at the California Academy of Sciences (CAS). Over the past few years, the CAS field team conducted systematic invertebrate inventories at various sites across Madagascar, including the dry vegetational formations, employing pitfall traps and different methods of soil litter extraction.

More recently, examination of some scorpions collected by the senior author in the dry vegetation sites of Toliara Province (Lourenço et al. 2008), revealed one more new species of *Pseudouroplectes*, which is described here.

### **Distributional pattern presented by the genus *Pseudouroplectes***

The distributional pattern of the genus *Pseudouroplectes* was discussed in detail by Lourenço and Goodman (2006), who presented details and a list of known localities for members of this genus. In summary, members of this genus, including the new species described herein, are restricted to the extreme southern dry forest formations. *Pseudouroplectes betschi* and *P. pidgeoni* apparently present a parapatric or even a small sympatric zone of distribution in the extreme southern portion of the island. A similar situation is observed between *P. maculatus* and the new species described here, with the two species presenting, at least, a small zone of sympatry (Fig. 13). One species, *Pseudouroplectes betschi*, is known from a single locality. This very restricted distribution can eventually be attributed to incomplete sampling collections. At the same time, the totality of the southwestern portion of the island was extensively prospected by Brian Fisher and colleagues. A more plausible explanation is the existence of very particular habitats to which some species are specifically adapted. In the case of scorpions, the possible ecological gradients responsible for these microendemic habitats are vegetation cover and humidity.

### **Methods**

Illustrations and measurements were made with the aid of a Wild M5 stereo-microscope with a drawing tube (camera lucida) and an ocular micrometer. Measurements

follow Stahnke (1970) and are given in mm. Trichobothrial notations follow Vachon (1974) while morphological terminology mostly follows Hjelle (1990).

### Taxonomic treatment

Family Buthidae C.L. Koch, 1837

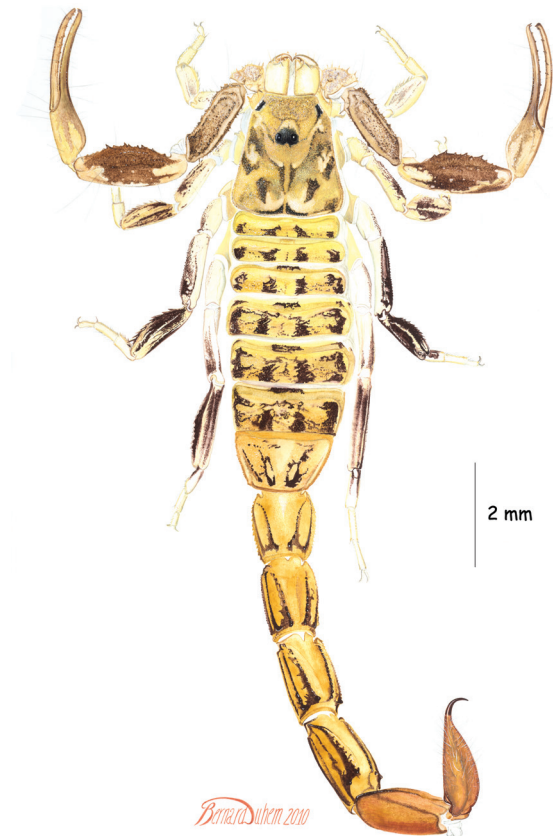
Genus *Pseudouroplectes* Lourenço, 1995

#### *Pseudouroplectes lalyae* sp. n.

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Figs 1, 3–8

**Type material:** Male holotype. Madagascar, Toliara Province, NE Ifaty, spiny forest thicket, 30 m alt., IX/2004 (W. R. Lourenço) (MNHN). Paratypes. Toliara Province,



**Figure 1.** Habitus of *Pseudouroplectes lalyae* sp. n., male holotype. Scale bar = 2 mm.



**Figure 2.** Habitus of *Pseudouroplectes maculatus*, female paratype. Scale bar = 2 mm.

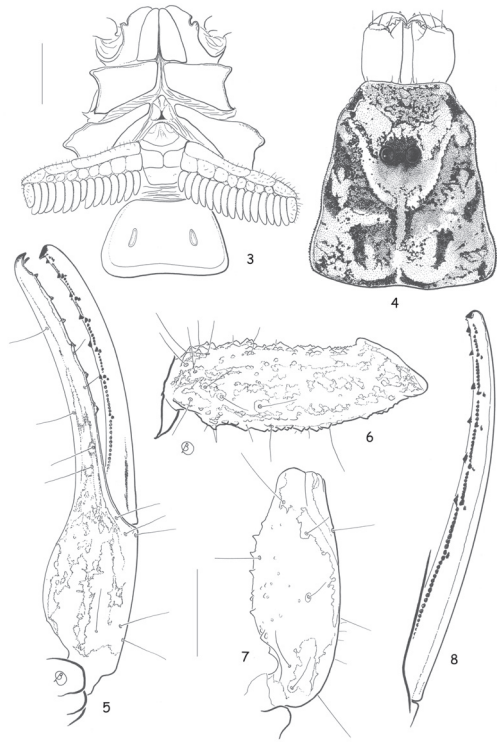
Forêt de Tsinjoriaky (22°48'08" S, 43°25'14" E), 6.2 km 84° E Tsifota, 70 m alt., 6–10/III/2002 (Fisher & Griswold et al.), general collecting, spiny forest-thicket, 2 male juveniles (CAS – MNHN). Note: The two paratypes were previously misidentified as *P. maculatus* (Lourenço & Goodman, 2006).

**Etymology:** The patronym is homage to Laly Ythier, daughter of the junior author.

**Diagnosis:** Small scorpions, when compared with the average size of most species of micro-buthid genera, and measuring up to 20.57 mm in total length (see morphometric values after the description). General coloration reddish-yellow with four longitudinal stripes starting on the posterior edge of carapace and running over tergites I to VII; dark spots over the pedipalps, legs and metasomal carinae. Carinae and granulations moderately to strongly marked.

**Relationships:** The new species can be readily distinguished from all the other species of the genus *Pseudouroplectes* Lourenço, by (i) presence of four longitudinal dark stripes running from the carapace and over all tergites, (ii) pedipalps, legs and





**Figures 3–8.** *Pseudouroplectes lalyae* sp. n. Male holotype. **3** Ventral aspect, showing coxapophysis, sternum, genital operculum, pectines and sternite III with spiracles **4** Carapace and chelicerae, dorsal aspect. **5–7** Trichobothrial pattern of the pedipalp **5** Chela, dorsoexternal aspect **6** Femur, dorsal aspect **7** Patella, dorsal aspect **8** Disposition of granules on the dentate margins of the pedipalp chela movable finger. Scale bars = 1 mm.

metasomal carinae intensely spotted, (iii) moderately marked carinae on tergites and metasomal segments, and (iv) pedipalps strongly granular.

Description based on male holotype.

**Coloration.** Reddish-yellow with four longitudinal dark stripes which start on the posterior edge of carapace and run over tergites I to VII. Carapace, pedipalps, and legs intensely marked with dark spots; carinae of metasomal segments densely spotted. Venter and chelicerae yellowish without spots.

**Morphology.** Carapace with a moderately to strongly marked granulation; anterior margin almost straight. Carinae weak; furrows inconspicuous. Median ocular tubercle distinctly on the anterior third of the carapace; median eyes separated by one ocular diameter. Three pairs of lateral eyes. Sternum subpentagonal. Mesosoma: tergites moderately granular. Median carina moderate to weak in all tergites. Tergite VII pentacarinata. Venter: genital operculum divided longitudinally, each plate having a more or less subtriangular shape. Pectines large: pectinal tooth count 16–15 (male paratypes with

15–16 and 16–16); basal middle lamellae of the pectines not dilated; fulcra inconspicuous. Sternites smooth with short semi-slit-like spiracles; VII punctuated and acarinated. Metasoma: segments I to IV with 10 carinae, moderately crenulate; ventral carinae reduced to vestigial on segments I to IV; intercarinal spaces weakly granular. Segment V rounded with five carinae. Telson has a very elongated “pear-like” shape, smooth with strong setation; aculeus short, weakly curved; subaculear tooth absent. Cheliceral dentition characteristic of the family Buthidae (Vachon, 1963); fixed finger with two moderate basal teeth; movable finger with two very weak and fused basal teeth; ventral aspect of both finger and manus with dense, long setae. Pedipalps: femur pentacarinat; patella with seven carinae; internal face of patella with 7–8 spinoid granules; chela with vestigial carinae; all faces moderately to strongly granular. Fixed and movable fingers with 7–8 almost linear rows of granules; two accessory granules present at the base of each row; extremity of fixed and movable fingers with one long and sharp denticle. Trichobothriotaxy; orthobothriotaxy A- $\alpha$  (Vachon, 1974, 1975). Legs: tarsus with very numerous fine median setae ventrally. Pedal spurs reduced; tibial spurs absent.

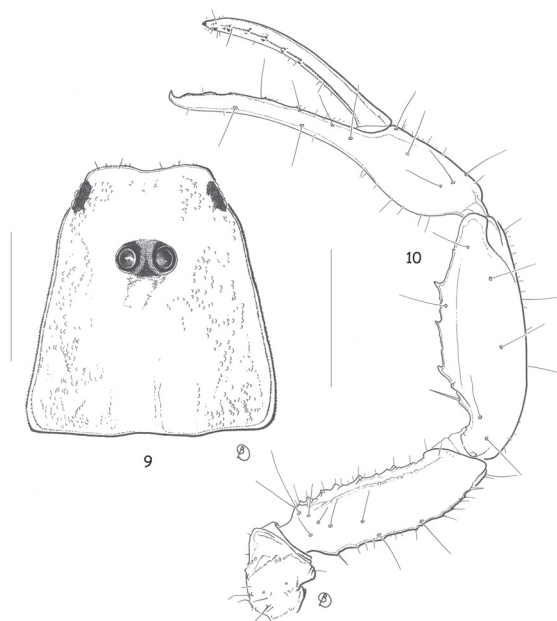
**Morphometric values** (in mm) of the holotype. Total length (including telson), 20.57. Carapace: length, 2.43; anterior width, 1.43; posterior width, 2.14. Metasomal segments. I: length, 1.43; width, 1.28. II: length, 1.71; width, 1.14. III: length, 1.86; width, 1.00. IV: length, 2.14; width, 1.00. V: length, 3.00; width, 1.00; depth, 1.00. Telson: length, 2.57. Vesicle: width, 0.71; depth, 0.71. Pedipalp: femur length, 1.78, width, 0.57; patella length, 2.36, width, 0.86; chela length, 3.14, width, 0.71, depth, 0.64; movable finger length, 2.07.

### Key to the known species of *Pseudouroplectes*

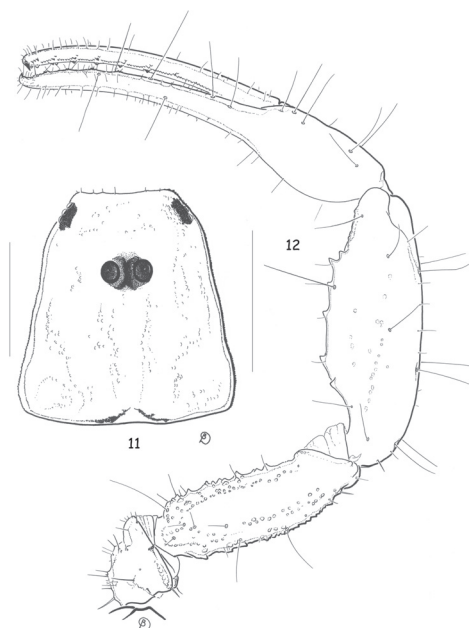
1. Pale scorpions, yellowish to reddish-yellow, with or without spots..... 2
- Dark scorpions with confluent blackish spots over the body and appendages..... *P. maculatus* (Fig. 2)
2. Coloration yellowish without any spots; pectinal tooth count 18/20..... *P. betschi* (Figs 9–10)
- Coloration yellowish with two or four longitudinal reddish-brown stripes over the tergites; pectinal tooth count 14/16..... 3
3. Two longitudinal brownish stripes over the tergites; carapace, pedipalps and metasomal segments without spots..... *P. pidgeoni* (Figs 11–12)
- Four longitudinal brownish stripes over the tergites; carapace, pedipalps and metasomal segments strongly spotted..... *P. lalyae* sp. n. (Fig. 1)

### Acknowledgements

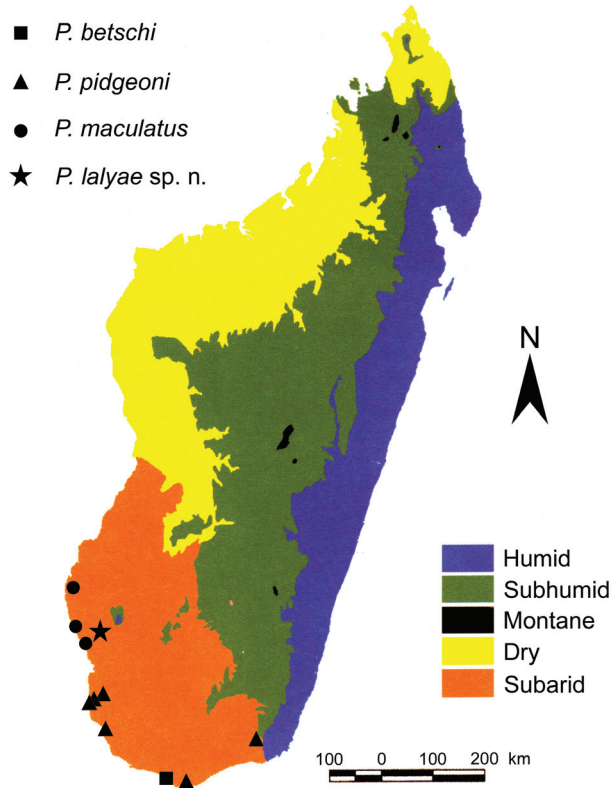
We are very grateful to Bernard Duhem, Muséum national d’Histoire naturelle, Paris, who prepared the remarkable illustrations for this article, to Elise-Anne Leguin of the same Muséum for assistance in the preparation of the plates, and to Steven M. Goodman for very useful comments on the manuscript.



**Figures 9–10.** *Pseudouroplectes betschi*, male from Cap Sainte Marie. Carapace and pedipalp, dorsal aspect, showing the absence of pigmentation. Scale bars = 1 mm.



**Figures 11–12.** *Pseudouroplectes pidgeoni*, male from Itampolo. Carapace and pedipalp, dorsal aspect, showing the very reduced pigmentation pattern. Scale bars = 1 mm.



**Figure 13.** Vegetation map of Madagascar showing the known distribution of *Pseudouroplectes* species.

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# On new species of *Microdiores* (Araneae, Zodariidae) from Central and East Africa

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## Abstract

The distribution of the genus *Microdiores* Jocqué, 1987, so far only known from East Africa, is extended to Central Africa with the description of the new species, *Microdiores ruwegura* sp. n. (♂) and *M. violaceus* sp. n. (♂♀), both from the Kibira National Park in Burundi. A third new species, *M. aurantioviolaceus* (♂), from northern Tanzania is described. The status of the genus is confirmed and a key to the males of the species is provided.

## Keywords

Afromontane forest, Araneae, *Dusmadiores*, Kibira National Park, *Microdiores*, Zodariidae

## Introduction

Our knowledge on the genus *Microdiores* Jocqué, 1987 was so far restricted to a single species, *M. chowo* Jocqué, 1987, from Malawi (Jocqué 1987, 1991; Platnick 2009). As the genus was based on one species only, its status has been doubtful. In the original publication, it was stated that more species from eastern and central Africa were known



to the author (Dippenaar-Schoeman and Jocqué, 1997). *Microdiores rwegura* sp. n. and *M. violaceus* sp. n., collected in the Kibira afromontane forest in Burundi, extend the known distribution area of *Microdiores* to Central Africa. A fourth species, *Microdiores aurantioviolaceus* sp. n., from Tanzania is also described here, and the status and definition of *Microdiores* are confirmed.

