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Lepidoptera from the Pantepui. Part VII. A distinctive *Lamprospilus* species from the Guiana Highlands (Lepidoptera: Lycaenidae: Theclinae)

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Abstract. *Lamprospilus ayawi* sp. nov. (Lycaenidae, Theclinae), whose male possesses distinctive transparent wing patches, is described from the Guiana Highlands of South America, on the basis of six males and five females from Venezuela (Auyán and Sororopán Tepuis) and one male from Guyana (Acarai Mts.).

Resumen. *Lamprospilus ayawi* sp. nov. (Lycaenidae, Theclinae), cuyo macho presenta porciones transparentes distintivas en las alas, se describe de las Tierras Altas del Escudo Guayanés en Suramérica, sobre la base de seis machos y cinco hembras de Venezuela (Auyán y Sororopán Tepui) y de un macho de Guyana (Montes Acarai).

Keywords. Calycopidina, Eumaeini, hyaline wing surface, Neotropical, sexual dimorphism.

INTRODUCTION

The Guiana Shield is a geological formation, presumed very ancient Precambrian basement rock, that underlies a large region of northern South America: south and southeastern Venezuela, Guyana, Surinam, French Guiana and adjacent areas of Brazil and Colombia. The Guiana Highlands (used here strictly in a physiographic sense) includes all the uplands of the Guiana Shield and can be divided into three areas: the Guiana Highlands proper**,** the Tumucumaque Uplands and the Chiribiquete Plateau (*cf.* Rull *et al.* 2019). The latter area is in Colombia on the western edge of the Guiana Shield and outside the scope of this manuscript. Encompassing all the highlands of southern and southeastern Venezuela, adjoining northwestern Guyana and adjacent Brazil, the Guiana Highlands proper are the predominant mountainous region of the Guiana Highlands and manifest by far its highest elevation (up to nearly 3000m). The dominant physiographical feature of this region is the numerous tepuis, many being sheer-sided table mountains composed of sedimentary rock. Auyán Tepui is an impressive quintessential table mountain, a simply stupendous landform, rising high above its surroundings (from 500 m to 2,450 m) and with an immense summit plateau of 667 km². Sororopán Tepui, a much smaller mountain compared to Auyán Tepui, is part of the Ptarí Massif and is located at the west end of the Sierra de Lema; densely covered by forest, it consists of a 10 km slightly inclined ridge (from the base at1400 m to

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the top at 2050 m) with a steep wall only on its southern face. The Pantepui is a biogeographic province (Costa *et al*. 2014b, Morrone 2014, 2017) and comprises the biota above approximately 1,000 m of the Guiana Highlands proper. Known for its high endemicity among numerous biotic groups, a team of lepidopterists has been involved in the exploration and the study of the Lepidoptera of the Pantepui; the work is still ongoing (Costa *et al.* 2014a, 2014b, 2016, 2017, 2018, 2019).

The Tumucumaque Uplands includes the uplands of the southern Guianas (Guyana, Suriname and French Guiana) and adjacent Brazil, and also the mountains of central Suriname. These ranges are predominantly east-west oriented, largely composed of metamorphic/igneous rocks and with the highest elevation in this region close to 1300 m. The Acarai Mountains are on the Guyana-Brazilian border, highest elevation in this range close to 1200 m. Many of the ranges of the Tumucumaque Uplands are very remote and even less explored than the tepuis (Fratello 2003, 2005). Whether the relatively small area of the Tumucumaque Uplands above approximately 1,000 m should be considered part of the Pantepui province is a study in its infancy and will be discussed later in this manuscript.

Fratello (2005) reported on the occurrence of a spectacular and distinctive hairstreak with transparent wing patches collected in the Acarai Mountains of Guyana. The single specimen was documented and discussed in detail and was identified as an undescribed species of *Lamprospilus* Geyer, [1832] (Fratello 2005), a calycopidine hairstreak (Duarte & Robbins 2010). This species remained hitherto unnamed. Recently, six males and five females of the same species have been collected by two of us (MC and MB) on the slopes of the Sororopán and Auyán Tepuis in Venezuela.

Calycopidine hairstreaks represent one of the most diverse groups of Eumaeini, a tribe constituting more than 90% of the Lycaenidae fauna in South America (Robbins 2004). In the Neotropical checklist, Robbins (2004) recognized a "*Lamprospilus* section" with seven genera, placing therein 157 species; 35 of these were remarked as unnamed, bearing the epithet "[n. sp.] Robbins, MS". Subsequently, this section has been revised and named as subtribe Calycopidina by Duarte & Robbins (2010), now constituting ten genera. As they stressed, the most remarkable character of the members of this subtribe is their larval detritivory.

One of the calycopidine genera is *Lamprospilus*, a poorly known genus established by monotypy. This genus-group name has traditionally been associated with species possessing large hyaline or white patches (*cf.* Draudt 1920, Lathy 1932), but D'Abrera (1995) widened the concept, combining many names conditionally with *Lamprospilus*, that formerly were placed in *Thecla* Fabricius, 1807. In the aforementioned checklist (Robbins 2004), the genus included 41 species (15 unnamed). Duarte & Robbins (2010) redescribed and revised the genus, listing three characters for distinguishing *Lamprospilus* from the rest of the Calycopidina, and reduced the number to ten described, plus four-five undescribed species.

The purpose of the present paper is to name, describe and discuss a new calycopidine hairstreak butterfly, as yet only found in the Guiana Highlands. The discussion includes the placement of this species within *Lamprospilus*, its sexual dimorphism including evidence supporting their conspecificity, the peculiarity and hypotheses regarding the male phenotype and considerations on butterfly endemism and biogeography.

MATERIALS AND METHODS

Acronyms: CF = Christophe Faynel, Montaud, France; HNHM = Hungarian National History Museum, Budapest; MB = Mohamed Benmesbah, Toulouse, France; MC = Mauro Costa, Caracas, Venezuela; MIZA = Museo del Instituto de Zoología Agrícola, Facultad de Agronomía, Universidad Central de Venezuela, Maracay; NHMUK = Natural History Museum United Kingdom, London; PB = Pierre Boyer, Le Puy Sainte Reparade, France; SF = Steven Fratello, New York, USA; USNM = United States National Museum, Smithsonian Institution, Washington, DC; ZB = Zsolt Bálint, HNHM, Budapest.

About 850 calycopidine specimens were examined in the HNHM for comparative purposes. The digital documentation of 81 *Lamprospilus* specimens deposited in the private collection of PB was also studied. Relevant *Lamprospilus* type material was examined by ZB in the NHMUK (*cf.* Bálint & Goodger 2003, Bálint 2005); when necessary, we consulted the images of type specimens on the web-site Butterflies of America (Warren *et al.* 2018). Depository of type specimens is indicated in the Type material entry.

For morphological studies we used standard entomological techniques (Winter 2000). Specimens were set and digitally documented in the private laboratory of Stéphane Attal (Paris, France), and were put on loan for the HNHM (coll. Lepidoptera, 2017-25). Abdomens were dissected in the HNHM laboratory, inventoried with serial numbers of Zsolt Bálint („gen. prep. nos") and the preparations are being kept with the relevant specimens in plastic microvials filled with glycerin. In the HNHM, an Olympus 70SZX12 optical stereo microscope was used to examine specimen anatomy; for digitalisation, an Olympus DP70 digital camera attached to the microscope was used.

Nomenclature for wing pattern and genitalia is compatible with other recent studies of the Calycopidina (*cf.* Duarte & Robbins 2010, Robbins & Duarte 2010).

RESULTS

Genus *Lamprospilus* Geyer, [1832]

Lamprospilus ayawi Bálint, Fratello, Costa & Benmesbah, sp. nov.

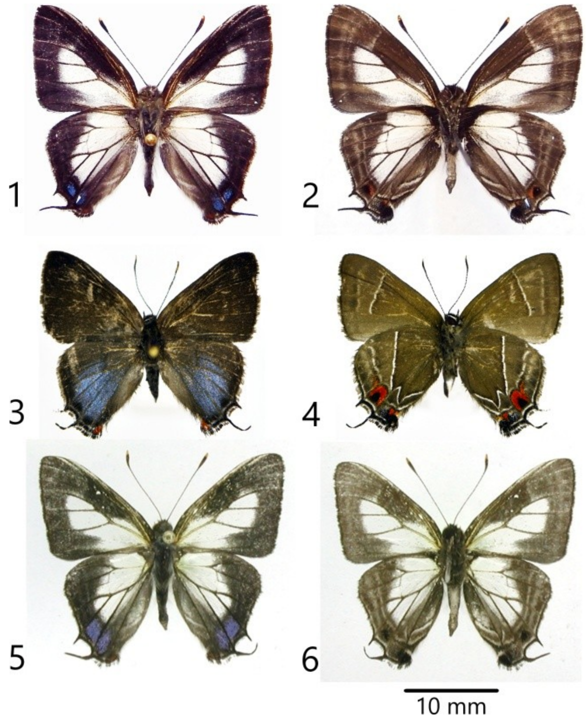
(Figures 1–7, 9–14)

Lamprospilus [n. sp.] Robbins MS; Robbins 2004: 127.
Lamprospilus Geyer n. sp. (Fratello, in prep.); Fratello 2005: 34–35, 37 figs. 10 (male recto), 11 (male verso), 12d (male recto).

Material examined (n = 12). *Holotype* ♂ (set dorsally, in perfect condition), Venezuela, Bolívar, Auyán Tepui, El Danto, 1500 m, 18.I.2017, 05°43'50"N, 62°32'27"W, M. Costa, & M. Benmesbah (MIZA) (Figs. 1–2). *Paratype* (allotype) ♀, Venezuela, Bolívar, Auyán Tepui, El Peñón, 1850 m, 29.I.2019, 05°44'40"N, 62°32'27"W, M. Costa & M. Benmesbah (MIZA) (Figs. 3–4). *Further paratypes* (6 ♂♂, 4 ♀♀): 1♂, Guyana: Acarai Mts./Ridge, Sipu River 2500–3000 ft, 31.X.–10.XI.2000, 1°22.2'N, 58°47.91'W, S. Fratello *et al.* (USNM) (Figs. 5–6); 1♂, *idem* holotype, 19.I.2017 (MB); 2♂♂, Venezuela, Bolívar, Auyán Tepui, entre Guayaraca y El Danto, 1400 m, 28.I.2019, 05°43'22"N, 62°32'30"W, M. Costa & M. Benmesbah (1 MIZA, 1 CF); 1♂, *idem*, (HNHM); 1♂, *idem*, (MC); 1♀, *idem* allotype (MIZA); 1♀, *idem* allotype (MIZA); 1♀, Venezuela, Bolívar, Sororopán Tepui, 1650 m, 19.VII. 2014, 5°42'08"N, 61°47'06"W, M. Costa (HNHM); 1♀, *idem* (MC).

Classification and generic placement. This species belongs to the tribe Eumaeini because it possesses the following three diagnostic characters: *(1)* ten forewing veins; *(2)* greyhound-shaped male genitalia without a sclerotized juxta; *(3)* male foretarsus fused and stubby tipped, used for walking (Eliot 1973). It is placed in the genus *Lamprospilus* (type species: *Lamprospilus genius* Geyer, [1832], by monotypy) because in the middle of the male genitalia gnathos, there is a single medium-sized tooth (Fig. 7, see also Duarte & Robbins 2010). Lastly, it is allied to the *Lamprospilus genius* species group (*Lamprospilus* sensu stricto), because the male forewing surface between veins M3 and CuA2 is partly, either hyaline without (or little) scaling or is covered by white scales (*cf.* Fig. 8).

Diagnosis. Within *Lamprospilus* there is a lineage of species having male phenotypes with hyaline or white bands across the wings (Duarte & Robbins 2010, fig. 61). The most similar in wing facies and the probable two closest relatives of *L. ayawi* are the hyaline patterned: *L. genius* (documented by D'Abrera 1995: p. 1099), a widespread Amazonian species, and the southeast Brazilian *L. japola* (E. Jones, 1912) (Figs. 1–2,

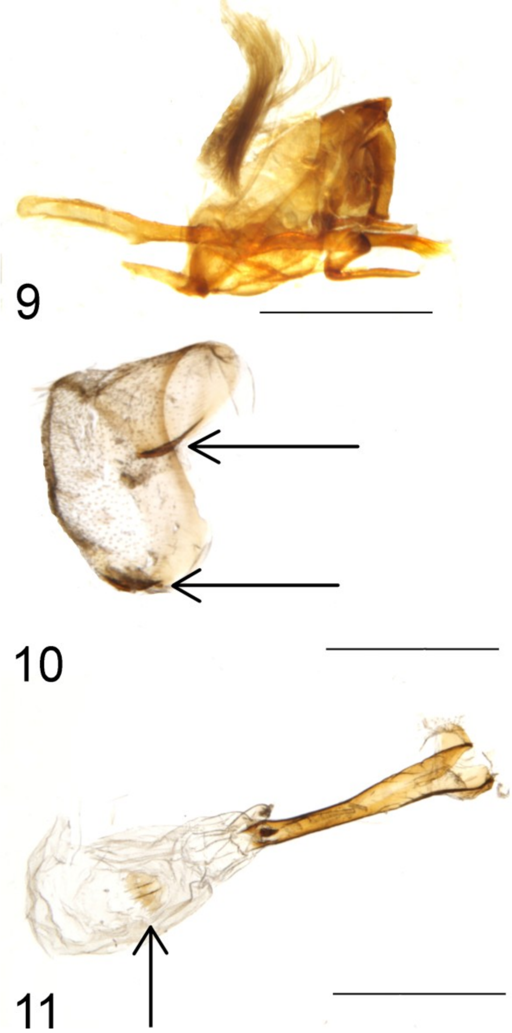


Figures 1-6. *Lamprospilus ayawi* sp. nov. adults. 1 = holotype male, recto; 2 = idem, verso; 3 = allotype female, recto; 4 = idem, verso; 5 = paratype male form Acarai Mountains, recto; 6 = idem, verso (for scale see the main text).

Figures 7-8. Two *Lamprospilus* characters**,** examples from *L. ayawi* sp. nov. and *L. genius* Geyer, 1832; 7 = the single medium-sized tooth in the middle of the *L. ayawi* male genitalia gnathos indicated by arrow (scale bar: 0.6mm); 8 = hyaline male forewing surface pattern between veins M3 and CuA2 in *L. genius* indicated by arrow, without (or little) scaling or is covered by white scales.

25–26, 31–32), from which it differs by the following characters: *a)* larger hyaline patches; *b)* transparent patches (translucent in *L. japola* and *L. genius*); *c)* presence of two large blue antemarginal spots in the dorsal hindwing tornus (lacking in *L. japola* and *L. genius*). This distinctive character of blue submarginal spots in cell CuA2 and CuA1 is also found in male *L. decorata* Lathy, 1926, an Andean species (Figs. 29–30). *L. decorata* is a larger, white-banded taxon whose blue spots are lighter, shining blue compared to the dark blue spots of the new species. Another taxon in this group with white-scaled hyaline bands is the Andean *L. nicetus* (C. Felder & R. Felder, 1865) (Figs. 27–28); a suite of wing pattern characters easily distinguish this species from *L. ayawi*. The Andean *L. draudti* Lathy, 1932, *L. occidentalis* K. Johnson & Salazar, 2004 and an undescribed species from Bolivia are similar to *L. nicetus*.

In overall wing pattern, *L. ayawi* females are most similar to *L. japola* females, their ventral surfaces correlating very closely (Figs. 3–4; D'Abrera 1995: p. 1209, male *T.* (? *L.*) *japola* is female *L. japola*). Besides some subtle ventral pattern differences, most notable is the greater extent of orange scaling conjoined with the hindwing tornal black spot in cell CuA1 for *L. ayawi.* Their dorsal surfaces have significant differences. *L. ayawi*, as compared to *L. japola*: *a)* dark brown ground color versus lighter brown, *b)* structural blue color on the forewing restricted to the region below the cubital vein versus more extensive, *c)* dark blue structural color on the hindwing versus lighter silvery blue. A few of the *L. ayawi* female specimens have a very similar wing shape compared to *L. japola* females, therefore wing shape would not be a good character to differentiate them. Female *L. genius* have substantial dorsal and ventral wing pattern differences with *L. ayawi* (Figs. 3–4; D'Abrera 1995: p. 1209, female *T.* (?*L.*) *teatea* Hewitson, 1868, is female *L. genius*). For comparison, outside the „*L. genius* group", the females of the sister taxa *L. collucia* (Hewitson, 1877) and *L. orcidia* (Hewitson, 1874) have similar dorsal patterns with *L. ayawi*: dark brown ground color; the structural blue color on the



Figures 9-11. *Lamprospilus ayawi* sp. nov. adult anatomy. 9 = male genitalia capsula in lateral view (scale bar: 2.2 mm); 10 = female 8th abdominal tergite with inwardly curved posterior sclerotization indicated by arrow (scale bar: 2.0 mm); 11 = female genitalia ductus and bursa with a pair of fan-shaped signa indicated by arrow (scale bar: 2.2. mm).

Figures 12-14. Variation of *Lamprospilus ayawi* sp. nov. male hindwing submarginal blue spots. 12 = holotype male from Auyán Tepui; 13 = paratype male from Auyán Tepui, 14 = paratype male from Acarai Mountains.

forewing restricted (or nearly so) below the cubital vein; extent of the structural blue color on the hindwing (Figs. 3, 43, 45). The hindwing structural blue color on *L. ayawi* is substantially darker and there are significant ventral pattern differences between *L. ayawi* and these two species (Figs. 4, 44, 46).

Description. Male. Body: frontoclypeus with erecting black hairs, labial palp black and extremely short, eyes brown, large and hairy, parocular area and scape brown, antenna with 17 segments, tip reddish brown, thorax and abdomen black dorsally, abdomen grey ventrally.

Wings. Forewing costal length measured from wing base to apex 12, 15 and 15mm (n = 3); hindwing with short filamentous black tail with white tip at vein CuA1 terminus, and with a longer tail at vein CuA2 terminus; dorsal wing surface translucent with 2–3mm wide black costal and outer marginal band, submarginal area in cell CuA1with smaller and cell CuA2 with larger highly reflective dark blue spot, hindwing tornus with small reddish scaled lobe; area of anal veins greyish covered by long hairs; fringes black in both wings; forewing ventral surface as in dorsum but coloration lighter brown and with additional patterns: a brownish white line running perpendicular to costa at 2/3 costal length to the middle of vein M1, plus a lighter brown narrow submarginal band running from apex to tornus parallel to outer margin, basally having a narrower short line in the subapical area to vein M1; hindwing ventral surface having area of anal veins with white postmedian and submedian lines (remnants of the familiar eumaeine W-pattern): postmedian one with basal black border, submarginal one with distal black border; large submarginal black spot in cell CuA1 bordered basally with orange scaling, tornus black, blue scaling between submarginal spot in cell CuA1 and black tornus; in both wings outer margin with fine white border line, fringes black (Figs 1–2).