## Material and methods

The specimens were obtained from the collection obtained by the first author in the afromontane forest of Kibira and from fieldwork in the Mkomazi Game Reserve in Tanzania. The primary types and some paratypes are deposited at MRAC and some paratypes are retained at INECN.

The epigynes and male palps were observed and drawn with a stereomicroscope Zeiss Stemi 2000. Specimens were measured with a WILD M 10 stereomicroscope.

The female epigyne was detached from the abdomen, cleared with methylsalicylate and temporarily mounted for examination. It was photographed with a Leica SMLB microscope and subject to automontage with the Syncroscopy software. All measurements are in mm. Coordinates are decimal.

## Abbreviations

<b>ALE</b>	anterior lateral eyes
<b>AME</b>	anterior median eyes
<b>AW</b>	anterior width
<b>d</b>	dorsal
<b>dl</b>	dorsolateral
<b>F</b>	femur
<b>INECN</b>	Institut National pour l'Environnement et la Conservation de la Nature (Bujumbura, Burundi)
<b>L</b>	length
<b>MA</b>	median apophysis
<b>MRAC</b>	Musée Royal de l'Afrique Centrale (Tervuren, Belgium)
<b>Mt</b>	metatarsus
<b>NP</b>	National Parc
<b>P</b>	patella
<b>pl</b>	prolateral
<b>PLE</b>	posterior lateral eyes
<b>PME</b>	posterior median eyes
<b>rl</b>	retrolateral
<b>t</b>	tarsus
<b>T</b>	tibia
<b>v</b>	ventral

## Taxonomy

Family Zodariidae

Subfamily Zodariinae

Genus *Microdiores* Jocqué, 1987

**Diagnosis.** Small Zodariidae (1.5 -2.5 mm) with large AME; carapace devoid of pores; femoral organ with barbed hairs; embolus curved and tapered, with rounded cross-section, originating from well delimited, posterior part of tegulum; epigyne with large adjacent spermathecae.

### *Microdiores aurantioviolaceus* sp. n.

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Figures 1A, B

**Material examined. Holotype male.** TANZANIA: Mkomazi Game Reserve, 5 km North of Ibaya, 9–10.VIII.1993, pitfalls, short grass and bushes, Ritchie M. and Makusi R. (MRAC 215708).

**Diagnosis.** The male of this species is recognized by the broad, curved retrolateral tibial apophysis with a large seta pointing outwards and the long embolus with broad base, its tip supported by the broad MA with a short triangular prong. In *M. violaceus* the MA has two short triangular prongs whereas in *M. rwegura* the tip is rounded.

**Etymology.** The specific name “*aurantioviolaceus*”, refers to the colour of the carapace and the abdomen respectively orange and sepia.

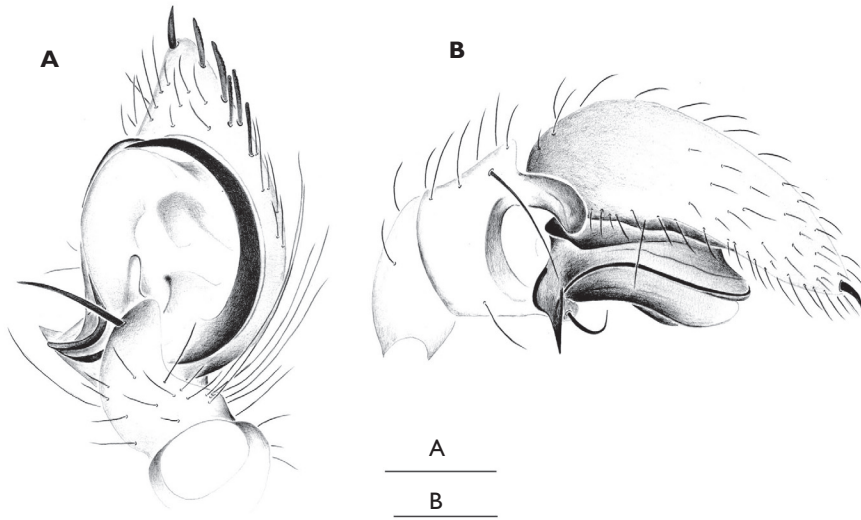
**Description. Male (holotype).** Total length 1.72, carapace 0.76 long and 0.60 wide. **Carapace** orange, with central violet spot; with a few long bristles in longitudinal row. **Eyes:** ocular area dark, AME 0.08, ALE 0.06, PME 0.06, PLE 0.06 PME-PME 0.08; AME almost touching. **Clypeus** with tuft of bristles. **Chelicerae** yellowish orange. **Sternum** pale orange, margin darker orange. **Legs** orange, with short hairs; spineless. **Abdomen**, Oval; dorsum sepia with some poorly marked pale chevrons; venter pale yellow. **Palp** (figs 1A, B): cymbium with distal spine and sub-distal row of four modified setae; tibia with retrolateral apophysis relatively broad, curved, rounded at the tip, and very broad ventral apophysis with broadly rounded tip and large spine pointing outwards; embolus originating on posterior part of tegulum, its base pointing forward to distal tip of tegulum, broadly curved towards MA.

#### Leg measurements:

Leg	F	P	T	Mt	t	Total
I	0.62	0.22	0.52	0.56	0.44	4.82
II	0.50	0.20	0.40	0.42	0.38	3.97
III	0.50	0.20	0.30	0.44	0.38	3.92
IV	0.70	0.20	0.58	0.66	0.40	5.42

**Female** Unknown

**Distribution.** Known only from the type locality.



**Figure 1A, B.** *Microdiores aurantioviolaceus* sp. n. **A** Male palp, ventral view **B** Male palp, retrolateral view. (Scale bars: 0.1mm)

***Microdiores rwegura* sp. n.**

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Figures 2A, B

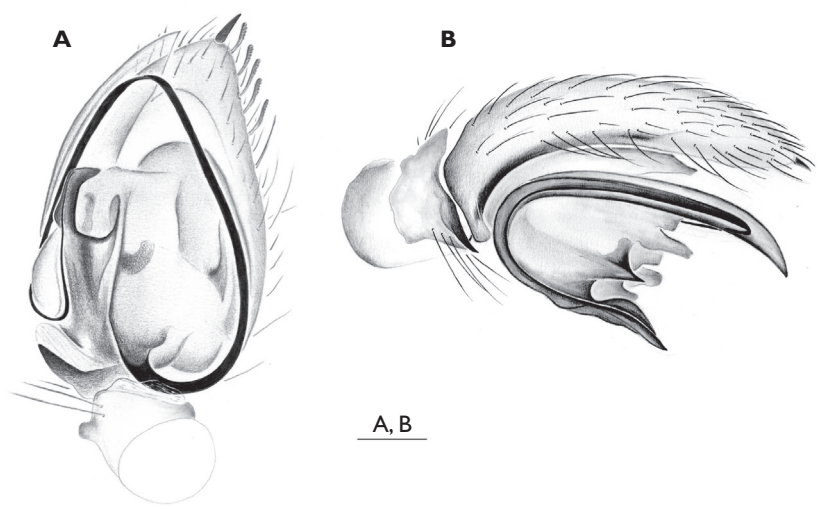
**Material examined. Holotype male.** BURUNDI: Zone of “Parc National de la Kibira, Forêt de Rwegura”, 02.89891°S, 029.50405°E, site 1, tea plantation adjacent to NP, 30.X.2004, 1970m, pitfalls, B. Nzigidahera (MRAC 227565).

**Paratypes:** BURUNDI: 1♂: 30.I.2004, same data as holotype (INECN); 1♂: 30.IX.2004 same data as holotype (INECN); 1♂: 02.89565°S, 029.50345°E, site 2, 30.I.2004, forest with *Polyscias fulva* and *Macaranga neomildbraediana*, 2120 m (INECN); 1♂: 02.88562°S, 029.50221°E, site 3, 14.VI.2005, forest of *Polyscias fulva* and *Hagenia abyssinica*, 2160 m (MRAC 227566).

**Diagnosis.** The male of this species is recognized by the shape of the embolus which is long and curved, with a very slender distal part supported by a complex MA which is clearly different from those in *M. violaceus* and *M. aurantioviolaceus*; in these species the end of the embolus is supported by the short triangular prong at the tip of the MA. The latter two species also differ in their violet carapace.

**Etymology.** The specific name “*rwegura*” is a noun in apposition taken from the type locality.

**Description. Male (holotype).** Total length 2.00, carapace 0.90 long and 0.72 wide. **Carapace** orange. **Eyes**, AME very large, round; anterior eye row straight, posterior row procurved; AME: 0.10; ALE: 0.06; PME: 0.04; PLE: 0.04; AME-AME: 0.02; AME-ALE: 0.00; PME-PME: 0.06; PME-PLE: 0.02. **Chelicerae** orange. **Sternum** yel-



**Figure 2A, B.** *Microdiores rwegura* sp. n. **A** Male palp, ventral view **B** Male palp, retrolateral view. (Scale bars: 0.1mm)

lowish orange with dark orange margins; some setae along margin. **Labium** yellowish orange. **Legs** yellowish orange; with some short hairs, spineless. **Abdomen** pale yellowish orange dorsally and ventrally. **Spinnerets** pale yellowish orange. **Palp** (fig. 2A, B), cymbium with distal spine and sub-distal row of five modified setae; tibial apophysis short, sharp, pointing downward; embolus originating on posterior part of tegulum; its base pointing backward, thence running forward to tip of cymbium from where it is supported by longitudinal prong of complex MA.

**Leg measurements:**

Leg	F	P	T	Mt	t	Total
I	0.70	0.24	0.60	0.70	0.54	2.78
II	0.60	0.24	0.44	0.50	0.48	2.26
III	0.60	0.22	0.42	0.54	0.40	2.18
IV	0.80	0.22	0.60	0.80	0.50	2.92

**Female** Unknown

**Variation.** Carapace colour may vary from bright orange to yellowish orange

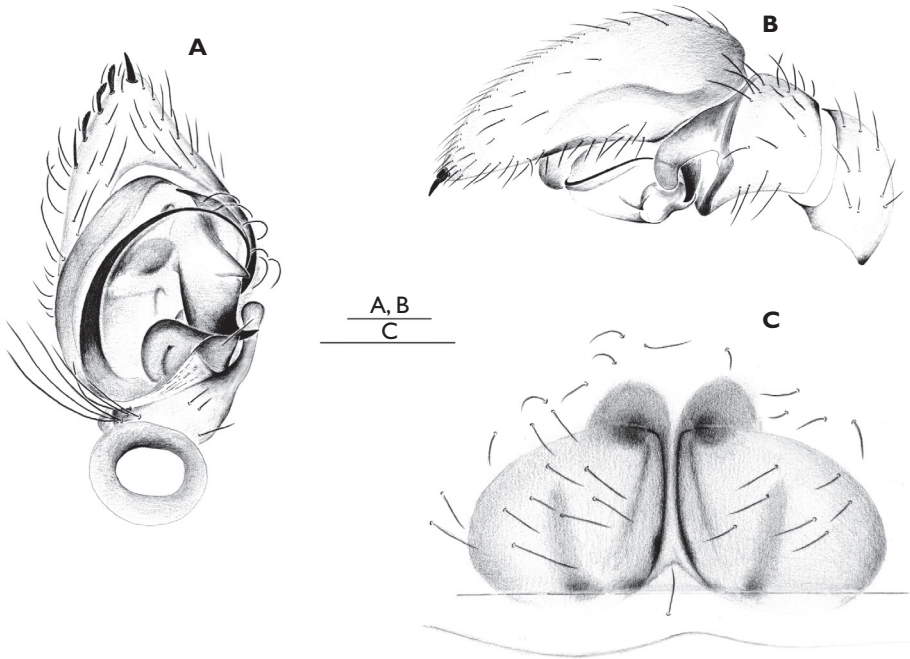
**Distribution.** Known only from the type locality.

***Microdiores violaceus* sp. n.**

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Figs 3A–C, 4

**Material examined. Holotype male.** BURUNDI: Parc National de la Kibira, Rwegura, Mt Musumba, 02.86455°S, 029.50427° E, site 4, forest with *Macaranga ne-*



**Figure 3A–C.** *Microdiores violaceus* sp. n. **A** Male palp, ventral view **B** Male palp, retrolateral view; **C** epigyne, ventral view. (Scale bars: 0.1mm)

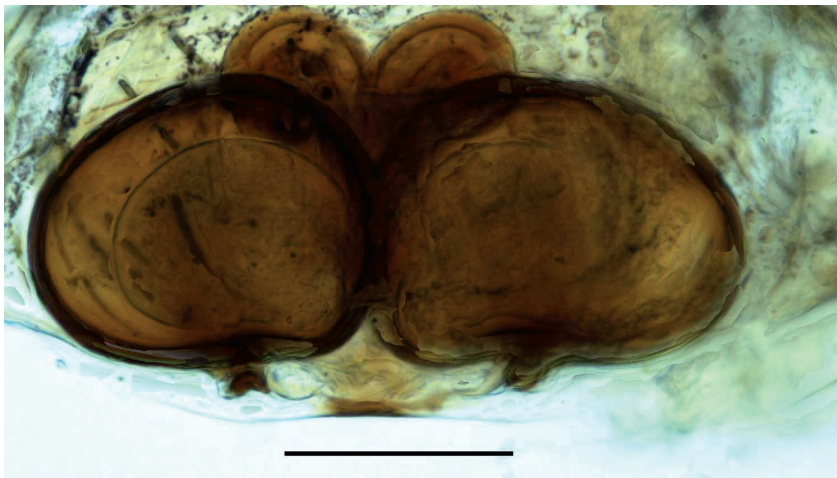
*omildbraediana* and *Polyscias fulva*, 10.IX.2008, 2352m, pitfalls, Nzigidahera Benoît (MRAC 226800).

**Paratypes.** All paratypes from BURUNDI, Zone of Kibira National Park, Rwegura, Mt Musumba, pitfalls, B. Nzigidahera, 02.86435°S, 029.49540° E, site 7, tea plantation adjacent to NP, 2100 m; 1♂: 25.VIII.2008 (MRAC 226799); 1♂: 25.XII.2008 (MRAC 226801); 1♂: 10.I.2008 (INECN); 1♂: 02.87149°S, 029.49641° E, site 3, 10.XI.2008, forest with *Hagenia abyssinica*, 2444 m (INECN); 6♂: 25.VIII.2008 (INECN); 1♂: 02.87696°S, 029.49709° E, site 1, 25.V.2008, mountain heather with *Philippia benguelensis*, 2650 m (INECN).

**Diagnosis.** The male of this species is recognized by the broad tibial apophysis with a rounded down curved tip and by the long embolus with broad base, its tip supported by the broad median apophysis with two short triangular prongs. The female is characterized by broadly oval spermathecae which are flask shaped in *M. chowo*.

**Etymology.** The specific name “*violaceus*”, refers to the colour of the abdomen which is violet.

**Description. Male (holotype).** Total length 1.80, carapace 0.90 long and 0.70 wide. **Carapace**, sepia with greyish brown, with slightly darker radiating striae. **Eyes** AME very large, round, dark; others small, pale; anterior eye row straight, posterior eye row procurved; AME: 0.08; ALE: 0.06; PME: 0.06; PLE: 0.06; AME-AME: 0.02; AME-ALE: 0.00; PME-



**Figure 4.** *Microdiores violaceus* sp. n. Epigyne, cleared, dorsal view (scale bar: 0.1 mm).

PME: 0.08; PME-PLE: 0.02. **Chelicerae** yellowish brown. **Sternum** greyish brown. **Labium** yellowish brown, triangular. **Legs** yellowish brown, with many short hairs. **Abdomen**, Dorsum oval, sepia with some poorly marked pale chevrons; venter pale. **Spinnerets** pale. **Palp** (fig. 3AB ): cymbium with distal spine and sub-distal row of three modified setae; tibial apophysis broad, with parallel sides pointing obliquely downward, with broadly rounded tip; embolus originating on posterior part of tegulum; its base pointing forward to distal tip of tegulum, broadly curved towards MA with two short, triangular prongs.