Genitalia. Brush organ present with densely arranged hairs, anterior base in lateral view situated on dorsal half of capsule, uncus width in lateral view two times less than height, uncus in dorsal view without posterior process; gnathos base at ventral edge membranous, longer than wide in lateral view, medium-sized tooth based on the basal half of gnathos, tip apiculate and as large as the medial tooth; ventral anterior end of vinculum strut situated on the ventral half of the capsule, saccus putty-knife shaped in dorso-ventral view, valva in lateral view with unequal triangle shape, base long resulting in a continuously tapering shape from the middle posteriorly, aedeagus almost three times as long as valval length with a single cornutus in lateral view upwardly bent (Fig. 9).

Female. Body as in male.

Wings. Forewing costal length measured from wing base to apex 13 mm (n = 2); wing shape with distal margins more rounded than for male (especially on the forewing); dorsal ground color dark brown, forewing light blue area below the cubital vein, hindwing substantial blue area, mostly on anal margin half, dark blue distally; tornal lobe reddish scaled, area of anal veins greyish covered by long hairs; forewing ventral surfaces with warm brown ground color and commonplace eumaeine pattern: forewing with a single postmedian transverse line with dark basal scaling running from costa to cubitus, submargin with a darker brown line scaled lighter basal and running parallel with outer margin from subapical region to tornus; hindwing with the typical "W" shaped medial-postmedial hairstreak pattern, marginal regions as in male but with smaller black spot in cell CuA1 and more extended orange scaling**,** also orange scaling distal to the postmedian line in cell M3 (Figs. 3–4). Abdominal 8th tergum with curved sclerotization at distal end (Fig. 10).

Genitalia. Typical of *Lamprospilus* (*cf.* Robbins & Duarte 2010) with simple slightly sclerotized duct and bursa with length equal to that of the duct, ornamented by a pair of "fan-shaped" signa (Fig. 11).

Variations. The specimens examined show little variation in color and pattern**.** The six Auyán Tepui males are all extremely similar. The only notable differences between these males and the Acarai specimen are: the size of the tornal upper dark blue spot (possibly also hue of these spots) on the dorsum and the amount of orange scaling basal to the ventral large black tornal spot in cell CuA1. The upper blue spot on the Acarai specimen is substantially larger (Figs. 12–14). The Pantepui specimens have more extensive orange scaling. Whether these differences are consistent and constitute geographic differences between populations from the Pantepui and the Guianan southern mountains will hopefully be ascertained when more specimens are collected.

The females from the two different tepuis, Auyán and Sororopán, showed slight wing pattern variation on the ventral hindwing. The Auyán females have orange distal to the white postmedian band in cell M3 that is lacking in the Sororopán females, also the black spot in cell CuA1 on the Sororopán females is smaller. There is also slight but noticeable wing shape differences between the five females, most conspicuous between the Auyán and Sororopán females.

Figure 15. Known localities of *Lamprospilus ayawi* sp. nov.

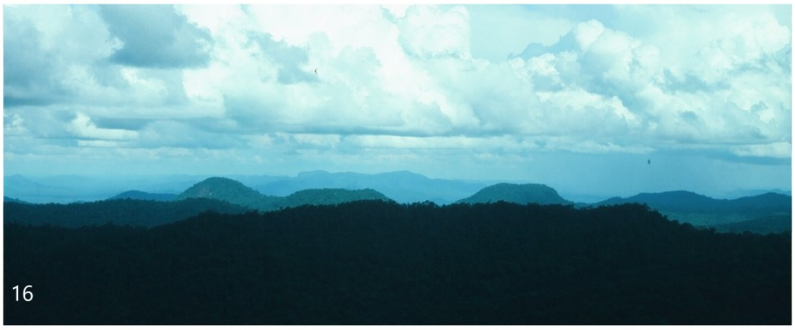
Distribution. L. ayawi is presently known from three localities: Auyán Tepui and Sororopán Tepui in Venezuela and the Acarai Mts, astride southernmost Guyana and adjacent Brazil (Fig. 15).

Bionomics. The Acarai male was collected at the edge of a large tree fall light gap on a high forested ridge at approximately 925 m (Fig. 16); this occurred in mid-afternoon, on what was a mostly sunny day. It was perched at approximately 5 m above the ground, the forest in this area estimated to have a canopy over 20 m high. This collecting site was an incredible spot for riodinids, a number of *Symmachia* Hübner, [1819] and *Argyrogrammana* Strand, 1932 were captured, and other taxa as well. The stunning *Symmachia miron* Grose-Smith, 1898 with its translucent wing patches was amongst them. One of the two known males of an undescribed *Mesosemia* Hübner, [1819] (known presently only from the Acarai Mts.) was also collected in this light gap.

The first two of the six Auyán Tepui males were collected (January, 2017) on a slope at 1,500 m (Figs. 17–18). They also perched at 4–5 m and had been seen flying straight and fast before landing, coming from elsewhere on the slope. Both perched in a near horizontal position after landing. They were caught on two consecutive days at the same spot and approximate time, late morning, both days mostly cloudy with little sunshine. The third consecutive day, another male was seen on the crown of the same tree (6–7m high) but was not collected. The uppermost portion of this tree's crown was in flower, these blossoms attractive to a number of Lycaenidae, Riodinidae and small moths.

The other four Auyán males were collected two years later in a light gap of a densely forested slope at 1400 m (at a distance of about one km from the site of the first two) (Figs. 17–18). They flew very fast and often perched momentarily before taking wing again. Similar to the locality of the Acarai male was the presence of several riodinids (mainly *Symmachia* and *Argyrogrammana)* and also Hesperiidae.

The three Auyán females were found on a slope at a higher elevation (1850m) (Figs. 17–18), feeding



Figures 16 -17. *Lamprospilus ayawi* sp. nov. habitats in Guyana/Brazil border region and Venezuela. 16 = Looking east (at approximately 925m), as seemingly 'endless' ridges of the Acarai Mts. (Guyana/Brazil border region) stretch to the horizon. *L. ayawi* sp. nov. was captured in the transition from lowland hill forest to lower premontane forest at this elevation, not too far distant from where this photo was taken. 17 = Premontane rain forest (1000 m) with the southern slopes and cliffs of Auyán Tepui (Venezuela) rising high above.

Figures 18-20. *Lamprospilus ayawi* sp. nov. habitats in Venezuela. 18 = Looking north from premontane forest at 1000m with the great escarpment of Auyán Tepui beyond (2200–2450 m). *L. ayawi* n.sp. was collected in the intermediate slopes between 1400 and 1850 m. 19 = Upland savannah at 1400 m, looking north to the Ptari Massif in the distance: Sororopán Tepui (2050 m) on the left, Ptarí Tepui (2400 m) in the center and Carrao Tepui (2200 m) on the right. 20 = Looking south over premontane slope forest at 1400m on Sororopán Tepui; midway from this point and the summit (2050 m), the first two female specimens of *L. ayawi* sp. nov. were collected at 1650 m.

on small yellow flowers of an unidentified plant, with dense shrubs the predominant vegetation (2 to 5/6 m); these flowers were also visited by *Catasticta duida* Brown, 1932, *Pirascca hanneri* Gallard *et al.*, 2017, *Ocaria elisa* Bálint & Costa, 2012 and other unidentified Lycaenidae, Hesperiidae and Erateinae.

The two Sororopán females were collected in upper premontane forest at 1650m (Figs**.** 19–20), though annotations on behavior were not recorded.

Type locality. Venezuela, Bolívar, Auyán Tepui, El Danto, 1500 m, 05°43'50"N, 62°32' 27"W.

Etymology. This spectacular unique eumaeine hairstreak is named in honor of Sayra Ayaw, who collected the first specimen in the Acarai Mountains. Sayra, an Amerindian living at Gunns Village, not only caught this beauty, his excellent effort in many facets was indispensable in making the Acarai Mts. expedition such a successful endeavor.