**Leg measurements:**

Leg	F	P	T	Mt	t	Total
I	0.68	0.24	0.52	0.52	0.50	2.46
II	0.60	0.22	0.44	0.41	0.40	2.07
III	0.60	0.24	0.40	0.46	0.40	2.10
IV	0.78	0.24	0.60	0.76	0.50	2.88

**Female** paratype (from site 3). Colour pattern similar to male. Total length 2.36, **Carapace** 0.90 long and 0.70 wide. **Eyes**, AME: 0.08; ALE: 0.06; PME: 0.06; PLE: 0.06; AME-AME: 0.02; AME-ALE: 0.00; PME-PME: 0.08; PME-PLE: 0.02.

**Leg measurements:**

Leg	F	P	T	Mt	t	Total
I	0.60	0.24	0.50	0.48	0.40	2.22
II	0.50	0.20	0.50	0.40	0.40	2.00
III	0.54	0.20	0.40	0.40	0.40	1.94
IV	0.70	0.24	0.50	0.70	0.52	2.66

**Epigyne** (figs 3C, 4) with a clearly sclerotised part on either side of the dark median longitudinal lines; posterior margin poorly sclerotised; spermathecae oval, adjacent.

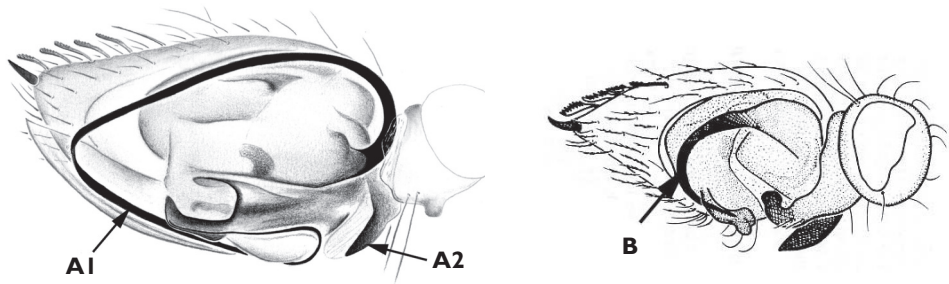
**Variation.** Carapace colour may vary from sepia to greyish brown.

**Distribution.** Known only from the type locality.

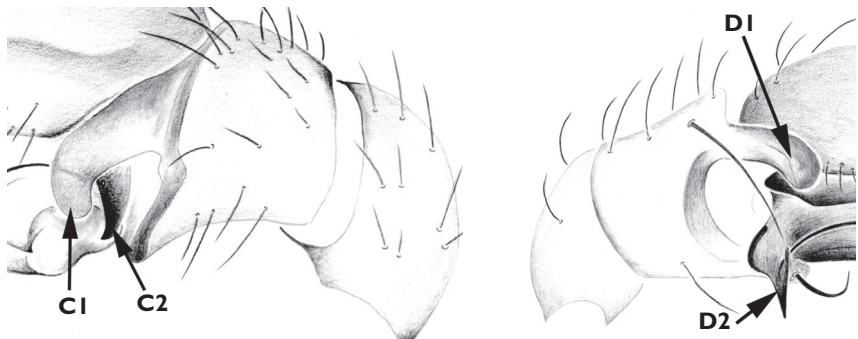


**Key to the species (males only)**

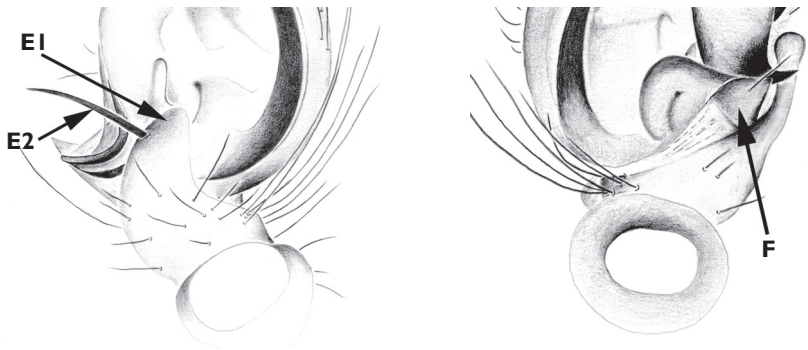
- 1. Embolus long, curved back and reaching RTA (A1) ..... 2
- Embolus shorter, curved back but not reaching RTA (B) ..... *M. chowo*



- 2. RTA in retrolateral view with large, rounded, downcurved tip (C1, D1); MA with sharp downpointing extremity at proximal end (C2, D2) ..... 3
- RTA in retrolateral view of different shape (A2); MA without downpointing tip ..... *M. rwegura*



- 3. Ventral tibial apophysis with rounded tip (E1), provided with outward pointing macroseta (E2) ..... *M. aurantioviolaceus*
- Ventral tibial apophysis with truncated tip (F); without macroseta ..... *M. violaceus*





## Discussion

*Microdiores* is a poorly known genus that has remained monotypic since its description. The present study confirms the validity of its diagnosis which is extended with more characters on the base of the newly described species. An important diagnostic character differentiating *Dusmadiores* Jocqué, 1987 from *Microdiores* is the absence of carapace pores in the latter. In *Microdiores* the embolus is slender with a rounded cross-section, whereas it is flat and broad in the closely related *Dusmadiores*. The epigyne of the two species of *Microdiores* for which females are known (*M. chowo* and *M. violaceus* sp. n.), is very simple and the spermathecae are large and adjacent whereas they are far apart in *Dusmadiores*.

Spiders were collected intensively in the forest ecosystems of western Burundi during several years (2003–2005–2008). Yet, the two species of *Microdiores* were so far only found in montane forest of the Kibira National Park. They have been collected again in the tea plantation in the adjacent zone of this protected area. In that forest, *Microdiores rwegura* sp. n. appears to occupy a small altitudinal gradient between 1970 and 2160m. *Microdiores violaceus* sp. n. on the other hand, occupies an extensive altitudinal gradient between 2100 to 2650 m and colonizes the heather vegetation at high altitude. Taking into account the results of Jocqué (1987), who found *M. chowo* in high altitude grassland in Malawi, *Microdiores* occupies a large range of habitats in Central and East Africa from dryish lowland savanna, to wet montane forest.

## Acknowledgments

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# Notes on and key to the genus *Phengaris* (s. str.) (Lepidoptera, Lycaenidae) from mainland China with description of a new species

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## Abstract

The lycaenid genus *Phengaris* (s. str.) from mainland China is briefly characterized, and a short identification key presented. *Phengaris xiushani* sp. n. is described and illustrated from northwestern Yunnan. The new species is similar to *P. daitozana* from Taiwan with respect to the wing maculation in having a whitish upperside and much smaller spots on the underside. Genitalia features are similar to *Phengaris* (*Maculinea*) *nausithous* from the western Palaearctic region. The type specimens are kept in the Insect Collection, South China Agricultural University, Guangzhou, China (SCAU), and the “Senckenberg Museum für Tierkunde” in Dresden, Germany (MTD).

## Keywords

Lepidoptera, Lycaenidae, *Maculinea*, Yunnan

## Introduction

The large blues of the lycaenid genus *Phengaris* Doherty, 1892 (s. str.) hitherto only encompassed three species: *P. atroguttata* Oberthür, 1876, *P. albida* Leech, 1893 and *P. daitozana* Wileman, 1908. These were distributed in the area between the Oriental and

Palearctic region of E. Asia. Recently, Fric et al. (2007) treated the Palearctic genus *Maculinea* Van Eecke, 1915 as a synonym of *Phengaris* and divided the genus (s. lat.) into four species groups and eleven species.

The large blues of former *Maculinea* Van Eecke, 1915 (s. str.; see Balletto et al. in press, on recent discussions of nomenclature) belong to the most intensively studied group of butterflies in Eurasia, which is probably due to their “obscure” biology and ecology (Als et al. 2004; Barbero et al. 2009; Nash et al. 2008; Pech et al. 2004; Thomas and Settele 2004; Thomas et al. 2009). Their specialized habitat requirements have made them vulnerable to global change (Settele and Kühn 2009), including climate change and habitat alteration. Large Blue populations have suffered severe declines in Europe, and one species, *M. arion* (Linnaeus, 1758) went extinct in the UK in the 1970s, but was then reintroduced from Sweden (Thomas et al. 2009), which sparked increased interest in the conservation and habitat restoration of this species. Four *Maculinea* species are listed in the IUCN Red List of Threatened Species as ‘near threatened’ and *M. rebeli* Hirschke, 1904 as ‘vulnerable’. Three species are included in Annexes II and IV of the European Habitats’ Directive, and all European species are being monitored and intensively studied under the European research projects MacMan and CLIMIT ([www.climit-project.net](http://www.climit-project.net)) (Settele et al. 2005; Settele and Kühn 2009).

Contrary to *Maculinea* in Europe, *Phengaris* (s. str. and s. lat.) in China is not so well studied and monitored due to lack of financial and personnel resources. Chou (1994) recorded 3 species in *Maculinea* (s. str.) and 2 species in *Phengaris* (s. str.) from China, Sibatani et al. (1994) recorded 6 species in *Maculinea* (s. str.) from China, Wang (1999) recorded 4 species of *Maculinea* (s. str.) from N.E. China. In their book, Wang & Fan (2002) documented 6 species in *Maculinea* (s. str.) and 3 species in *Phengaris* (s. str.) in China.

In the course of a Chinese-German workshop on butterfly conservation held in Guangzhou in December 2009, we examined specimens kept in the Insect Collections of the South China Agricultural University, which led to the discovery of a *Phengaris* species which had not previously been reported. We herewith describe the new species.

## Materials and methods

We investigated 5 dried specimens collected by netting during day time from Nujiang County on the 24<sup>th</sup> of July 2006. Pictures of mounted adults were taken with a Nikon Coolpix 990 digital camera. The whole abdomen of the holotype was removed and macerated in boiling 10% NaOH liquid for 3–4 minutes. The genitalia was checked and mounted on a slide in glycerin under the Leica 12.5 stereoscope. The genitalic photos were taken with a Nikon Coolpix 990 connected to an eye lens of the stereoscope. All the images were processed with Adobe Photoshop 6.0. The type specimens are deposited in the Insect Collections, Department of Entomology, South China Ag-

ricultural University, Guangzhou, China (1 male holotype and 3 female paratypes) and the “Museum für Tierkunde” in Dresden, Germany (1 male paratype).

## Description

### *Phengaris xiushani* Wang & Settele sp. n.

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**Type material.** Holotype male (SCAU): China, Yunnan, Nujiang County, alt. 2800 m, 24.VII.2006, Min WANG & Xiaoling FAN leg. Paratypes. One male and three females, same data as holotype.

**Male.** Forewing length 21 mm, antenna length 9.5 mm.

Forewing upperside ground colour whitish, with black margin gradually broadened from tornus to the mid of termen and then sharply widened to apex, where overlapped with three darker black dots, one traceable smaller spot each in the mid of space M3 and distal cell. Cilia are white checkered with black. Underside ground color same as upperside, with black spots in mid and distal cell, and postdiscal, submarginal and marginal series. Postdiscal series with the spots in spaces M1 and M2 prominently shifted outwardly. Submarginal series is much broader than marginal series.

Hindwing upperside ground color similar to that on forewing, with traceable markings which shine through from the underside. Cilia almost white, with fine black checkers at the end of each vein. Underside ground color same as upperside, with black spots consisting of discal, postdiscal, submarginal and marginal series, as well as a black spot each at basal and mid space Sc+R1. The black spot of postdiscal series in space CuA2 shifted outwardly.

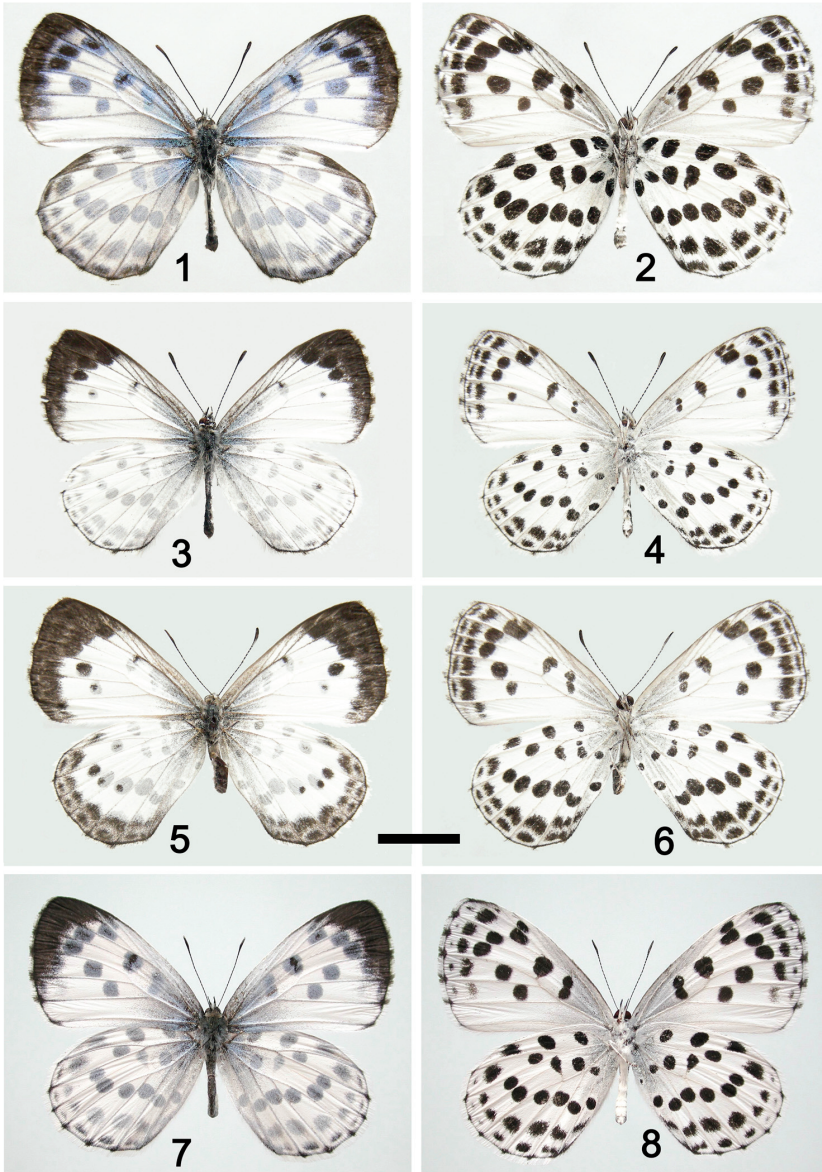
**Male genitalia.** Heavily sclerotized, tegumen broad and large, vinculum narrow, saccus absent, brachia stout and short, valve oblong, with a projection distally, juxta V-shaped, aedeagus stout with elaborate distal structure.

**Female.** Similar to male, but slightly larger, black margins of both wings are well developed.

**Distribution.** Yunnan, China.

**Diagnosis.** Superficially, the species is similar to *P. daitozana* as shown in Shirôzu's book (1960) from Taiwan in having whitish ground color on upperside and smaller black spots on underside, but the black spot in space CuA1 of the postdiscal series is distinctly shifted outwards, also the valva of the male genitalia with its dorsal part is not so well inflated distally and, compared with drawings in Higgins (1975), has similar genitalia to the Palearctic *P. (Maculinea) nausithous* (Bergsträsser, 1779). The species is also easily recognized from *P. atroguttata* (Figs 1, 2, 10) and *P. albida* (Figs 7, 8, 11) by the wing maculation and genitalia features.

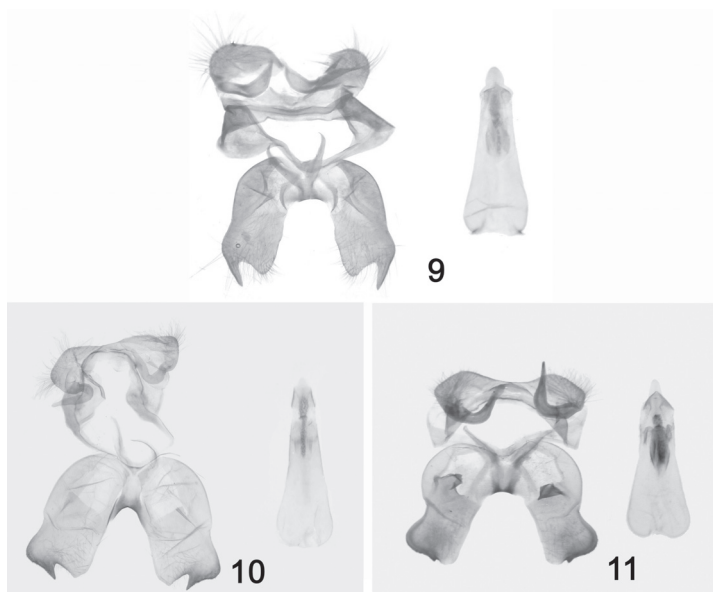
There are several taxa names published previously in mainland China and neighboring countries now treated as subspecies of *P. atroguttata* or separate species: *juenana*



**Figures 1–8.** *Phengaris* spp. **1–2** *P. atroguttata* **3–6** *P. xiushani* **7–8** *P. albida* (1 3 5 7 upperside 2 4 6 8 underside); black bar = 1 cm

(Forster, 1940) from Dali, Yunnan; *lamppra* (Röber, 1926) from Assam, India; *intermedia* Oberthür, 1916 from Tianquan, Sichuan. Examination of the types of the above mentioned taxa, except for *juenana* (Forster, 1940), showed that *lamppra* (Röber, 1926) belongs to *P. atroguttata* in having a black spot at basal cell C, whereas *intermedia* Oberthür, 1916 is identical to *P. albida*. Though the type of *juenana* (Forster, 1940) was not inspected in our study, we can postulate from Forster's original description that





**Figures 9–11.** Male genitalia of *Phengaris* spp. **9** *P. xiushani* sp. n. **10** *P. atroguttata* **11** *P. albida*

the taxon is related to *lampira* (Röber, 1926) and belongs to *P. atroguttata*, which was verified by Huang (2003).

The name *dohertyi* Hemming appeared in D'Abrera (1993) for a taxon from Naga Hills and northern Myanmar, but could not be found in any further literature. It is possible that the name *dohertyi* was never published (John E. Chainey, personal communication).

**Biological notes.** The species occurs together with *P. atroguttata* in one locality, which we assume is their usual habitat within undisturbed forested mountains (Fig. 12); many adults were flying together. Only one locality was encountered during a 6 days field trip.

**Etymology.** The specific name refers: (a) to the beautiful mountain on the slopes of which it was found (Xiu-Shan in Chinese means “beautiful mountain”), and (b) more importantly we dedicate this species to Dr. Xiushan LI who brought the two authors of this description together and who has committed much of his life to research on ecology and conservation of butterflies (e.g. Li et al., 2006, 2010).

#### Short key to *Phengaris* (s. str.) of mainland China

- 1      Underside forewing without black discal spot in cell ..... *P. daitozana*
- Underside forewing with a prominent black discal spot in cell ..... **2**
- 2      Hindwing underside with a black spot at the basal cell C..... *P. atroguttata*
- Hindwing underside without a black spot at the basal cell C..... **3**
- 3      Valva of male genitalia with a prominent process distally ..... *P. xiushani*
- Valva of male genitalia with a well reduced process ..... *P. albida*





**Figure 12.** Habitat of *P. atroguttata* and *P. xiushani* sp. n. in northwestern Yunnan, alt. 2800m

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We thank Dr. Xiushan Li, Beijing Forestry University for his efforts in organizing a Chinese-German work-shop on butterfly conservation held in Guangzhou, which made the paper become possible, as well as Dr. T. Hirowatari, Osaka Prefecture University for offering his reprints for the study. Cordial thanks are due to Mr. John E. Chainey and Ms Blanca Huertas of the Department of Entomology, The Natural History Museum, London, for supplying images of the types of *Phengaris albida*, *P. atroguttata* and *P. intermedia*, and Matthias Nuss of the Senckenberg Museum für Tierkunde in Dresden, Germany, for the photos of *P. lampira* (Röber, 1926) type. Special thanks are also due to two anonymous referees who contributed significantly to the improvement of the manuscript. Simon G. Potts of the University of Reading, UK, kindly helped to polish “our” English. This study was partly supported by the National Nature Science Foundation of China (30570211, 40971037). We also thank for support within the German-Chinese year of Science, funded by BMBF (German Ministry for Science and Education) through the project LepiPub (in particular we are indebted to Christiana Tings, Petra Bauer and Martin Barth of the BMBF and Cornelia Fischer, Ellen Selent and Christine Will at the UFZ), and for funding through the EU FP 5 project MacMan and the FP 6 BiodivERsA project CLIMIT (Climate change impacts on insects and their mitigation; [www.climit-project.net](http://www.climit-project.net); Settele & Kühn 2009, Thomas et al. 2009).

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# A new genus and species of Callipogonini, description of the male of *Strongylaspis boliviana* Monné & Santos-Silva, 2003, and a new distributional record for *Chorenta reticulata* (Dalman, 1817) (Coleoptera, Cerambycidae)

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## Abstract

*Seticeros* **gen. n.** and *Seticeros tunupai* **sp. n.** of the tribe Callipogonini (Coleoptera, Cerambycidae) from Yungas, Bolivia and the male of *Strongylaspis boliviana* Monné & Santos-Silva, 2003 are described and illustrated. *Chorenta aquilus* (Thomson, 1865) is transferred to *Seticeros* **gen. n.** A new distributional record for *Chorenta reticulata* (Dalman, 1817) is given.

## Keywords

Bolivia, Callipogonini, Macrotomini, Neotropical, Prioninae, taxonomy, Yungas

## Introduction

The Bolivian Yungas, a mountain forest area mainly located in the departments of La Paz and Cochabamba, is one of the world's biodiversity hotspots and is characterized by high levels of endemism (Barthlott and Winiger 1998). Wappes et al. (2006) cited records for six species of Prioninae for the departments of La Paz and Cochabamba and 15 for the department of Santa Cruz, which is mainly covered by lowland forests. Nine species were cited with country record only. Of the listed prionine species from the department of La Paz, *Strongylaspis boliviana* Monné & Santos-Silva, 2003 is the only known endemic representative, while the female holotype is the only known specimen (Monné and Santos-Silva 2003).

Wappes et al. (2006) affirm that the higher level of knowledge about the fauna of the department of Santa Cruz – as a result of the collection bias – is one of the reasons for the difference found between the Cerambycidae diversity in Santa Cruz and the remaining departments.

This paper contributes to the knowledge of the cerambycid diversity of the Bolivian Yungas, while it proposes a new species of the tribe Callipogonini possibly endemic to this area.

A new genus for the newly described species is proposed and, based on the similarities from important characteristics, *Chorenta aquilus* (Thomson, 1865) from Colombia is also transferred to the new genus.

The male of *Strongylaspis boliviana* is described and a new distributional record for *Chorenta reticulata* (Dalman, 1817) for the Bolivian Yungas is given.

## Materials and methods

Specimens examined for this study are from the following institutions / private collections:

<b>MNHN</b>	Muséum National d'Histoire Naturelle, Paris, France;
<b>MZSP</b>	Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil;
<b>NDC</b>	Norbert Delahaye, Private Collection, Plaisir, France;
<b>RPC</b>	Robert Perger, Private Collection, San José, Costa Rica;
<b>UCR</b>	Museo de Insectos, Escuela de Agronomía, Universidad de Costa Rica, San José, Costa Rica

## CALLIPOGONINI

### *Seticeros* gen. n.

urn:lsid:zoobank.org:act:40B98954-E133-4084-8A1B-F7B5510DC740

**Etymology.** The name refers to the hairs/bristles (setae) on the ventral surface of the antennae (*ceros*, Greek for horn). Masculine gender.

**Type species.** *Anacanthus aquilus* Thomson, 1865: 577.

Size moderately large (21–47.4 mm). Integument brown to dark-brown, lighter on elytra and parts of ventral surface.

Male. Body weakly depressed; head (without mandibles) + prothorax smaller than 2.0 times to almost 2.5 times of the elytral length. Head (Figs 1, 3, 6, 8) proportionally large and wide; punctation of dorsal surface (Figs 6, 8) consistently coarse and deep or confluent. Eyes large; upper ocular lobe slightly narrower than lower ocular lobe; distance between upper ocular lobes (Figs 1, 3) little larger than 2.0 times the width of antennomere III at basal third; distance between lower ocular lobes (Figs 6, 8) equal to approximately 1.5 times distance between posterior tentorial pits. Ocular carina (Figs 1, 2, 3) indistinct or absent. Clypeus wide, strongly depressed centrally, and strongly oblique towards labrum. Labrum horizontal, narrow, concave frontally, and distinctly lower than base of clypeus. Hypostomal area sculptured; pilosity moderately long, sparse; hypostomal carina narrow and slightly distinct. Galea surpassing base of second segment of maxillary palps. Mandibles (Figs 1, 2, 3, 6, 8) longer or approximately as long as half of length of head; inner surface with sparse hairs; lower-inner margin with single, somewhat rounded and wide tooth, near inner apical tooth. Antennae (Figs 1, 2) reach apical fourth of elytra; scape reaching or just surpassing posterior edge of eye; ventral surface of antennal segments (Fig. 2) with somewhat long and abundant hairs, gradually shorter and sparser towards segment XI.

Prothorax transverse; anterior angles rounded or somewhat angulated, not projected forward; lateral angles rounded and indistinct, or with obtuse angled lateral edge; posterior angles well marked, angulate. Pronotal disc (Figs 1, 3) with impunctate and shining protuberances on central area, distinctly punctate towards base and apex, and coarsely, confluent punctate laterally (somewhat rugose); lateral margins serrate in upper 1/3 to 2/3, from distinctly rounded to distinctly convergent apically. Prosternum elevated centrally, glabrous and smooth on this area, coarsely punctate and with or without some hairs laterally. Prosternal process wide, with lateral margins parallel, and apex protruding beyond procoxae. Elytra glabrous, abundantly punctate, with three ridges distinct; apex with spine (sometimes moderately long or slightly distinct). Procoxal cavities widely opened behind. Metepisterna and metasternum with pilosity moderately long and very abundant. Metepisterna wide at base and distinctly narrowed towards apex. Profemura rugose. Tibiae slightly enlarged towards apex, with sides subparallel; protibia shorter and proportionally thicker than others. Tarsomere V in all tarsi shorter than tarsomeres I–II together or, at most, as long as in protarsi.

Female. Eyes proportionally larger than in male. Distance between upper ocular lobes (Figs 4, 5) from as wide as the width of a lobe, to approximately equal, to 1.5 times the width; distance between lower ocular lobes (Figs 7, 9) as in male. Antennae (Fig. 4) from just surpassing the middle of elytra to reaching the posterior third; pilosity of segments less conspicuous than in male. Hypostomal area (Figs 7, 9) glabrous or nearly so. Lateral and posterior angles of pronotum distinct, frequently with lateral or lateral and posterior spine.



**Included species:** *Seticeros aquilus* (Thomson, 1865) new combination; *Seticeros tunupai* sp. n.

**Material examined:** *Seticeros aquilus*: COLOMBIA, *Cundinamarca*: Fusagasugá, 1 ♂, 3 ♀, 1931, P. Apolinar col. (MZSP). We also examined photos of the five syntypes of this species.

**Geographical distribution:** Colombia and Bolivia.

**Comments.** *Seticeros* gen. n. differs from *Chorenta* Gistel, 1848 as follows: ventral surface of antennal segments (Fig. 2) with somewhat long and abundant hairs, mainly in segments III–VI, more conspicuous in female; hypostomal area of male without abundant pilosity (Figs 6, 8), and in female more distinctly punctate (Figs 7, 9), metasternum and metepisternum with abundant pilosity. In *Chorenta* the antennal segments are glabrous in both sexes; the hypostomal area of the male (Figs 10, 12) has somewhat long and very abundant pilosity, in the female less punctate (Figs 11, 13) and the metasternum and metepisternum are glabrous.

It differs from *Hephialtes* Thomson, 1864 as follows: labrum narrow and placed distinctly lower than the base of clypeus; antennal segments, metasternum and metepisterna as described in the comparison with *Chorenta*; protibia not distinctly enlarged towards apex; elytral carina very distinct. In *Hephialtes* the labrum is wide and coplanar with the clypeus, the antennal segments, metasternum, and metepisterna are glabrous, the protibia is distinctly enlarged towards apex, and the elytral carinae is not strongly marked.

From *Stictosomus* Audinet-Serville, 1832 it differs in the following characters: mandibles short in both sexes (approximately as long as the half of the head); antennal segments, metasternum and metepisterna as described in the comparison with *Chorenta*; profemurs rugose; metatarsomere V at most as long as the metatarsomeres I–II together. In *Stictosomus* the mandibles are distinctly longer than the half of the length of head (mainly in the male), the antennal segments, metasternum, and metepisterna are glabrous, in the male the third antennal segment is about as large as antennal segments IV, V, and VI together; the profemurs are smooth, and tarsomere V in all tarsi is longer than I–II together.

### ***Seticeros tunupai* sp. n.**

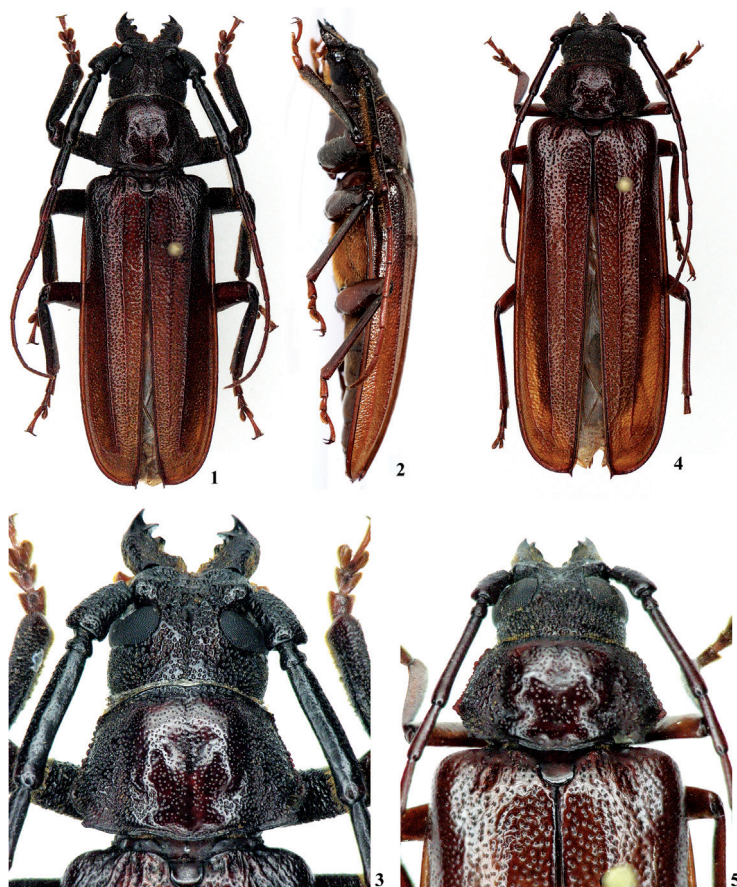
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Figs 1–5

**Etymology.** Named after Tunupa, a god of the Aymara tribe, which is the largest group of native people living in the Yungas area. Tunupa is believed to be the creator of the Altiplano.