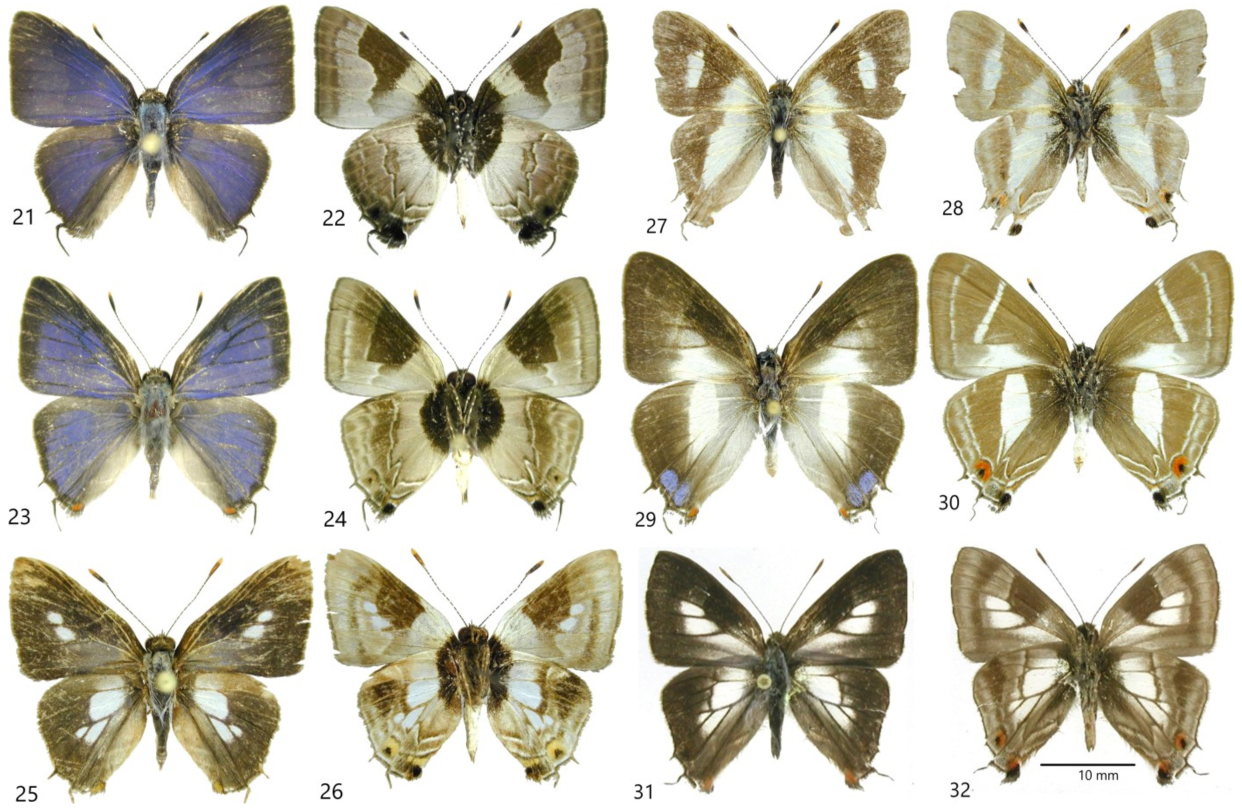
DISCUSSION

Characters of *Lamprospilus* and the *Lamprospilus genius* species-group

Duarte & Robbins (2010) presented the following distinguishing characters for *Lamprospilus*: *(1)* „one medium-sized tooth in the middle of the male genitalia gnathos”, *(2)* „a dark brown patch at the base of the ventral hindwing in males only”, *(3)* „ventral forewing with a dark postmedian band in males only” and *(4)* female 8th abdominal tergite with an inwardly curved posterior sclerotization.

Character 1 is not stable, as it was remarked that it is poorly developed or even absent in *Lamprospilus coelicolor* (A. Butler & H. Druce, 1872) (Robbins & Duarte 2010). This is not a unique phenomenon in the genus, as we could not detect this gnathos tooth in an undescribed *Lamprospilus* collected in Bolivia. However, in *L. ayawi* it is evident and confirms its placement in the genus. Character 2 is present in all *Lamprospilus* taxa examined by the authors. It is very prominent in *L. genius* and *L. aunus*, the two taxa figured in Duarte & Robbins (2010) (Figs. 22, 26). It is easily discerned but sometimes less conspicuous in other taxa (Figs. 2, 24, 28, 30, 32, 34, 36, also D'Abrera 1995: p. 1099 for a less worn specimen of *L. nicetus*). We did not have access to specimens or good quality images of *L. draudti* and *L. occidentalis* to check for this character. Character 3 is not a valid character for all *Lamprospilus,* actually less than half of the described taxa possess it. This trait is also very conspicuous in the two species illustrated in Duarte & Robbins (2010) but this dark band/patch is medial rather than postmedian. It is also prominent on *L. coelicolor* (Fig. 24) and on *L. japola* (Fig. 32); *L. decorata*, *L. ayawi*, *L. collucia* and *L. orcidia* all lack this character. In *L. decorata*, the medial area possesses the same brown coloration that is the ground color for the greater portion of the forewing (Fig. 30). For *L. ayawi* (which though undescribed, was known by at least one of these authors), a good portion of the medial area is part of the large transparent patch. *L. ayawi* manifests a costal dark patch from the wing base to approximately two thirds out along the costal margin (Fig. 2). A medial dark band/patch is obviously absent in both *L. collucia* and *L. orcidia* (Figs. 34, 36). This character is ambiguous for *L. nicetus* and closely related taxa: *L. draudti*, *L. occidentalis* and an undescribed species from Bolivia. In all these taxa, there are significant portions of the forewing, both distal and basal to the medial area, which are as dark as the medial area (D'Abrera 1995: p. 1099). Character 4 also confirms the placement in *Lamprospilus* but more investigation is needed to evaluate the variability of this trait; lacking adequate material, we cannot explore this further at this time.

Duarte & Robbins (2010) mentioned that "*Lamprospilus* was traditionally restricted to males that had white or hyaline longitudinal bands across the dorsal and ventral wings (Lathy 1932; D’Abrera 1995), a monophyletic grouping — after one species with white bands in both sexes (*Thecla azaria* Hewitson, 1867) was moved to another section of the Eumaeini (Robbins 2004)." This group of species, *Lamprospilus* in a strict



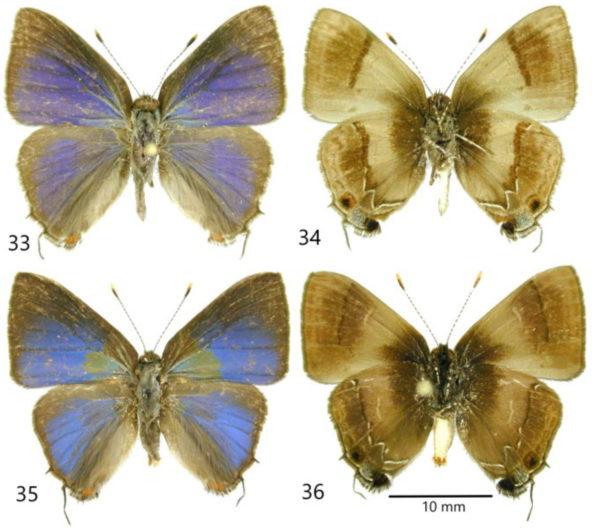
Figures 21-32. Male *Lamprospilus* imagines. 21 = *L. aunus*, French Guyana, recto; 22 = idem, verso; 23 = *L.* ("*Gigantorubra*") *coelicolor*; French Guyana, recto; 24 = idem, verso; 25 = *L. genius*, recto; 26= idem, verso; 27 = *L. nicetus*, Venezuela, recto; 28 = idem, verso; 29 = *L. decorata*, Peru, recto; 30 = idem, verso; 31 = *L. japola*, SE Brazil, recto; 32 = idem, verso.

sense, constitutes the *Lamprospilus genius* species group and is represented by several species distributed widely in the more mesic forested areas of the northern half of South America: Amazonia, the Andes, the Atlantic Forest and the Guiana Highlands. All the males can be identified on the basis of wing pattern (see the Diagnosis above) (*cf.* Figs. 1–2, 25–32).

The hypothetical sister species group of *Lamprospilus* s. str. (= *Lamprospilus genius* species group) is the group of taxa presently placed in the genus, which possess dorsally blue or violet colored males. Formally most of the species representing this group were placed in the genus *Gigantorubra* Johnson, 1993 (type species: *Thecla collucia* Hewitson, 1877, by original designation) (Johnson 1993, Austin & Johnson 1997). This genus was synonymized with *Lamprospilus* by Robbins (2004) and Duarte & Robbins (2010). Probably a fine graded approach (Oláh *et al.*, 2018) for this clade would demonstrate that there is evidence to apply the name *Lamprospilus* in a strict sense to the hyaline and white patterned species and also to use the genus-group name *Gigantorubra* for the species with structurally colored males (Figs. 21–24, 33–36).

Associating the female phenotype

Associating sexes of eumaeine lycaenids is difficult. For this quandary, there are good examples in *Lamprospilus*, as male and female phenotypes were described several times as distinct species because of marked sexual dimorphism (see Robbins 2004, and Warren *et al.* 2018). A number of taxa illustrated demonstrate the phenomenon of pronounced sexual dimorphism in *Lamprospilus* (Figs. 23–24, 27–30 and 33–46). Our reasons for associating the male phenotype col-



Figures 33-36. Male *Lamprospilus* ("*Gigantorubra*") imagines. 33 = *L. collucia*, Mexico, recto; 34 = idem, verso; 35 = *L. orcidia*, Brazil (Amazonas), recto; 36 = idem, verso.

lected on Auyán Tepui and in the Acarai Mountains with the phenotype represented by five female specimens from Auyán and Sororopán Tepuis are as follows.

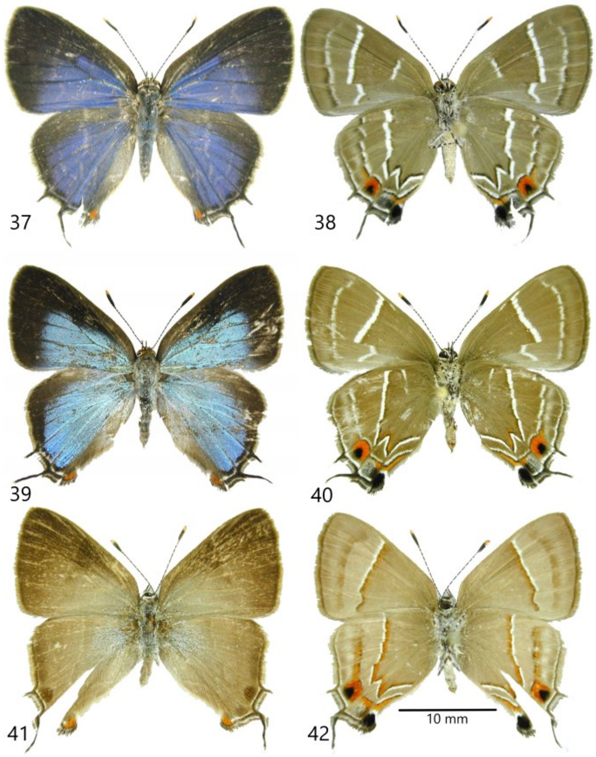
The *Lamprospilus* female phenotypes are not easy to identify even on the generic level. Wing shape and pattern all follow the general groundplan of the tribe: dorsal wing surfaces manifest structural blue coloration; ventral wing surfaces with a white postmedial line, this line often with basal red scaling and forming a W-shaped pattern between veins M3 and CuA2 basal to the submarginal Thecla-spot; vein termini CuA1 and CuA2 are tailed. Similarly, there is no clear-cut character in the female genitalia, although the 8th tergite is with modification. This is also a subtribal character, the distinctively curved sclerotization at the lateral edge also occurring in other calycopidine genera (*cf.* Duarte & Robbins 2010: figs. 16–23). Nevertheless, with the combination of the mentioned characters and comparison with male ventral surfaces, candidate female specimens can be placed in *Lamprospilus* with great certainty, as the five specimens collected on Auyán and Sororopán Tepuis.