Male (Fig. 1). Size (holotype) 47.4 mm. Head, prothorax, femora, tibia, antennal segment I to IV, and base of elytra dark-brown. Antennal segments V to XI, remainder of elytra, and tarsi brown. Length of elytra 2.2 times as long as length of head (without mandibles) and prothorax. Punctuation of dorsal surface of head (Fig. 1, 3) evenly





**Figures 1–5.** *Seticeros tunupai* sp. n.: **1** holotype male, habitus, dorsal **2** idem, lateral **3** idem, head and pronotum, dorsal **4** paratype female, habitus, dorsal **5** idem, head and pronotum, dorsal.

coarse and deep. Vertex and frons sulcate. Eyes large, finely faceted; distance between upper ocular lobes (Figs 1, 3) 1.4 times narrower than distance between lower ocular lobes (Fig. 6). Ocular carina (Figs 1, 3) absent. Mandibles (Figs 1, 2, 3) approximately 0.65 times length of head (without mandibles) and as wide as scape; inner face between base and rounded tooth with sparse hairs. Palpi (Fig. 6) with long hairs.

Hypostomal area finely and densely punctate, with long light-brown hair, pilosity only visible from lateral view (Fig. 2). Antennae (Figs 1, 2) reaching apical fourth of elytra; scape reaching posterior edge of eye; third antennal segment as long as segments IV–V together; ventral surface of antennal segments with somewhat long and abundant light-brown hairs, gradually shorter and sparser towards segment XI.

Pronotum about 1.4 times as wide as long, broadened towards base up to obtuse-angled lateral edge in lower third; posterior angles with lateral, distinct spine, from lateral view coplanar with dorsal surface of elytra, lateral edge positioned lower; lateral margin serrate in upper 2/3, basal margin bordered, well defined. Pronotal dorsum

(Figs 1, 3) shining, sparsely punctate, with embossed, red-brown, annular ridge, divided by short longitudinal fissure; coarsely, confluent punctate laterally (somewhat rugosely). Prosternum distinctly elevated centrally, glabrous and smooth. Metasternum and metepisternum with dense light-brown hairs. Elytra glabrous, abundantly punctate, with three ridges distinct, median convergent with outer; apex with distinct, moderately long spine.

Legs robust. Profemur rugose; ventral surface of pro- and mesofemura with longitudinal grooves. Dorsal surface of protibia with depression gradually deeper towards the tibial-femur joint. Tibia and tarsi medial with short light-brown hairs.

Female (Fig. 4). Size 38–42 mm. Coloration of the elytra uniformly brown, pronotum dark brown, or as in elytra. Length of elytra 2.8–2.9 times as long as length of head (without mandibles) and prothorax. Size of mandibles and legs smaller than in male.

Dorsal surface of pronotum (Figs 4, 5) impunctate and shining medially, with lateral protuberances (each protuberance with impressions), distinctly punctate towards base and apex, and coarsely, confluent punctate laterally; lateral spine more distinct. Prosternum as in male, hairs on metasternum somewhat smaller.

**Type material:** Holotype ♂, BOLIVIA, Department of La Paz, Nor Yungas, street from Caranavi to Coroico, 1600–1800 m, XI.2009 (UCR). Allotype ♀, same data (UCR). Paratypes: 3 ♀, same data (RPC); ♀, same data (MZSP), ♀, X.1990, P. Bleuzen col. (MZSP).

**Comments:** *Seticeros tunupai* sp. n. differs from *Seticeros aquilus* (Thomson, 1865) as follows: hypostomal area less coarsely punctate, more pilose. Pronotum in *S. aquilus* about 1.7 times as wide as long, anterior and lateral angles rounded and not clearly distinct, posterior angles without spine. Protuberances in central area of pronotum in *S. aquilus* without impressions, median elytral ridge convergent with the inner. Apical spine of elytra in *S. tunupai* sp. n. considerably longer than in *S. aquilus*.

### ***Chorenta reticulata* (Dalman, 1817)**

Figs 10–11

*Prionus reticulatus* Dalman, 1817: 147.

*Chorenta reticulata* Monné, 2006: 34 (cat.; comb. n.).

*Chorenta reticulatus* Monné & Hovore, 2006: 9 (cat.); Monné & Bezark, 2008: 10.

Also collected with *Seticeros tunupai* sp. n. were specimens of *Chorenta reticulata*, which is a new distributional record for Bolivia. This species was known to be distributed in southeastern Brazil (Bahia to Rio Grande do Sul) and Argentina (Misiones) (Monné 2006; Monné & Bezark 2008). Those regions are somewhat distant from La Paz in Bolivia, which suggests that the species may also occur in central Brazil (Mato Grosso and Mato Grosso do Sul). In recent years there has been extensive collecting in the Department of Santa Cruz in Bolivia, but no specimen of that species has been found.



**Figures 6–13.** Head, ventral view: **6** *Seticeros tunupai* sp. n., holotype male **7** idem, paratype female **8** *S. aquilus*, male **9** idem, female **10** *Chorenta reticulata*, male **11** idem, female **12** *C. biramiguelus* (Santos-Silva, 2004), male **13** idem, female.

Despite the absence of specimens in southeastern Brazil and middle-eastern Argentina, the specimens collected in Bolivia are consistent with the specimens examined by us (more than 100 specimens from Brazil).

**Material examined.** BOLIVIA: 1 ♂, Department of La Paz, Nor Yungas, street from Caranavi to Coroico, 1600–1800 m, XI.2009 (NDC); 1 ♂, 1 ♀, same data (RPC).

## MACROTOMINI

### *Strongylaspis boliviana* Monné & Santos-Silva, 2003

Figs 14–15

*Strongylaspis bolivianus* Monné & Santos-Silva, 2003: 36; Monné, 2006: 60 (cat.); Monné & Hovore, 2006: 14 (cat.); Wappes et al., 2006: 4 (cat.); Monné & Bezark, 2008: 15 (cat.). *Strongylaspis boliviana*; Santos-Silva & Esteban-Durán, 2009: 353 (in key).

Male (Fig. 14). Integument dark-brown. Elytra as in female, yellowish-brown, with circum-scutellar area slightly darker; narrow band blackish along the suture and epipleura. General pilosity yellowish.



14



15

**Figures 14–15.** *Strongylaspis boliviana*, male habitus: **14** dorsal **15** lateral.

Head longitudinally deeply sulcated between upper ocular lobes; punctuation coarse, very abundant, confluent between upper ocular lobes and occiput; sparser on antennal tubercles near clypeus, and confluent near upper ocular lobes. Frons and clypeus coarsely, confluent punctate. Antennal tubercles closer at base; apex rounded. Mandible short (ca.  $1/3$  of length of head); dorsal carina low, wide, not well marked; latero-outer face with projection near median region (boundary between dorsal punctate and smooth areas); pilosity moderately long and abundant on dorsal face. Hypostomal area coarsely, confluent punctate; pilosity moderately sparse. Gula coarsely punctate (punctures closer near hypostomal area, sparser towards prothorax). Antennae (Figs 14, 15) reaching posterior third of elytra. Scape slightly longer than antennomere III; coarsely, abundantly punctate on dorsal face (punctures confluent on basal  $2/3$ ). Antennomere III slightly shorter than IV–V together; coarsely, confluent punctate on basal half, sparser in remaining portion.

Prothorax transverse, convex with disc almost flat; anterior angles not projected forward; posterior angles with spine, directed upward and backward. Pronotal surface densely rugosely punctate; disc with “M”-like depression at antero-central portion; postero-central region with transversal depression at each side of longitudinal depression that begins at base and reaches almost to middle; pilosity long, moderately abundant. Prosternum strongly elevated at central area; pilosity on prosternum, proepisterna, and proepimera moderately long and abundant. Prosternal process somewhat wide, longitudinally, slightly sulcated on basal half; finely, abundantly punctate on basal half; coarsely, confluent punctate on apical half; pilosity long and abundant; apex rounded, project-



ing slightly beyond apex of procoxae. Mesosternum (Fig. 15) with long and abundant hairs. Mesosternal process longitudinally, strongly, sulcate; apex strongly emarginate. Metasternum and metepisternae (Fig. 15) with pilosity long and very abundant. Central area of metasternum, around metasternal suture, with triangular region separated from remaining surface by narrow band almost smooth (base of triangle near metacoxae). Scutellum strongly convex, slightly longitudinally sulcate; asperities small and abundant. Circum-scutellar area of elytra (Fig. 14) with blackish granules, abundant, well marked, and gradually smaller towards apex, punctures becoming piliferous; elytral apex rounded.

Sternites finely, abundantly punctate; pilosity of sternites I-IV abundant laterally, sparser medially; sternite V strongly emarginate at apex, and with pilosity sub-equally distributed throughout. Profemora and protibiae scabrous, with coarse, small, spines on ventral face; mesofemora and mesotibiae less scabrous, and with spines of ventral face smaller and sparser; metafemora not scabrous, abundantly punctate on ventral face, sub-smooth in remaining areas, without spines on ventral face; metatibiae distinctly less scabrous than pro- and meso-tibiae, and with spines of ventral face less distinct and sparser. Metatarsomere I as long as II-III together.

**Dimension in mm** (♂). Total length (including mandibles), 34.0; prothorax length, 5.0; prothorax width (apices of spines of posterior angles), 9.0; elytral length, 25.0; humeral width, 10.0.

**Material examined.** BOLIVIA: 1 ♂, Department of La Paz, Nor Yungas, street from Caranavi to Coroico, 1600–1800 m, XI.2009 (MZSP).

**Comments.** Monné & Santos-Silva (2003) described *Strongylaspis boliviana* based on a single female from Nor Yungas (Bolivia). The specimen mentioned above is the first collected after the original description. The male can be included in the key presented by Monné & Santos-Silva (2003) together with the female.

## Acknowledgements

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# New genus of diminutive microhylid frogs from Papua New Guinea

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## Abstract

A new genus of diminutive (10.1–11.3 mm) microhylid frogs is described from New Guinea that is unique in its combination of having only seven presacral vertebrae, a reduced phalangeal formula that leaves the first fingers and first toes as vestigial nubs, and reduction of the prepollex and prehallux to single elements. Relationships to other genera are unknown, but overall similarity suggests some relationship to *Cophixalus*, although that genus also differs in some muscle characters and likely remains paraphyletic. The new genus contains two species, which are among the smallest known frogs in the world. Their miniaturization may be related to their inhabiting leaf litter, exploitation of which may select for small size. The new genus is currently known only from one mountaintop in the southeasternmost portion of New Guinea and another on a nearby island. This region is part of the East Papuan Composite Terrane and, should this lineage prove endemic to that region, it may suggest that it originated prior to that geological unit's docking with mainland New Guinea at 23–29 MY.

## Keywords

ecomorph, Microhylidae, Milne Bay Province, miniaturization, *Paedophryne* gen. n., smallest frogs

## Introduction

The Asterophryinae is one of 11 subfamilies of microhylid frogs, but it contains more than half the species diversity within that family (Frost 2010). This subfamily is largely endemic to the Papuan region (comprising New Guinea and satellite islands, the Ad-



miralty and Bismarck Archipelagos, and the Solomon Islands), contains 250+ species, is monophyletic (Savage 1973, van Bocxlaer et al. 2006, Frost et al. 2006, Roelants et al. 2007, van der Meijden et al. 2007), and is relatively young: molecular evidence suggests the extant members of this clade arose within the past ~30 MY (van Bocxlaer et al. 2006, Roelants et al. 2007), approximately consistent with geological evidence for the origin of New Guinea (Davies et al. 1996, 1997). Taxonomy within Astero-phryinae has been fluid, and the number of recognized genera has expanded from nine in the monograph of Parker (1934) to 20 at present (Günther 2009a, Frost 2010), mostly due to partitioning of recognized genera into more tractable, morphologically cohesive (e.g., Zweifel 2000) or monophyletic (Günther 2009a) groups. Nonetheless, additional partitioning is necessary to achieve a completely monophyletic taxonomy of Astero-phryinae (Köhler and Günther 2008), and species diversity within this clade, though great, is severely underestimated (FK, unpubl. data).

Astero-phryinae is morphologically and ecologically diverse, encompassing a variety of fossorial, terrestrial, semi-aquatic, scansorial, and arboreal forms (Burton 1986, Menzies 2006, FK, unpubl. data). This range of ecological diversity is greater than that for any other microhylid clade, and is rare within amphibian families generally. Furthermore, many of these adaptive ecotypes have clearly been derived independently, appearing in otherwise unrelated astero-phryine lineages (Köhler and Günther 2008). However, the exact number of independent origins of each ecotype has yet to be determined, and our understanding of astero-phryine morphological diversity continues to expand and evolve.

During the course of conducting biotic surveys in Papua New Guinea I discovered two new species of a diminutive, morphologically unique astero-phryine frog that expand the ecomorphological range already known for the subfamily. Closer examination indicates that these species represent a lineage showing a combination of osteological and myological attributes that do not allow them to be accommodated within any existing genus. I take this opportunity to place these frogs in a new genus and describe the constituent species.

## Materials and methods

All measurements were made with digital calipers or an optical micrometer to the nearest 0.1 mm, with the exception that disc widths were measured to the nearest 0.01 mm. Measurements, terminology, and abbreviations follow Zweifel (1985) and Kraus and Allison (2006): body length from snout–vent (SV); tibia length from heel to outer surface of flexed knee (TL); horizontal diameter of eye (EY); distance from anterior corner of eye to center of naris (EN); internarial distance, between centers of external nares (IN); distance from anterior corner of eye to tip of snout (SN); head width at widest point, typically at the level of the tympana (HW); head length, from tip of snout to posterior margin of tympanum (HL); horizontal tympanum diameter (TY); width of the third finger disc (3<sup>rd</sup> F); and width of the fourth toe disc (4<sup>th</sup> T).

I confirmed skeletal and musculature features by dissection, X-ray, and double clearing and staining of select specimens; I follow the terminology of Fabrezi and Alberch (1996) for the carpals. Type specimens are deposited in the Bernice P. Bishop Museum, Honolulu (BPBM). All latitude and longitude coordinates use the Australian Geodetic Datum, 1966 (AGD 66).

**Genus *Paedophryne* Kraus, gen. n.**

urn:lsid:zoobank.org:act:3FBFB770-88E8-4DBD-8B82-D0F4E09DA960

**Type species.** *Paedophryne kathismaphlox* sp. n.

**Content.** Two species: *Paedophryne kathismaphlox* sp. n., and *P. oyatabu* sp. n.

**Diagnosis.** A genus of minute (male SV = 10.1 mm, female SV = 10.4–11.3 mm) frogs with short legs (TL/SV = 0.35–0.40); eleutherognathine jaw; absence of clavicles, procoracoid cartilage, and omosternum (Fig. 1A); seven presacral vertebrae lacking neural crests (Fig. 2B); tips of digits flattened; phalangeal formula 1-2-3-2 on hand, 1-2-3-4-2 on foot, reducing digits F1 and T1 to vestigial nubs (Fig. 1C, D); prepollex and prehallux each reduced to a single element; *M. depressor mandibulae* overlying posterior margin of tympanum (Fig. 3G); *M. adductor mandibularis anterior longus* small and inserting only on lateral portions of frontoparietals (Fig. 3H); *M. submentalis* hypertrophied (Fig. 3I); and tongue long, straplike, attached to floor of mouth along anterior third.

**Comparisons with other genera.** The new genus differs from all known genera within the Asterophryinae in having the phalanges on the first digits of each hand and foot reduced to tiny cartilaginous elements, imparting to these digits the external appearance of a rudimentary nub (Fig. 4D, E, 5D, E), and in having the prepollex and prehallux reduced to single elements. Its diminutive size also distinguishes it from the vast majority of other asterophryines: although a few small species of *Albericus*, *Aphantophryne*, *Choerophryne*, *Cophixalus*, and *Oreophryne* approach this small a size, only one species of *Oreophryne* attains it. *Paedophryne* further differs from all other asterophryine genera except *Aphantophryne*, some *Albericus* (Menzies 1997), and occasional aberrant individuals of *Cophixalus* (Zweifel & Parker 1989) in having seven (instead of eight) presacral vertebrae; and the length and narrowness of the straplike tongue is only approximated in some other very small species of *Cophixalus* and some *Oreophryne*.

The small species of *Albericus*, *Choerophryne*, and *Oreophryne* are most readily distinguished from *Paedophryne* by having expanded digital discs; as well, the last-named retains clavicles and a procoracoid cartilage. The new genus is superficially most similar to *Aphantophryne* (in vertebral number, short legs, and having the *M. depressor mandibulae* overlying the posterior margin of tympanum, Fig. 3G) and to smaller species of *Cophixalus* (in general appearance and tendency toward digital reduction in some species). In addition to the characters noted above, *Paedophryne* differs from *Aphantophryne* in its more gracile habitus (squat in *Aphantophryne*); in having the tips

of the digits flattened (rounded in *Aphantophryne*); in having a long, straplike tongue (ovoid in *Aphantophryne*); in its more widely expanded sacral diapophyses; in lacking neural crests on the presacral vertebrae (present in *Aphantophryne*); and in having the *M. adductor mandibularis anterior longus* small and inserting only on lateral portions of frontoparietals (*M. adductor mandibularis anterior longus* hypertrophied and inserting on the medial portions of frontoparietals in *Aphantophryne*, Fig. 3B, Table 1). *Paedophryne* further differs from all *Cophixalus* species in lacking neural crests on the presacral vertebrae (present in *Cophixalus*), differs from all *Cophixalus* species except *C. sphagnicola* Zweifel & Allison in having the *M. submentalis* hypertrophied (*M. submentalis* a small strap in *Cophixalus*, Fig. 3C), and differs from all *Cophixalus* except *C. cryptotympanum* Zweifel and *C. kaindiensis* Zweifel in having the *M. depressor mandibulae* overlying the posterior margin of the tympanum (*M. depressor mandibulae* runs entirely behind posterior margin of tympanum in all other *Cophixalus*, Fig. 3D, Table 1).

**Distribution.** Known from one mountain in the southeastern tip of New Guinea and from one mountain on nearby Fergusson Island, D'Entrecasteaux Islands (Fig. 6).

**Etymology.** The name is a feminine, latinized noun derived from the Greek “paidos”, meaning “child”, and “phryne”, meaning “toad”. It refers to the juvenilized appearance of the frogs.

***Paedophryne kathismaphlox* sp. n.**

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Figs 1, 2, 3G, H, I, 5, 7

**Holotype.** BPBM 17977 (field tag FK 7471), adult female, collected by local villagers on NE slope Mt. Simpson, 10.03157°S, 149.57667, 2170 m, Milne Bay Province, Papua New Guinea, 21 February 2003.

**Paratypes (n = 3).** BPBM 17975, 35353, same data as holotype, except collected 19 February 2003; BPBM 17976, same data as holotype.

**Diagnosis.** A minute microhylid (male SV = 10.1 mm, female SV = 10.4–10.9 mm) with the features of the genus and a relatively short leg (TL/SV = 0.35–0.39, Fig. 4A); short snout (EN/SV = 0.067–0.079, EN/IN = 0.78–0.80, Fig. 4C); medium-sized eye (EY/SV = 0.12, EY/SN = 0.92–1.00, Fig. 4C); dorsal pattern of small dark-brown blotches on a dark-brown ground (Fig. 4A); ventral pattern of tiny, scattered light straw flecks on a dark-brown ground (fig 4B); and a burnt-orange patch (in life) below the anus that contrasts with the dark-brown on the remainder of the animal.

**Comparisons with other species.** The new species differs from other asterophryines in the characters that typify the genus and in its unique burnt-orange rump patch.

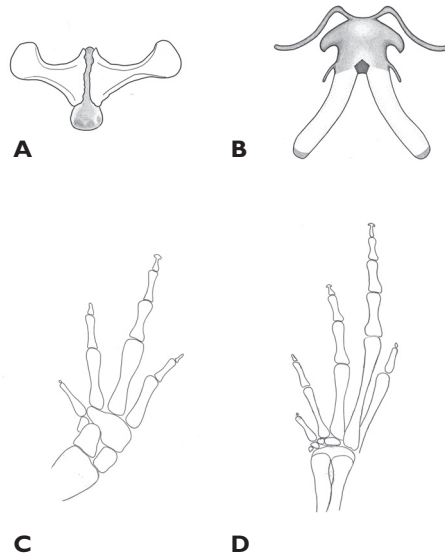
**Description of holotype.** An adult female with a small mid-ventral incision. Head moderately wide (HW/SV = 0.35, Fig. 4A), with steeply oblique loreal region; canthus rostralis rounded, slightly convex when viewed from above; nostrils directed anterolaterally, closer to tip of snout than to eyes; internarial distance larger than distance from

**Table 1.** Features diagnosing *Paedophryne* gen. n. from its most similar-appearing relatives. Features given for *Cophixalus* exclude mention of uncommon variants discussed in the text.

Character	<i>Aphantophryne</i>	<i>Cophixalus</i>	<i>Paedophryne</i>
Number of presacral vertebrae	8	8	7
Neural crests	present	present	absent
Number of elements in prepollex	2	2-3	1
Number of elements in prehallux	2	2-3	1
Phalangeal formula on hand	2-2-3-3	usually 2-2-3-3, sometimes 1-2-4-2, 2-2-4-2, or 2-2-3-4	1-2-3-2
Phalangeal formula on foot	2-2-3-4-3	2-2-3-4-3 or 2-2-3-4-2	1-2-3-4-1
Tongue	Ovoid	Usually ovoid; straplike in some small species	Long, straplike
<i>M. adductor mandibularis anterior longus</i>	hypertrophied; inserts on medial portions of parietals	small; inserts on lateral portions of parietals	small; inserts on lateral portions of parietals
<i>M. depressor mandibulae</i>	overlies posterior margin of tympanum	entirely behind posterior margin of tympanum	overlies posterior margin of tympanum
<i>M. submentalis</i>	hypertrophied	small straps	hypertrophied

naris to eye (EN/IN = 0.80, IN/SV = 0.095, EN/SV = 0.076); snout rounded when viewed from the side or from above (Fig. 4A, C); eyes moderately large (EY/SV = 0.12; EY/SN = 0.93, Fig. 4C), pupil horizontal; eyelid more than half width of interorbital distance; tympanum indistinct and small (TY/SV = 0.057), visible only when skin dries slightly. Skin smooth; supratympanic fold absent. Fingers unwebbed, flattened; F1 very reduced in size; relative lengths  $3 > 2 = 4 > 1$  (Fig. 4D). Disc present only on F3, not wider than penultimate phalanx, circum-marginal groove absent. Subarticular and metacarpal tubercles absent. Toes unwebbed; T2, T3, and T4 with flattened discs, but only T4 has a terminal groove. Fifth toe reduced in size, with round tip and no disc; T1 a vestigial nub; relative lengths of toes  $4 > 3 > 2 = 5 > 1$  (Fig. 4E). Toe discs barely wider than finger disc ( $3^{\text{rd}}\text{F}/4^{\text{th}}\text{T} = 0.85$ ); disc of fourth toe not wider than penultimate phalanx. Subarticular and metatarsal tubercles absent. Hind legs rather short (TL/SV = 0.39, Fig. 4A). Tongue elongate, straplike, anterior third attached to floor of mouth.

In preservative, dorsum medium brown, irregularly and vaguely marked with darker brown, but pattern indistinct (Fig. 4A); darker markings somewhat more obvious on limbs. Face and behind eye brown spotted with light straw brown (Fig. 4C). Venter and under legs dark brown with scattered light straw-brown flecks; rear of thighs same (Fig. 4B). Dirty gray-white patch below anus and proximal portion of thighs (Fig. 4B). Iris black.

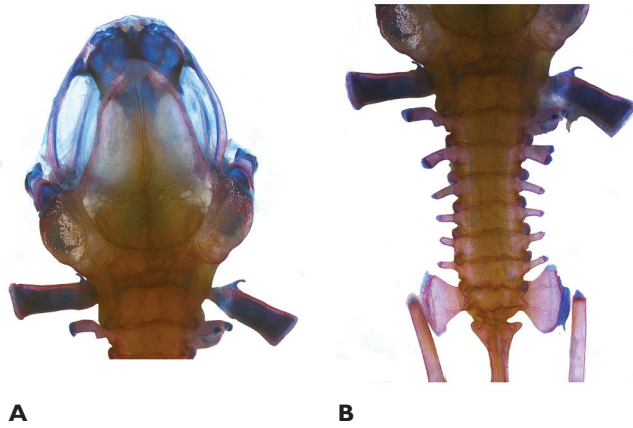


**Figure 1.** **A** Pectoral girdle **B** hyoid **C** ventral view of bones of right hand, and **D** dorsal view of bones of right foot of *Paedophryne kathismaphlox* (BPBM 35353).

*Measurements (in mm):* SV = 10.5, TL = 4.1, HW = 3.7, HL = 3.3, IN = 1.0, EN = 0.8, SN = 1.4, EY = 1.3, TY = 0.6, 3<sup>rd</sup> F = 0.33, 4<sup>th</sup> T = 0.39.

**Variation.** There is little mensural variation in the small type series (Table 2); the same is true for color pattern. The holotype is marginally lighter in ground color than the three paratypes; two paratypes have a vague, lighter brown interorbital bar; and the light ventral flecks in the type series vary from minute to small in size. The skin of the three paratypes is more rugose than seen in the holotype, with each animal appearing rather warty in preservative. Each of these three also clearly had warty or rugose skin in life (Fig. 7).

**Osteology.** Frontoparietals narrower anteriorly than posteriorly; separate anteriorly, fused posteriorly and fused to exoccipital. Prootics inflated, lacking dorsal crest (Fig. 2A). Sphenethmoid ossified posteroventrally and dorsally, but chondrified anteroventrally. Nasals large but barely meeting at midline, with posterior ramus, chondrified peripherally, hollow centrally, overlying dorsal portion of sphenethmoid (Fig. 2A). Squamosal ossified centrally, chondrified distally, articulating on anteroventral/anterolateral surface of prootic. Quadratojugal largely chondrified. Columella large, ossified centrally, chondrified distally, surrounded by chondrified tympanic annulus. Maxilla largely chondrified centrally, including palatine process. Dorsal process of premaxilla well ossified, slender relative to width of labial process; labial process poorly mineralized. Vomers two large chondrified plates meeting at midline, without teeth or lateral processes. Mentomeckelians chondrified at both ends, connected to dentary by hinge, connected to each other by thin strap of cartilage.



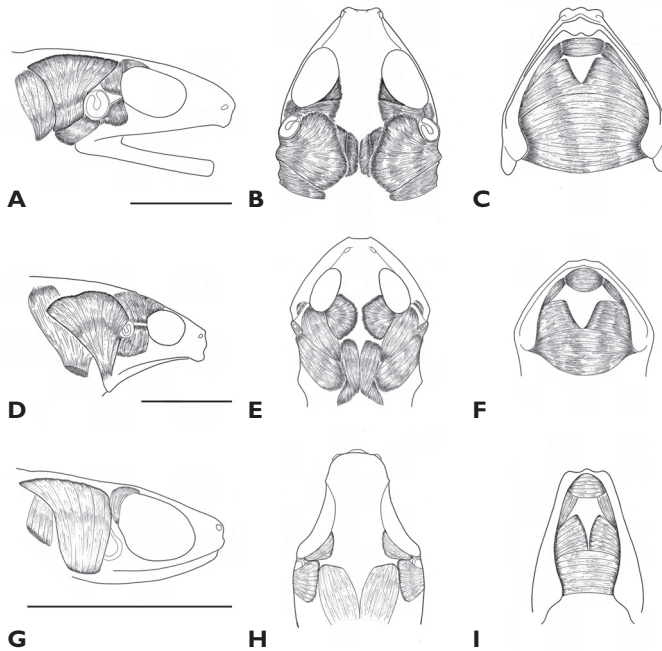
**Figure 2.** Photos of **A** skull, and **B** vertebral column of *Paedophryne kathismaphlox* (BPBM 35353).

Scapulae, suprascapulae, and coracoids present; first two fully ossified; suprascapula largely chondrified centrally, ossified peripherally, with small anterodorsal chondrified hook curving laterally (Fig. 2A). Clavicles, procoracoids, and omosternum absent; sternum a small, poorly chondrified plate (Fig. 1A).

Seven presacral vertebrae relatively stout, with length approximately one-third to one-half width; longer anteriorly, progressively narrowing posteriorly; all but the first with transverse processes, these longer anteriorly, progressively decreasing posteriorly, most with chondrified tips (Fig. 2B). Neural crests absent. Sacrum with widely expanded diapophyses.

**Table 2.** Mensural data for type series of *Paedophryne kathismaphlox* sp. n.

Character	BPBM 17975	BPBM 17976	BPBM 17977	BPBM 35353
	female	female	female	male
SV (mm)	10.4	10.9	10.5	10.1
TL/SV	0.35	0.38	0.39	0.39
EN/SV	0.067	0.073	0.076	0.079
IN/SV	0.087	0.092	0.095	0.099
SN/SV	0.13	0.12	0.13	0.12
TY/SV	0.058	0.073	0.057	0.050
EY/SV	0.12	0.12	0.12	0.12
HW/SV	0.38	0.35	0.35	0.37
HL/SV	0.28	0.32	0.31	0.31
3 <sup>rd</sup> F/SV	0.024	0.028	0.031	0.029
4 <sup>th</sup> T/SV	0.037	0.032	0.037	0.035
EN/IN	0.78	0.80	0.80	0.80
3 <sup>rd</sup> F/4 <sup>th</sup> T	0.66	0.86	0.85	0.83
HL/HW	0.74	0.92	0.89	0.84
EY/SN	0.92	1.00	0.93	1.00

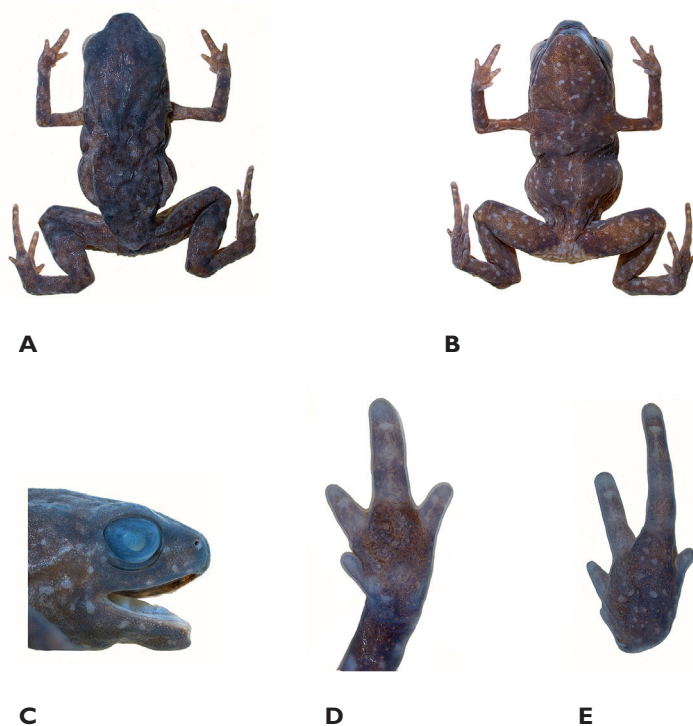


**Figure 3.** **A** Lateral **B** dorsal, and **C** ventral superficial head muscles for *Cophixalus verrucosus* (BPBM 15282) **D** lateral **E** dorsal, and **F** ventral superficial head muscles for *Aphantophryne pansa* (BPBM 25278), and **G** lateral **H** dorsal, and **I** ventral superficial head muscles for *Paedophryne kathismaphlox* (BPBM 35353). Scale bar = 5 mm.