During the one decade long survey in the Pantepui region (*cf.* Costa *et al.* 2017) only two males of *L. coelicolor* have been collected : between San Francisco de Yuruaní and Paraitepui, km 7, 1200 m, 27.III.2005 and between Uruyén and Guayaraca, 1000 m, 22.III.2013. (Bálint *et al.,* unpublished). The female of *L. coelicolor*, described as *Thecla hena* Hewitson, 1874 (*cf.* D'Abrera 1995: 1206, ventral figure), has a character unique in the genus for female phenotypes: the forewing ventral surface reveals a submedian white line in the discal cell (Fig. 38). Thus the Auyán/ Sororopán specimens cannot represent the female of *L. coelicolor*.

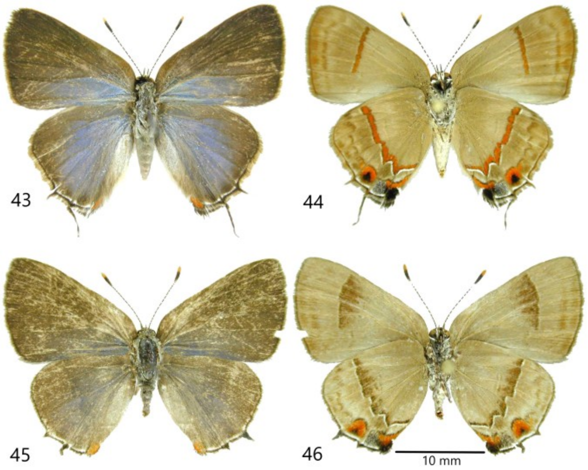
When we consider male phenotypes, the closest species to *L. ayawi* is *L. japola* (Figs. 1–2, 5–6 and 31–32). Accordingly, we suspect that their females should also be similar. And indeed, the female phenotype of *L. japola* is quite similar with the Auyán/Sororopán specimens (*cf.* D'Abrera 1995: 1209 (labelled as male)**,** (Figs. 3–4)), but there are two distinctive characters: *(1)* the dorsal non-iridescent ground color *(2)* the extent of dorsal structural blue coloration on the forewing and difference in hue on the hindwing. The differences for these two characters are elucidated in the Diagnosis above, but we present here a short discussion on their variability placed in a wider taxonomic scope.

Character *(1)*, when the whole spectrum of female phenotypes is known for a genus, is often helpful for positive identification (for example in hairstreaks representing the genus *Penaincisalia* K. Johnson, 1990). Character *(2)* involves structural blue coloration, which is often species specific and stable in the case of the polyommatine lycaenid butterfly males, even under strong environmental pressure (Kertész *et al.* 2017).

Interestingly, dorsal structural coloration is quite plastic in the case of females, because as experiments demonstrate, cold shock activates genes that produce structural color generating scales (Kertész *et al.* 2019). It is an interesting topic for further investigation in tropical Lycaenidae, how the wing scaling of different phenotypes would react to various environmental variables. At the moment, no experimental data is available on how structural color relates comparatively in females and how variable it is, but we suspect that it also has an important sexual role.



Figures 37-42. Female *Lamprospilus* imagines. 37 = *L.* ("*Gigantorubra*") *coelicolor,* Ecuador, recto; 38 = idem, verso; 39 = *L. decorata,* Ecuador, recto; 40 = idem, verso; 41 = *L. nicetus,* Venezuela, recto; 42 = idem, verso.



Figures 43-46. Female *Lamprospilus* ("*Gigantorubra*") imagines. 43 = *L. collucia*, Mexico, recto; 44 = idem, verso; 45 = *L. orcidia*, Ecuador, recto; 46 = idem, verso.

As noted above, the wing shapes of a few of the *L. ayawi* females are very similar to that of *L. japola* females. Although wing shape will probably not be a reliable character to separate these two taxa, we remark that wing shape in eumaeines is often a good character; for example distinguishing *Johnsonita* Salazar & Constantino, 1995 and *Salazaria* D'Abrera & Bálint, 2001 (Bálint in prep.), or the several species groups (or genera) of *Penaincisalia* (*cf.* Bálint & Wojtusiak 2006).

In summary: regarding female wing facies, *L. ayawi* has the closest resemblance to *L. japola*, with dorsal differences stated above and the two taxa sharing quite similar ventral patterns. Other hyaline patterned *Lamprospilus* species have corresponding females with distinctive phenotypes, their intensive ventral wing surface patterns ornamented with white (*L. genius*) or orange (*L. nicetus*) (Fig. 42) scaling. Therefore we are very confident in our association of the two phenotypes for *L. ayawi*.

The male phenotype

It seems that male eumaeine dorsal coloration is also species specific in tropical ecosystems (*cf.* Bálint *et al.* 2008 and 2009), and amongst them the phenomenon of discoloration (Biró *et al.* 2003) also occurs (Bálint 2004). In *Lamprospilus*, only *L. aunus* and *L. coelicolor*, plus *L. collucia* and *L. orcidia* species pairs, have structurally blue colored males. The male of *L. genius* possesses both structural blue color on the forewing and hyaline patches. It intermediates the structurally blue colored species, and the hyaline and white banded species, that according to Duarte & Robbins (2010, fig. 61), constitute the sister group of the blue species. The undescribed species from Bolivia seems to be the only species in the genus having a male phenotype in the discolored state.

It is generally assumed that the myriad bright colors and/or distinctive patterns that adorn the dorsal surfaces of the world's diurnal Lepidoptera are predominantly for communication: in the great majority for sexual attraction and territorial display; to a much lesser degree but still numerous, for aposematic display. The vast majority of the multitudinous Neotropical eumaeines manifest various hues of brilliant blue/purple structural color dorsally, often covering a good portion of this surface, more prevalent in males and also often more pronounced in this sex. Taking into account the high diversity of taxa that occurs together in many habitats throughout the Neotropical region, especially in lowland and premontane rainforests but still diverse in montane and upper montane forests and even in high altitude puna and paramo regions, it follows logically that the various hues, as well as the patterns of structural color, would be for mate selection. Field experience with these dazzling jewels poses interesting questions concerning eumaeine communication.

In thousands of days exploring Neotropical rainforests, in the lowlands and montane regions: Central America, the Guiana Highlands and the Andes, not one eumaeine was seen perching with its wings open from the thousands that were observed (all authors, pers. obs.). This includes a small number observed in upper forest levels including the canopy. Though upper forest levels might be a major microhabitat for Neotropical eumaeines and observation there was minimal, the overall data strongly suggests that these hairstreaks, including *Lamprospilus*, predominantly perch with their wings closed. All of them fly rapidly and erratically, could visual signals for mate selection be given in flight with only small interval bursts of color and certainly almost no way to discern pattern at this speed by human eyes? However, experiment based evidence suggests that the optical systems of diurnal Lepidoptera are able to detect and distinguish these four dimensional species specific signals, and females prefer the brightest individuals (Kemp 2007, Imafuku & Kitamura 2018). Considering this evidence, the question arises: why do so many eumaeine males possess androconia, olfactory communication possibly being paramount for mate selection?

Lamprospilus manifests a number of very distinctive phenotypes, various aspects of this discussed previously. The taxa with blue structurally colored males, though possessing aberrant 'banded' undersides, have dorsal blue uppersides that place them in the realm of the majority of Neotropical eumaeines, though they and other *Lamprospilus* lack androconia.

Though there are some eumaeines that in both sexes or only the females are predominantly dorsally white [*e.g. Arawacus* Kaye, 1904 sp.; *Laothus* K. Johnson, Kruse & Kroenlein, 1997 sp.; *Rekoa meton* (Cramer, 1779); *Brangas neildonatus* Bálint & Faynel, 2008 (Bálint, unpublished); and also female *L. draudti* (Bravo *et al.* 2009)], taxa dorsally banded with white/white-scaled hyaline is restricted to male *Lamprospilus*: *L. decorata*, *L. nicetus* and allies, and also *Thestius azaria* (Hewitson, 1867). Wing surfaces of white diurnal Lepidoptera, or on a smaller scale, banded with white, reflect a much wider spectrum of the available light because of their nanomorphology (Luke *et al.* 2009). This would constitute a quite different signal than the blue/ purple species whose reflectivity would be in a much narrower zone of the visible spectrum. Could this result in a communicative advantage for these *Lamprospilus* in various microhabitats of the Andean forests that they inhabit?

Another similarly plausible explanation and related to the previous one, is that in forest light islands where there are high a aggregation of patrolling eumaeine species, present in the same habitat not only in time and space but also similar in the manner how the great majority of male dorsal wing surfaces produce signals, having a different way to communicate could be advantageous (*cf.* Robbins & Busby 2009). It was recorded for example, that in one Colombian eumaeine community, blue and white-banded *Lamprospilus* species shared the same habitat niche (Prieto and Dahners 2006, 2009). Was this facilitated by their different ways of communicating? We note that a few members of the riodinid genus *Siseme* Westwood, 1851 (and to a lesser degree the riodinid genus *Anteros* Hübner, [1819]) have a similarity in general wing pattern to these white-banded *Lamprospilus*. We lack the empirical experience to know if they coexist in the same Andean forests and will not conjecture on whether this resemblance bears any significance. Further evaluation in the field is required.