Hyoid plate cartilage, with slight mineralization anteromedially and posteriorly, and with recurved anterolateral processes and thinner posterolateral processes; hyales recurved, chondrified; posteromedial processes ossified, elongate, slightly curved, chondrified at distal ends; ventromedial portion of hyoid proximal to the posteromedial processes with a pentagonal thickening (Fig. 1B).

Hand with six carpal elements: small distal carpal 2, distal carpals 3–5 fused into a single large element, prepollex reduced to a single element, and a large radiale lying between a small Element Y and moderate-sized ulnare (Fig. 1C). Metacarpals long and relatively wide; phalanx of F1 unossified, reduced to a vestigial spot of cartilage; two phalanges on F2, three on F3, two on F4 (Fig. 1C). Terminal phalanx of F3 with expanded, T-shaped tip; those of F2 and F4 pointed, unexpanded (Fig. 1C). Foot with four tarsal elements, with prehallux reduced to a single element. Metatarsals long and relatively narrower than metacarpals; phalanx of T1 unossified, reduced to a vestigial spot of cartilage; two phalanges on T2 and T5, three on T3, four on T4 (Fig. 1D). Terminal phalanges of T3 and T4 with expanded, T-shaped tips; that of T2 pointed, unexpanded; those of T1 and T5, vestigial and rounded (Fig. 1D).





**Figure 4.** **A** Dorsum **B** ventrum **C** side of head **D** palmar view of left hand, and **E** plantar view of left foot of holotype of *Paedophryne kathismaphlox* (BPBM 17977).

**Color in life.** BPBM 17975: “Dorsum brown with irregular black markings; large brown patch on back of thighs near anus. Venter black with gray flecks.” BPBM 35353: “Dorsum black with dark brick-orange blotches mid-dorsally, on forearm, and on tibia. Large brick-orange patch on back of thighs near anus. Venter black.” BPBM 17976 (Fig. 7): “Dorsum mottled black and dark brown. Venter black with blue-white flecks. Burnt-orange anal patch on rear of thighs. Iris burnt orange.” Color images of BPBM 17975–76 in life indicate the sides of each animal were black or very dark brown minutely punctated with light blue-gray flecks (Fig. 7). Each had a narrow reddish rim around the pupil.

**Etymology.** The name is a noun in apposition derived from the Greek roots “kathisma”, meaning “rump”, and “phlox”, meaning “flame”. It alludes to the distinctive burnt-orange patch beneath the anus of living animals.

**Range.** Known only from the type locality on the N side of Mt. Simpson, Milne Bay Province, Papua New Guinea (Fig. 6, filled circle).

**Ecological notes.** Animals were collected during the day from wet *Dicranopteris linearis* leaf litter at a former hunting camp cleared from *D. linearis* scrub at an ecotone between montane forest and *D. linearis* shrubland. The area appeared to be a former

landslip. The species was syntopic with *Cophixalus timidus* Kraus & Allison and a small undescribed species of *Oreophryne*.

***Paedophryne oyatabu* Kraus, sp. n.**

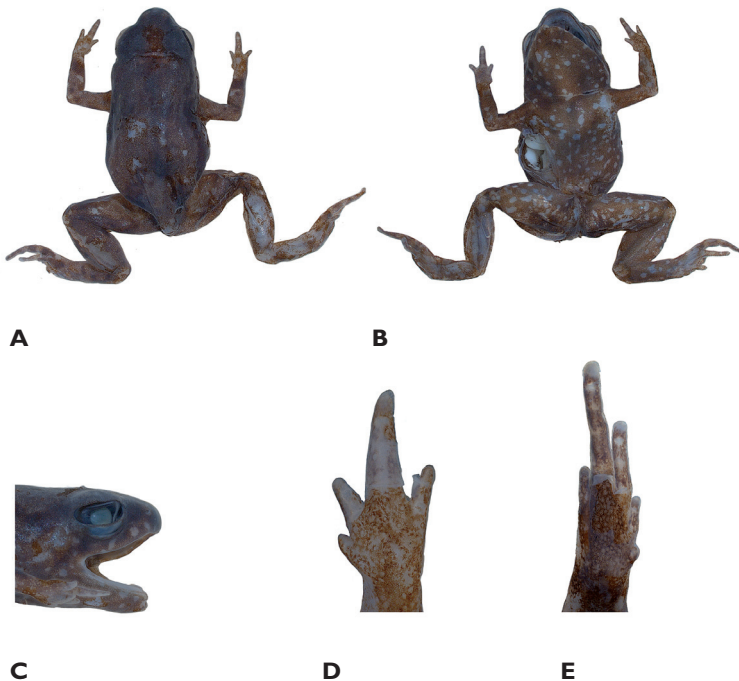
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Fig. 5

**Holotype.** BPBM 16433 (field tag FK 6157), adult female, collected by D. Salepuna on E slope Oya Tabu, 9.4591333, 150.7808666, 1400 m, Fergusson Island, Milne Bay Province, Papua New Guinea, 28 August 2002.

**Diagnosis.** A minute microhylid (female SV = 11.3 mm) with a relatively short leg (TL/SV = 0.40, Fig. 5A), short snout (EN/SV = 0.062, EN/IN = 0.64, Fig. 5C), medium-sized eye (EY/SV = 0.13, EY/SN = 1.07, Fig. 5C), dorsal pattern of a pair of obscure dark-brown chevrons on a lighter-brown ground (Fig. 5A), and ventral pattern of scattered light-gray spots on a dark-brown ground (Fig. 5B).

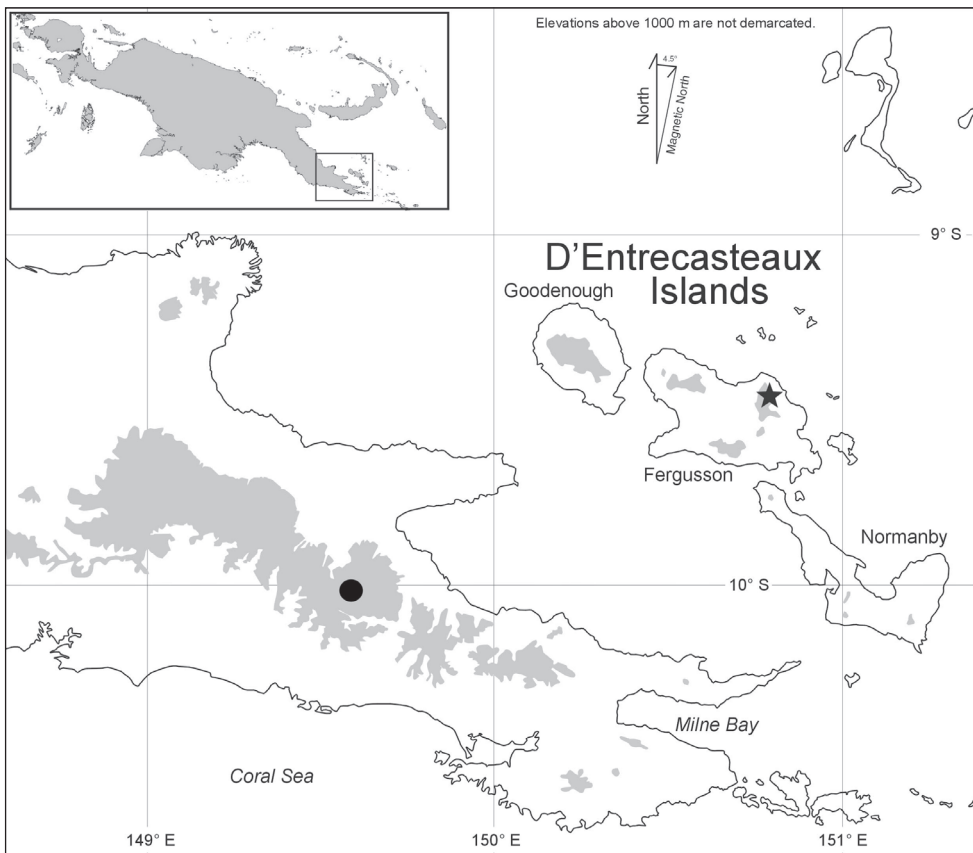
**Comparisons with other species.** The new species differs from *Paedophryne kathismaphlox* in its larger size (females to 10.9 mm in *P. kathismaphlox*), shorter snout (EN/SV = 0.067–0.079, EN/IN = 0.78–0.80 in *P. kathismaphlox*), slightly larger eye



**Figure 5.** A Dorsum B ventrum C side of head D palmar view of left hand, and E plantar view of right foot of holotype of *Paedophryne oyatabu* (BPBM 16433).

( $EY/SN = 0.92\text{--}1.00$  in *P. kathismaphlox*), dorsal pattern of two vague chevrons (vs. irregular small blotches in *P. kathismaphlox*), more boldly spotted venter (light flecks smaller in *P. kathismaphlox*), and absence of a burnt-orange rump patch.

**Description of holotype.** An adult female with right-lateral incision. Head moderately wide ( $HW/SV = 0.37$ , Fig. 5C), with steeply oblique loreal region; canthus rostralis rounded, slightly convex when viewed from above; nostrils directed anterolaterally, closer to tip of snout than to eyes; internarial distance much larger than distance from naris to eye ( $EN/IN = 0.64$ ,  $IN/SV = 0.097$ ,  $EN/SV = 0.062$ ); snout rounded when viewed from the side or from above (Fig. 5A, C); eyes large ( $EY/SV = 0.13$ ;  $EY/SN = 1.07$ , Fig. 5C), pupil horizontal; eyelid almost as wide as interorbital distance; tympanum indistinct posteriorly, small ( $TY/SV = 0.062$ ). Skin smooth; supratympanic fold absent. Fingers unwebbed, flattened; F1 very reduced in size; relative lengths  $3>2=4>1$  (Fig. 5D). Disc present only on F3, not wider than penultimate phalanx, circum-marginal groove absent. Subarticular and metacarpal tubercles absent. Toes unwebbed; T2, T3, and T4 bearing slightly flattened discs, with terminal grooves on T3 and T4. Fifth



**Figure 6.** Map of southeastern Papua New Guinea, showing type localities for *Paedophryne kathismaphlox* (filled circle) and *P. oyatabu* (star).



**Figure 7.** Portrait of paratype of *Paedophryne kathismaphlox* (BPBM 17976) in life.

toe reduced in size, with round tip and no disc; T1 a vestigial nub; relative lengths of toes  $4 > 3 > 2 = 5 > 1$  (Fig. 5E). Toe discs somewhat wider than finger disc ( $3^{\text{rd}}\text{F}/4^{\text{th}}\text{T} = 0.80$ ); disc of fourth toe same width as penultimate phalanx. Subarticular tubercles absent; inner metatarsal tubercle small and elongate, outer lacking. Hind legs rather short ( $\text{TL}/\text{SV} = 0.40$ , Fig. 5A). Tongue elongate, straplike, anterior third attached to floor of mouth.

Dorsum brown with obscure, darker brown chevron markings, one in the scapular region, the other in the lumbar region (Fig. 5a). Face and behind eye dark brown with few distinct light-gray spots (Fig. 5C). Venter and under legs dark brown with scattered, moderately large light-gray spots (Fig. 5B). Rear of thighs brown. Iris black.

*Measurements (in mm).*— $\text{SV} = 11.3$ ,  $\text{TL} = 4.5$ ,  $\text{HW} = 4.2$ ,  $\text{HL} = 3.6$ ,  $\text{IN} = 1.1$ ,  $\text{EN} = 0.7$ ,  $\text{SN} = 1.4$ ,  $\text{EY} = 1.5$ ,  $\text{TY} = 0.7$ ,  $3^{\text{rd}}\text{F} = 0.28$ ,  $4^{\text{th}}\text{T} = 0.35$ .

**Color in life.** “Dorsum light gray brown with two obscure black chevrons on back – one above shoulders, one above groin – and a black mark between the eyes. Forelimbs reddish brown. Entire ventral side black with light-gray flecks.”

**Etymology.** The species is named for its sole known location of occurrence on the highest mountain on Fergusson Island.

**Range.** Known only from Oya Tabu (Mt. Kilkerran), Milne Bay Province, Papua New Guinea (Fig. 6, star).

**Ecological notes.** The sole specimen was retrieved by a native collector under a log during the day in mid-elevation (1400 m) montane forest. The area was suffering drought due to an El Niño, so additional frogs or ecological information could not be obtained.

## Discussion

The most immediately striking feature of *Paedophryne* is its diminutive size. Lehr and Colima (2008) provided a summary of body sizes seen in what they claimed to be the 40 smallest species of frogs then known. Of these, only two were of smaller average size than *P. kathismaphlox*. Similarly, only five of their listed species may prove smaller than *P. oyatabu*, although the paucity of specimens for this latter species makes comparison less certain. However, Lehr and Colima's (2008) brief review overlooked five species of equally small-sized asterophryines in the genera *Aphantophryne*, *Choerophryne*, *Cophixalus*, and *Oreophryne* (Zweifel and Parker 1989, Richards and Iskandar 2000, Richards and Burton 2003, Kraus and Allison 2006, Richards et al. 2007), and four additional diminutive species in *Austrochaperina*, *Choerophryne* and *Cophixalus* have been described since (Günther 2008, 2009b, Kraus and Allison 2009). Of these nine, only *Oreophryne minuta* Richards & Iskandar is as small as the two *Paedophryne* species, with males of the former ranging from 9.2–11.5 mm SV. All these species, as well as most others mentioned by Lehr and Colima (2008), are diminutive outliers in genera having larger average body sizes. *Paedophryne* may be an exception to this pattern. It clearly constitutes one of the most miniaturized frog clades in the world, yet close relatives of larger size are not apparent (see below).

Aside from overall body size, this new genus expands the range of morphological variation within asterophryine microhylids in two other dimensions. First, it is the only asterophryine to have such an extreme reduction in skeletal elements in the hands and feet. Members of *Aphantophryne*, *Choerophryne*, *Cophixalus*, and *Copiula* examined by me (Appendix I, II) typically have phalangeal formulae of 2-2-3-3 (but may have 1-2-4-2, 2-2-4-2, or 2-2-3-4) for hands and 2-2-3-4-3 or 2-2-3-4-2 for feet, whereas *Paedophryne* has 1-2-3-2 on hands and 1-2-3-4-2 on feet. This marks a net loss of 1–3 phalanges on each hand and 2–4 phalanges on each foot vs. the conditions seen in other small asterophryines. But phalangeal reduction is not limited solely to number: in *Paedophryne* the phalanges that remain on F1 and T1 are vestigial and chondrified, and the second phalanx of T5 is also vestigial (Fig. 1) relative to those seen in other asterophryines. Lastly, all related asterophryines examined by me (Appendix I, II) have the prepollex and prehallux each consisting of two or three elements, whereas *Paedophryne* has only a single element for each, which is uncommon in frogs generally (Fabrezi 2001). Losses in these bony elements produce a unique pattern of reduced digital development that goes considerably beyond what is known in other small asterophryines. This presumably limits the flexibility of the hands and feet and, hence, the degree to which *Paedophryne* species can grasp and climb.



Secondly, seven presacral vertebrae, instead of eight, appear rarely within Asterophryinae, being diagnostic for *Aphantophryne* (Zweifel and Parker 1989) but also present as individual variants in some *Cophixalus* and *Albericus* (Zweifel and Parker 1989, Menzies 1997). The shared state between *Paedophryne* and *Aphantophryne* is likely to have been independently acquired inasmuch as the vertebrae of the two genera differ in other features: *Aphantophryne* has well-developed neural crests while *Paedophryne* lacks them, and the sacral diapophyses are far more expanded in *Paedophryne* than they are in *Aphantophryne*. What, if any, functional consequences attend reduced vertebral number for these frogs remain to be ascertained, but the presence of variation in some other asterophryine species makes the subject liable to direct investigation.

Given the morphological uniqueness exhibited by *Paedophryne* it is not immediately certain wherein its relationships might lie. As noted earlier, it is superficially most similar to several species of small, semi-fossorial or terrestrial species of *Cophixalus* in general appearance and in having indications of digital reduction, such as reduced discs or reduced-sized digits (Kraus and Allison 2000, 2009, Günther 2006). However, this digital reduction in *Cophixalus* is not accompanied by similar loss of bony elements (see, e.g., Günther 2006), and the two genera differ in several other features (Table 1), so it seems unlikely that *Paedophryne* represents merely an extreme form of *Cophixalus*. Further, *Cophixalus* has historically been a dumping ground for asterophryines having an eleutherognatine jaw but lacking clavicles, procoracoid cartilages, and omosternum (Parker 1934). In recent decades, the genera *Albericus*, *Aphantophryne*, and *Copiula* have been removed from this genus (Menzies and Tyler 1977, Zweifel and Parker 1989, Burton and Zweifel 1995), and the morphological diversity still remaining within *Cophixalus* makes its monophyly questionable. Until such monophyly is demonstrated, it is unclear what a “close relationship” between *Paedophryne* and a paraphyletic *Cophixalus* would signify. None of the other asterophryine genera of small size appears particularly similar to *Paedophryne*: *Albericus* is arboreal or scansorial and has expanded digital discs; the scansorial or terrestrial *Choerophryne* has expanded digital discs and a long snout involving horizontal orientation of elongated alary processes of the premaxillae; the terrestrial *Copiula* has expanded digital discs and a serous rostral gland; *Aphantophryne* is squat with rounded digits and exhibits several other differences from *Paedophryne* (Table 1); and *Austrochaperina* and *Oxydactyla* have clavicles, procoracoids, and an omosternum. None seems a likely candidate for sister-taxon to *Paedophryne*, and resolution of this question will require a comprehensive assessment of asterophryine relationships.

What accounts for the extremely small size of *Paedophryne*? As the name suggests, *Paedophryne* has several features that suggest morphological juvenilization, or paedomorphosis. Among these are the loss of bony elements in the hands and feet, chondrification of many of the cranial elements, overall size miniaturization, and reduction in vertebral number. Each of these is suggestive of curtailed development relative to other asterophryines via early truncation of either osteosis or somitogenesis. Of course, to demonstrate whether this is true and which particular heterochronic mechanism might be involved requires interpretation from a resolved cladogram of asterophryine rela-

tionships (Alberch et al. 1979). This is currently lacking, so at present paedomorphosis can only be presumed as likely. Should paedomorphic evolution in *Paedophryne* prove true, as it has for other miniaturized frogs (e.g., Trueb and Alberch 1985, Yeh 2002), similar loss of bony elements in diminutive species of *Cophixalus* and in *Aphantophryne* may reflect independent acquisition in each lineage via paedomorphosis. This may be a consequence of shared lifestyles: each lineage consists of small frogs with relatively short legs and somewhat reduced digits that live in leaf litter and moss. Hence, it may be that exploitation of those constrictive habitats selects for small size and its attendant vertebral, limb, and phalangeal reduction. Based on present evidence, this lifestyle and some of the associated morphological changes were acquired independently within Asterophryinae at least twice (to wit, in *Aphantophryne* and *Cophixalus*, Köhler and Günther 2008), and possible more often. Clarifying this exact number will depend on determining the phylogenetic position of *Paedophryne* and additional miniaturized asterophryines in densely sampled asterophryine phylogenetic investigations.

The biogeographic origins of *Paedophryne* also remain uncertain. New Guinea has been formed over the past 60 million years by the sequential accretion of at least four prior island-arc systems or composite offshore terranes (Pigram and Davies 1987, Davies et al. 1996, 1997). As a result, New Guinea is composed of several dozen geological terranes many with emergent offshore origins and these can be grouped into five major geological regions that reflect different periods of accretion history. Relevant to understanding the history of *Paedophryne* is that the genus is currently known only from the southeastern end of one of these major geological regions: the East Papuan Composite Terrane (EPCT), which comprises the present-day Papuan Peninsula and its immediately adjacent islands. This composite was assembled offshore from a variety of terranes and later sutured *in toto* onto the New Guinea mainland at about 23–29 MY (Davies et al. 1996, 1997). Should additional search prove *Paedophryne* to be restricted to the EPCT, it may suggest that this lineage arose during offshore construction of the EPCT, prior to its docking with the remainder of New Guinea. If true, this could indicate that the Asterophryinae is either older than the estimated date of ~30 MY provided by van Bocxlaer et al. (2006) and Roelants et al. (2007), that *Paedophryne* is one of the earlier lineages of Asterophryinae, or both. Long evolutionary isolation may help explain some of the morphological oddities of the genus as well as present uncertainty about its closest relatives. However, the small size and inconspicuous habits of these frogs have delayed their discovery until the present time, and it may be that the genus is more widespread in New Guinea than currently appreciated. If true, the biogeographic origins of *Paedophryne* would then presumably postdate the origin of the EPCT.

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## Appendix I

### Cleared-and-stained specimens examined for musculature and skeletal attributes

*Aphantophryne pansa* Fry: Papua New Guinea: Morobe Province: Bulldog Road, 15.5 km. SSW of Wau, 7.477355°S, 146.6757246°E, 2800 m (BPBM 25278, 25286).

*Cophixalus balbus* Günther: Papua New Guinea: West Sepik Province: 3.2 km SSE Mt. Sapau summit, Torricelli Mts., 550 m (BPBM 22701).

*Cophixalus cheesmanae* Parker: Papua New Guinea: Morobe Province: 5.3–5.6 km NW summit Mt Shungol, 750–780 m (BPBM 18411).

*Cophixalus cryptotympanum* Zweifel: Papua New Guinea: Morobe Province, Mt. Kaindi summit, 2360 m (BPBM 9532).

*Cophixalus desticans* Kraus and Allison: Papua New Guinea: Milne Bay Province: Dubo, Pini Range, 10.4184333°S, 150.3068333°E, 300 m (BPBM 15704, paratype).

*Cophixalus iovaorum* Kraus and Allison: Papua New Guinea: Central Province: Siruohu, W slope Mt. Obree, 9.44467°S, 148.00923°E, 1560 m (BPBM 19283, paratype).

*Cophixalus kaindiensis* Zweifel: Papua New Guinea: Morobe Province: Mt. Kaindi summit, 7.3577898°S, 146.6775362°E, 2360 m (BPBM 9529).

*Cophixalus parkeri* Loveridge: Papua New Guinea: Morobe Province: Biaru Road, 4.2 km N, 4.3 km E of Nako airstrip, 2180 m (BPBM 23724).

*Cophixalus pipilans* Zweifel: Papua New Guinea: Morobe Province: Kamiali Wildlife Management Area, 500–900 m (BPBM 25738).

*Cophixalus riparius* Zweifel: Papua New Guinea: Morobe Province: Bulldog Road, 14.5 km SSW of Wau, 7.4682971°S, 146.6793478°E, 2600 m (BPBM 23779).

*Cophixalus shellyi* Zweifel: Papua New Guinea: Morobe Province: Mt. Missim, 1550–1600 m (BPBM 9364).

- Cophixalus sisypheus* Kraus and Allison: Papua New Guinea: Central Province: W slope Mt. Obree, 9.4574°S, 148.0277°E, 1760–1870 m (BPBM 19316, paratype).
- Cophixalus sphagnicola* Zweifel and Allison: Papua New Guinea: Morobe Province: Bulldog Road, 17 km SSW of Wau, 7.4882246°S, 146.6684782°E, 2800 m (BPBM 24334).
- Cophixalus timidus* Kraus and Allison: Papua New Guinea: Milne Bay Province: vicinity Bunisi, 10.0244565°S, 149.5947176°E, 1420–1540 m (BPBM 18116, paratype).
- Cophixalus variabilis* Kraus and Allison: Papua New Guinea: Milne Bay Province: near Upaelisafupi Stream, Cloudy Mts., 10.4971°S, 150.2330°E, 715–1000 m (BPBM 15781, paratype).
- Cophixalus verrucosus* (Boulenger): Papua New Guinea: Milne Bay Province: near Upaelisafupi Stream, Cloudy Mts., 10.4970833°S, 150.2329666°E, 715 m (BPBM 15282).
- Paedophryne kathismaphlox* Kraus: Papua New Guinea: Milne Bay Province: NE slope Mt. Simpson, 10.03157°S, 149.57667, 2170 m (BPBM 35353, paratype).

## Appendix II

### X-rayed specimens examined for skeletal attributes

- Albericus sanguinopictus* Kraus and Allison: Papua New Guinea: Milne Bay Province: Etakaba Creek, N slope of Mt. Simpson, approximately 1 km SE Bunisi Village, 10.0245°S, 149.5947°E, 1490–1540 m (BPBM 17857, paratype).
- Aphantophryne pansa* Fry: Papua New Guinea: Morobe Province: Bulldog Road, 15.5 km SSW of Wau, 7.477355°S, 146.6757246°E, 2800 m (BPBM 25276).
- Aphantophryne sabini* Zweifel and Parker: Papua New Guinea: Oro Province: Myola Guest House, 7 km S and 6 km W Mt. Bellamy, 9.1494565°S, 147.7747502°E, 2080 m (BPBM 11562, paratype).
- Choerophryne rostellifer* (Wandolleck): Papua New Guinea: West Sepik Province: Torricelli Mtns., 1.6 km SSW Mt. Sapau summit, 3.38074°S, 142.51548°E, 1200 m (BPBM 22684).
- Cophixalus balbus* Günther: Papua New Guinea: West Sepik Province: 3.2 km SSE Mt. Sapau summit, Torricelli Mts., 550 m (BPBM 22693).
- Cophixalus desticans* Kraus and Allison: Papua New Guinea: Milne Bay Province: Normanby Island, SE end Sewa Bay, 10.0407608°S, 150.9771689°E, 80 m (BPBM 20240, paratype).
- Cophixalus interruptus* Kraus and Allison: Papua New Guinea: Morobe Province: Oomsis Forestry Camp, 6.6983695°S, 146.8156702°E, 400 m (BPBM 1153, holotype).
- Cophixalus iovaorum* Kraus and Allison: Papua New Guinea: Central Province: Siruohu, W slope Mt. Obree, 9.44467°S, 148.00923°E, 1560 m (BPBM 19279, paratype).

- Cophixalus kaindiensis* Zweifel: Papua New Guinea: Morobe Province: Mt. Missim, 7.2404891°S, 146.7961956°E, 2360 m (BPBM 21588).
- Cophixalus kethuk* Kraus and Allison: Papua New Guinea: Milne Bay Province: Rossel Island, along Rupu River, 11.33537°S, 154.2247°E, 280 m (BPBM 20203, holotype).
- Cophixalus linnaeus* Kraus and Allison: Papua New Guinea: Morobe Province: Kamiali Wildlife Management Area, 1.3 km N and 6.2 km W of Cape Dinga, 7.295997634°S, 147.092878935°E, 520 m (BPBM 26181, paratype).
- Cophixalus melanops* Kraus and Allison: Papua New Guinea: Milne Bay Province: Sudest Island, W slope Mt. Rio, 11.5081521°S, 153.4308608°E, 720–800 m (BPBM 20198, holotype).
- Cophixalus phaeobalius* Kraus and Allison: Papua New Guinea: Morobe Province: Kamiali Wildlife Management Area, 3 km N and 12.9 km W of Cape Dinga, 7.277998011°S, 147.033451568°E, 1520 m (BPBM 26193, holotype).
- Cophixalus pipilans* Zweifel: Papua New Guinea: Morobe Province: Kamiali Wildlife Management Area, 7.28188171°S, 147.06502234°E, 900 m (BPBM 25750).
- Cophixalus shellyi* Zweifel: Papua New Guinea: Madang Province: Adelbert Mts., Mt. Mengam, 4.709692°S, 145.2734234°E, 1500 m (BPBM 5788).
- Cophixalus sisypheus* Kraus and Allison: Papua New Guinea: Central Province: W slope Mt. Obree, 9.4456521°S, 148.0063578°E, 1580–1640 m (BPBM 19308, paratype).
- Cophixalus sphagnicola* Zweifel and Allison: Papua New Guinea: Morobe Province: Bulldog Road, 15 km SSW of Wau, 7.477355°S, 146.6757246°E, 2480 m (BPBM 24916).
- Cophixalus teztlaffi* Günther: Indonesia: Papua Province: E bank Saengga River, 2.4575°S, 133.11082°E, 60–85 m (BPBM 15829).
- Cophixalus tagulensis* Zweifel: Papua New Guinea: Milne Bay Province: Sudest Island, W slope Mt. Rio, 250–350 m (AMNH 60066, holotype).
- Cophixalus timidus* Kraus and Allison: Papua New Guinea: Milne Bay Province: N slope Mt. Simpson, 10.03642°S, 149.57488°E, 2480 m (BPBM 18106, paratype).
- Cophixalus tomaiodactylus* Kraus and Allison: Papua New Guinea: Morobe Province: Kamiali Wildlife Management Area, 2.6 km N and 9.3 km W of Cape Dinga, 7.28188171°S, 147.065022341°E, 900 m (BPBM 26195, paratype).
- Cophixalus variabilis* Kraus and Allison: Papua New Guinea: Milne Bay Province: near Upaelisafupi Stream, Cloudy Mts., 10.4971°S, 150.2330°E, 715–1000 m (BPBM 15803, paratype).
- Cophixalus verecundus* Zweifel and Parker: Papua New Guinea: Oro Province: Myola Guest House, 7 km S and 6 km W Mt. Bellamy, 9.1494565°S, 147.7747502°E, 2080 m (AMNH 130410).
- Copiula fistulans* Menzies and Tyler: Papua New Guinea: Morobe Province: 5.6 km NW summit Mt. Shungol, 6.81625°S, 146.6915333°E, 750 m (BPBM 18633).
- Copiula oxyrhina* (Boulenger): Papua New Guinea: Milne Bay Province: Misima Island, Oya Tau, 10.65592°S, 152.62765, 860 m (BPBM 17090).

- Copiula tyleri* Burton: Papua New Guinea: West Sepik Province: Torricelli Mtns., 1.2 km S Mt. Sapau summit, 3.3772645, 142.518018°E, 1120–1320 m (BPBM 22735).
- Paedophryne kathismaphlox* Kraus: Papua New Guinea: Milne Bay Province: NE slope Mt. Simpson, 10.03157°S, 149.57667, 2170 m (BPBM 17975–77, 35353, type series).
- Paedophryne oyatabu* Kraus: Papua New Guinea: Milne Bay Province: Fergusson Island, E slope Oya Tabu, 9.4591333, 150.7808666, 1400 m (BPBM 16433, holotype).

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