Also very distinctive among eumaeines are the male hyaline patched *L. genius*, *L. japola* and *L. ayawi*. The relatively widely distributed *L. genius* has smaller hyaline patches than *L. japola*, substantially smaller compared to *L. ayawi*. What the function is for individual elements or the dorsal pattern in totality for this exquisite 'intermediate' *Lamprospilus* is an interesting enigma. A plausible explanation for the small fenestrated patches that adorn the wings of *L. genius* is that this represents an example of protective resemblance camouflage involving water droplets. This phenomenon also occurs in a number of saturniid taxa and will be discussed further below. *L. japola* and *L. ayawi*, as in *L. nicetus*, have significant areas of their wings hyaline. Fenestrated wing areas are unique to *Lamprospilus* among the world's lycaenids. *L. ayawi*, which has the largest percentage of its wing area hyaline, is unique in that these areas are truly transparent, not translucent as in other taxa.

Transparency/translucency reaches its zenith in the Neotropics, both in total diversity and that all butterfly families have members with this quality, this phenomenon being much more restricted in the Afrotropical, Oriental and Australian regions. This can partly be explained by: the overall great diversity of the Neotropical butterfly fauna; the speciose ithomiines, the dominant hyaline butterfly group, with numerous transparent/translucent species (among others); and the presence of mimicry rings with these ithomiines presumably as models, in which occur all or most of the hyaline species of other butterfly families (*e.g.*, papilionids, dismorphiine pierids, riodinids). Seeing transparent-winged ithomiines flitting through the dark understory of a lowland tropical understory or *Cithaerias* Hübner, [1819] and *Haetera* Fabricius, 1807 (haeterine satyrines) flying ghost-like just above the forest floor in these same forests, leaves little doubt that camouflage by transparency is in effect (all authors, pers. obs., Siddique *et al.* 2015). Obviously, when these and other hyaline-winged butterflies are resting in the dark forest interior, camouflage by transparency would be a very effective protection mechanism. When *L. ayawi* was first discussed (Fratello 2005), it was speculated that its large transparent wing patches might render it less visible when at rest, again camouflage by transparency. This might not be the case at all and herein are given other possible explanations.

As mentioned above for *L. genius*, the hyaline patches of *L. japola* and *L. ayawi* might also be examples of protective resemblance camouflage involving water droplets. What could make this an effective deception is the way in which many eumaeines perch. When perching, usually on the upper surface of leaves, they often angle their closed wings closer to a horizontal rather than vertical position (all authors, pers. obs.; *cf.* Hoskins & Bálint 2016). It is conjectured that this manner of perching is for defensive purposes in regards to sharp-eyed predators (e.g. birds): they are less obtrusive from the leaf surface and also their shadows are minimized. In fact, the Auyán males were recorded perching in this manner (the manner in which the Acarai Mts. male was perched was not observed). Could the larger transparent patches of *L. ayawi* (and larger translucent patches of *L. japola* as well) serve to function for a different purpose? Dushkina *et al.* (2017) stated that the hyaline wing surface has practically no reflectivity. Siddique *et al.* (2015) stated, following experimental results, that the ithomiine *Greta oto* (= *Greta morgane oto* (Hewitson, [1855]), (Lamas 2004) has "transparent wings with remarkable low haze and reflectance over the whole visible spectral range even for large view angles of 80°." Is there the possibility that if *L. ayawi* males were perched as stated above, that incident sunlight at a certain angle range could be reflected effectively enough from its transparent patches to be a signal for females? Empirical evidence (MC & MB, pers. ob.) from the latest expedition to Auyán Tepui (2019) might shed some light on this last hypothesis. SF (2005) hypothesized that while flying, the small size and rapid flight of this hairstreak would render the transparency of its wing patches not observable to human eyes. That this was verified by recent observations is not surprising. What is surprising is that both in flight and at rest (5–6 meters distant), *L. ayawi* appeared as a small brilliant white butterfly with black borders. Even at rest at this relatively close distance, transparency was not observed. In flight caused by the rapid wing beats or at rest with the two wing membranes acting like a mirror, microstructures could be causing the scattering of light randomly and intensely, with the resultant brilliant white color. Future field observation in its remote Guiana Highlands home and experiments in the lab, will hopefully give deeper insight into the function of the enigmatic large transparent wing patches possessed by a small lycaenid.

Distribution and endemism

Auyán Tepui and Sororopán Tepui are proximate to each other (nearly 90 km) (Fig. 15). How extensively *L. ayawi* ranges in the Pantepui will hopefully be discovered in the future. Though a fair number of tepuis have been explored for Lepidoptera (Fratello 2004, Costa *et al.* 2014a, 2014b, 2016, 2017, 2018, 2019), still many remained totally unexplored for this group. Also considering the vicissitudes of weather, often inclement in these misty highlands, the unknown phenology of these montane taxa, and other variables, a few weeks on a single tepui will hardly reveal the extent of its butterfly diversity. However, considering that *L. ayawi* is also present on Sororopán Tepui, one of the tepuis that rise from the extensive Gran Sabana plateau (about 10,800 km^2), we surmise that this species probably inhabits the slopes of other tepuis of the Gran Sabana. It is remarkable that *L. ayawi* has never been reported from the intermediate levels of the Gran Sabana plateau (900–1200 m), despite this elevational zone having been sampled much more extensively than the higher tepui slopes (Figs**.** 17–20).

Besides the Acarai Mts., four other ranges in southern Guyana: Iwokrama Mts., Kanuku Mts., Kamoa Mts. and Wassarai Mts., possess high ridges/peaks at an elevation equal to or higher than the elevation (approximately 925 m) at which the Acarai Mts. *L. ayawi* was collected. The Kamoa and Wassarai Mts. remained unexplored for Lepidoptera. A total of a few weeks' time has been spent exploring for Lepidoptera on the high ridges/peaks of just small portions of the Iwokrama and more extensive Kanuku Mts. As in the Pantepui, much more exploration is needed to ascertain the butterfly diversity of all these ranges and whether *L. ayawi* inhabits them. The Acarai Mts. are the western and highest part of a continuous upland area that forms the border between Guyana, Suriname and French Guiana to the north, and Brazil to the south; rivers to the south of these mountains drain to the Amazon, rivers to the north have an Atlantic drainage. Further exploration of these mountains that are lower than the Acarai, *e.g.* the Tumuc Humac Mts. bordering French Guiana/Surinam and Brazil, will hopefully ascertain whether *L. ayawi* dwells below the lower premontane zone.

The only other mountains in the Guiana Highlands to attain 925 m are central Suriname's Wilhelmina Mts. which include: Tafelberg (1026 m), the easternmost tepui and Julianatop (1280 m), the highest peak in the Guiana Highlands outside the Guiana Highlands proper. To our knowledge, their heights are unexplored for Lepidoptera but could possibly harbour populations of what seems to be a taxon endemic to the premontane forests of the Guiana Highlands.

With 12 specimens collected within the elevational range of approx. 925–1,850 m and none collected in extensive exploration of Amazonian lowlands, we presume *L. ayawi* to be endemic to premontane forest of the Guiana Highlands. As the Pantepui region has by far, much more extensive premontane forest than other mountainous areas in the Guiana Highlands, and no other mountains in the Guiana Highlands come close to 1,850 m elevation, present evidence strongly suggests that *L. ayawi* is primarily a Pantepui species. It is noteworthy to mention that this is the first and only butterfly taxon known to us that seems to be a premontane species and is found in both the Pantepui and Guianan southern mountains. Present evidence (SF, unpublished data) suggests that the Pantepui and Guiana southern mountains have significantly different butterfly faunas at the lower premontane level. Future exploration might ascertain a stronger correlation between the lower premontane butterfly faunas of these two subregions of the Guiana Highlands. If the Guianan southern mountains (including Surinam's Wilhelmina Mts.) contain populations of a number of taxa now considered Pantepui endemics, a refined definition of Pantepui endemic (Costa *et al.* 2014b) could include all areas of the Guiana Shield above approximately 1,000 m, not solely those areas in the Pantepui sensu stricto.

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The first earthworm records from Batanta Island, West Papua, Indonesia (Megadrili: Acanthodrilidae, Megascolecidae)

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Abstract. Identification of a small but valuable earthworm material collected on Batanta and the neighbouring small Birie Island in 2014 and 2019 resulted in recording five species. The only acanthodrilid species in the sample, *Dichogaster annae* (Horst, 1893), is a widely introduced circumtropical peregrine worm. The two closely related *Polypheretima* species, *P. annulata* (Horst, 1883) and *P. fakfakensis* (Cognetti, 1908), bear a typical West Papuan distribution. *Amynthas halmaherae* (Michaelsen, 1896) is found from North Maluku to New Britain. *A. hendersonianus* (Cognetti, 1914) was most probably introduced to its type locality, the Henderson Island, and its natural range covers New Guinea and the neighbouring islands.

Keywords. Clitellata, Oligochaeta, *Amynthas*, *Polypheretima*, distribution.

INTRODUCTION

Batanta, with its 453 km^2 area, is the smallest member of the Raja Ampat island group located in West Papua, Indonesia. Almost untouched rainforest covers the island. Its highest point is 1184 m (Kovács *et al.* 2015a).

Its invertebrate fauna is only partially studied; there are published data just on certain groups, *e.g.*, Decapoda (Wowor & Ng 2009), Heteroptera (Polhemus & Polhemus 2000, 2011), Hymenoptera (Nugroho *et al.* 2010) and Coleoptera (Baehr 2011, Shaverdo *et al.* 2016). Systematic surveys, initially of the aquatic insect fauna, began in 2010 (Kovács *et al.* 2015a), and were later extended to other animal groups as well. These researches provided a huge amount of new data and resulted in descriptions of several new species (Oláh 2012, 2013, 2014, Oláh & Kovács 2015, 2018, Kovács *et al.* 2015b, Varga & Páll-Gergely 2017).

Regarding its earthworm fauna, Batanta is totally unknown. Moreover, we have only sporadic data from the whole West Papuan region (Horst 1883, Cognetti 1908, 1911, 1912, 1913a, 1913b, 1914b, 1915, 1922, Michaelsen 1910, 1923, 1938, Ude 1905, 1932, Easton 1979). During the expeditions in 2014 and 2019, as a byproduct of other collecting activities, a small amount of earthworm material was also collected for the first time from Batanta and the neighbouring small Birie Island. The results are herein presented.

MATERIAL AND METHODS

Earthworms were collected by hand-sampling *i.e.,* searching under fallen logs, *etc.* The specimens were killed and fixed in 75% ethanol and deposited in the earthworm collection of the Hungarian Natural History Museum (HNHM/AF). In the descriptions, the segment positions are indicated with Roman numerals and intersegments with Arabic numerals.

TAXONOMY

Family Acanthodrilidae Claus, 1880

Dichogaster annae (Horst, 1893)

Benhamia annae Horst, 1893: 32.
Dichogaster (*Diplothecodrilus*) *annae*: Csuzdi 2010: 194.

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Material examined. HNHM/AF5686 1 ex., Indonesia, West Papua, Batanta Island, valley of Weras stream, S00°49’42.05” E130°38’12.23”, 27.01.2014, leg. P. Juhász, T. Kovács.

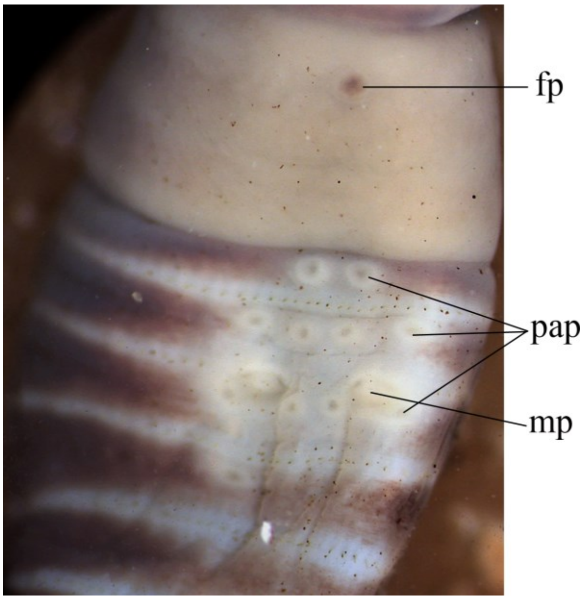
Family Megascolecidae Rosa, 1891

Amynthas halmaherae (Michaelsen, 1896)

(Figures 1–4)

Perichaeta halmaherae Michaelsen, 1896: 208.
Pheretima halmaherae: Ude 1905: 461.
Pheretima (*Pheretima*) *halmaherae*: Ude 1932: 147.
Amynthas halmaherae halmaherae: Sims & Easton 1972: 234, Blakemore 2007: 45.

Material examined. HNHM/AF5708 1 ex., Indonesia, West Papua, Batanta Island, valley of Warmon stream, between the lower and upper waterfall, S00°50’04.50” E130°42’54.01” and S00°50’23.5” E130°42’35.18”, under fallen log, 09.02.2019, leg. R. Horváth, P. Juhász, E. Kondorosy, T. Kovács.



Figures 1. *Amynthas halmaherae* (Michaelsen , 1896). Ventral view of the clitellar region. *fp* = female pore, *pap* = papillae, *mp* = male pore

Description. External characters. Body length 157 mm, diameter 5 mm. Segment number 110. Colour stripy purple brown dorsally, paler ventrally. Prostomium epilobous. First dorsal pore in 11/12. Setae perichaetine, setal number on segment II=20, V=31, X=51, XIII=55, XX=53, XXVI=57. Clitellum annular on XIV–XVI. Spermathecal pores ventral, two pairs in 7/8/9, five setae between them. Female pore on XIV. Male pores superficial on XVIII on an oval porophore, with a 10 setae hiatus between them. Genital markings in XVII: one pair presetal ventrally, one pair postsetal ventrally and one pair postsetal laterally; in XVIII: one papilla posteromedial and the other posterolateral to each male porophore; in XIX: one single postsetal laterally (Fig. 1).

Internal characters. Septa 5/6–7/8 and 10/11–12/13 thickened. Gizzard in VIII–X. Intestinal caeca paired in XXVII, simple, extending anteriorly to XXIV (Fig. 2). Last hearts paired in XIII. Spermathecae two pairs in VIII and IX. Ampulla sac-shaped with a stout duct, diverticulum with a curved stalk and an oval seminal chamber (Fig. 3). Holandric, testes in paired testis sacs in X, XI. Seminal vesicles paired in XI, XII. Prostatic glands paired in XVII–XIX, racemose. Ducts muscular, straight (Fig. 4). Accessory glands present, small, sessile and round. Excretory system meroic.

Remarks. Our specimen somewhat differs from the original description in the distribution of the genital markings, and has fewer setae after segment XIII.

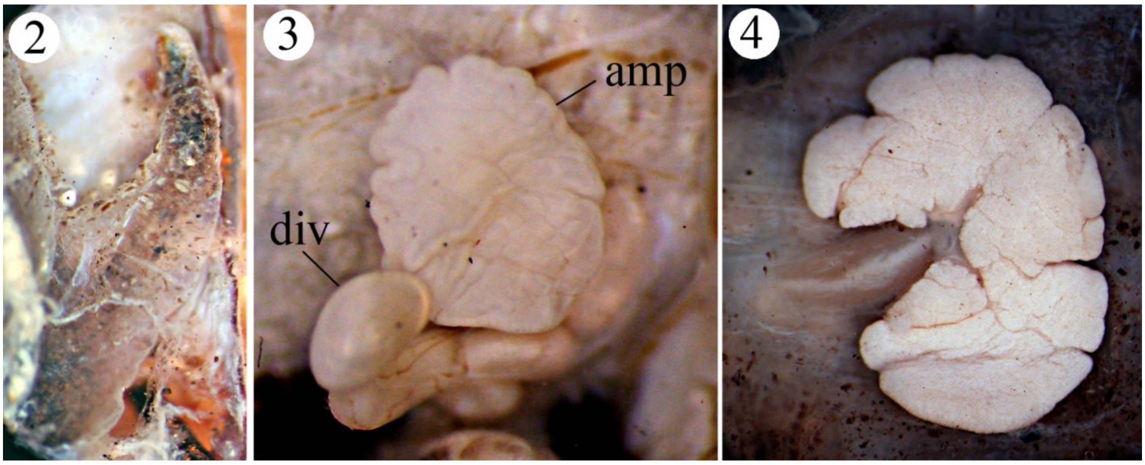
Amynthas hendersonianus (Cognetti, 1914)

(Figures 5–7)

Pheretima hendersoniana Cognetti, 1914a: 255.
Amynthas hendersonianus hendersonianus: Sims & Easton 1972: 234, Blakemore 2007: 46.

Material exmained. HNHM/AF5705 2 ex., Indonesia, West Papua, Birie Island, Papua Paradise Eco Resort, marsh, under fallen log, S00°46’14” E130°44’51”, 16.02.2019, leg. T. Kovács. HNHM/AF5707 2 ex., Indonesia West Papua, Batanta Island, valley of Warai stream, from soil, between S00°50’25.19” E130°34’ 59.19” and S00°50’59.3” E130°35’18.0”, 22.02. 2019, leg. R. Horváth, P. Juhász, E. Kondorosy, T. Kovács.

Description. External characters. Body length 90–96 mm, diameter 3.5–4 mm. Segment number



Figures 2-4. *Amynthas halmaherae* (Michaelsen, 1896). 2 = intestinal caecum. 3 = Spermatheca. 4 = prostate gland. *amp* = spermathecal ampoule, *div* = spermathecal diverticulum.

104–116. Colour purple brown dorsally, pale ventrally. Prostomium epilobous. First dorsal pore in 11/12. Setae perichaetine, setal number on segment III=28, VI=39, X=52, XIII=54, XVII=61, XXVI=64. Clitellum annular on XIV–XVI. Spermathecal pores ventral, two pairs in 7/8/9, four setae between them. Female pore on XIV. Male pores superficial on XVIII, with an 8 setae hiatus between them. Genital markings one pair presetal in IX and X, one or two pairs presetal in XVII ventrally, one pair ventrally in 17/18 and one or two laterally, one pair between male pores in XVIII, one pair postsetal laterally in XVIII, two pairs in 19/20 ventrally, one pair in 20/21 (Fig. 5), one single on left in 21/22 in one specimen.

Internal characters. Septa 10/11–13/14 slightly thickened. Gizzard in VIII–X. Intestinal caeca paired in XXVII, simple, extending anteriorly to XXIII. Last hearts paired in XIII. Spermathecae two pairs in VIII and IX. Ampulla heart-shaped with a stout duct, diverticulum with a curved stalk and an oval seminal chamber (Fig. 6). Holandric, testes in paired testis sacs in X, XI. Seminal vesicles paired in XI, XII. Prostatic glands paired in XVI–XIX, racemose. Ducts muscular, slightly S-shaped (Fig. 7). Accessory glands present, small, sessile and round. Excretory system meroic.

Remarks. Our specimens differ slightly from the original description in the position of the first dorsal pore (11/12 *vs*. 12/13), the setal numbers and the genital markings, but are similar in any other characteristics. Due to the bad conditions of the preserved specimens, setal counts were taken from one specimen only.

Cognetti (1914b) described *Pheretima hendersoniana* var. *coelogaster* (now treated as subspecies) based on the differences in the distribution of the genital markings and the presence of a concave connection ventrally on segment XVIII. Regarding these characters, it is questionable whether *coelogaster* represents an independent taxon.

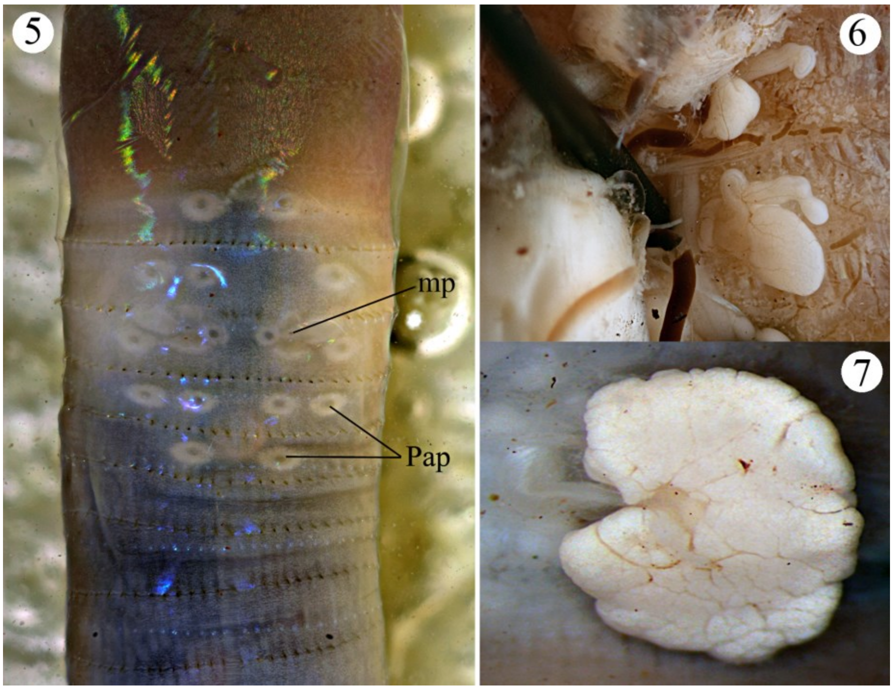
Polypheretima annulata (Horst, 1883)

(Figures 8–9)

Megascolex annulatus Horst, 1883: 195.
Polypheretima annulata: Easton 1979: 35, Blakemore 2007: 7.

Material examined. HNHM/AF5706 1 ex., Indonesia, West Papua, Batanta Island, valley of Tanjung Lampu River, under bark, between S00°54’18.6” E130°36’48.6” and S00°53’43.0” E130°36’38.5”, 12.02.2019, 12.02.2019, leg. R. Horváth, P. Juhász, E. Kondorosy, T. Kovács.

Description. External characters. Preadult specimen. Body length 117 mm, diameter 5 mm. Segment number 131. Colour dark purple dorsal



Figures 5-7. *Amynthas hendersonianus* (Cognetti, 1914). 5 = ventral view of the clitellar region. *Pap* = papillae, *mp* = male pore. 6 = spermathecae, 7 = prostate gland.

ly, pale ventrally. Prostomium epilobous. First dorsal pore in 11/12. Setae perichaetine, setal number on segment VII=44, XX=59. Clitellum annular on XIV–XVI. Spermathecal pores two pairs in segment VII and VIII, presetal, 0.5 body circumference apart. Female pore on XIV. Male pores superficial on XVIII on a small porophore, with 19 setae between them. Genital markings preclitellar presetal one pair on VII and VIII, postsetal one pair on VII ventrally to the spermathecal pores.

Internal characters. Septa 5/6–7/8 and 9/10–13/14 thickened. Tufted nephridia in V and VI. Gizzard in VIII–IX. Intestinal origin in XV, caeca absent. Last hearts paired in XIII. Spermathecae two pairs in VII and VIII. Ampulla sac-shaped, diverticulum *ca*. half as short as the ampulla, with a slightly bent thin stalk (Fig. 8). Holandric, testes in paired testis sacs in X, XI. Seminal vesicles paired in XI, XII, pseudovesicles in XIII. Prostatic glands paired in XVII–XIX, racemose. Ducts muscular, hook-shaped (Fig. 9). Accessory glands absent. Excretory system meroic.

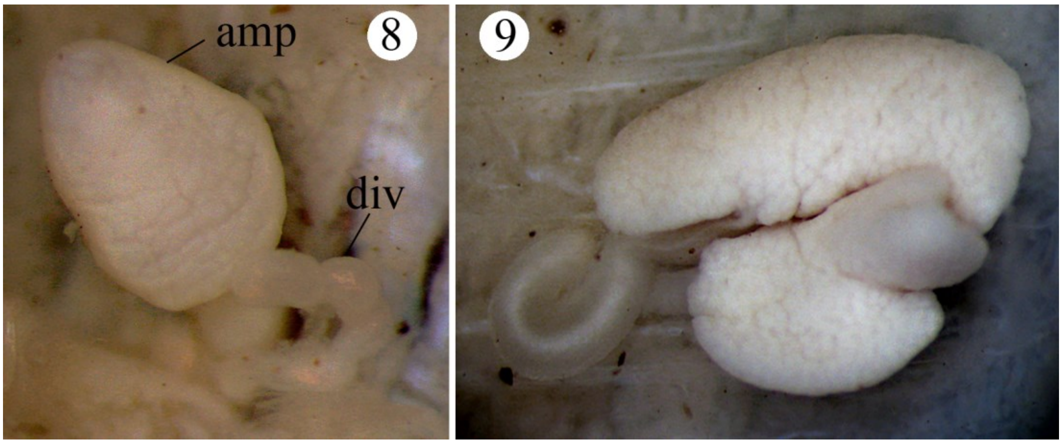
Polypheretima fakfakensis **(Cognetti, 1908)**

(Figures 10–11)

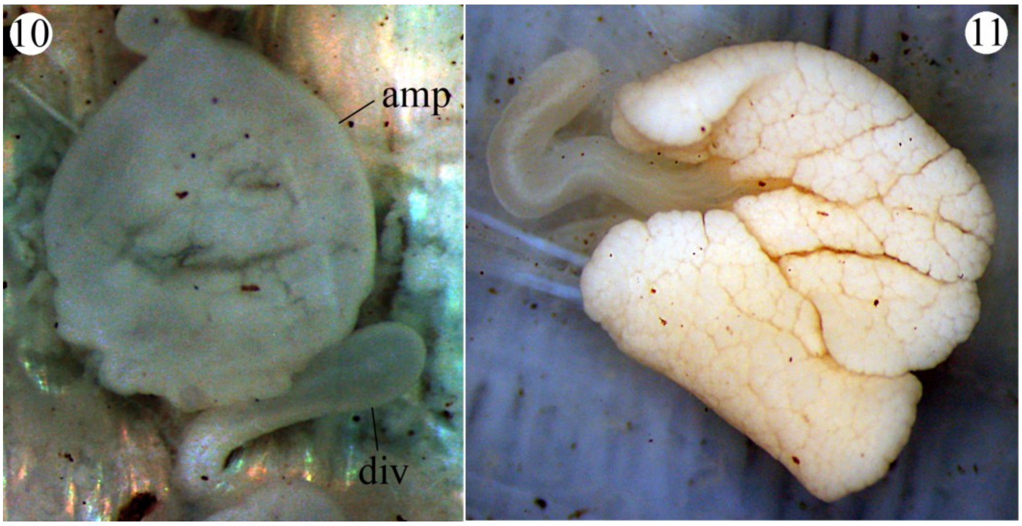
Pheretima fakfakensis Cognetti, 1908: 1.
Polypheretima fakfakensis: Easton 1979: 36, Blakemore 2007: 35.

Material examined. HNHM/AF5685 1 ex., Indonesia, West Papua, Batanta Island, valley of Waridor River, under fallen log, between S00° 50’30.55” E130°31’30.54” and S00°52’ 09.66” E130°32’11.54”, 18.01.2014, leg. R. Horváth, P. Juhász, T. Kovács.

Description. External characters. Body length 169 mm, diameter 7 mm. Segment number 136. Colour stripy dark purple dorsally, pale ventrally. Prostomium epilobous. First dorsal pore in 11/12. Setae perichaetine, setal number on segment VII=51, XX=61. Clitellum annular on XIV–XVI. Spermathecal pores three pairs in segment VII, VIII and IX, presetal, 0.4 body circumference apart. Female pore on XIV. Male pores superficial on XVIII on a circular porophore, with 24 setae



Figures 8-9. *Polypheretima annulata* (Horst, 1883). 8 = spermatheca. 9 = prostate gland. *amp* = spermathecal ampoule, *div* = spermathecal diverticulum



Figures 10-11. *Polypheretima fakfakensis* (Cognetti, 1908). 10 = spermatheca. 11 = prostate gland. *amp*= spermathecal ampoule, *div* = spermathecal diverticulum.

between them. Preclitellar genital markings presetal on VII and VIII, ventrally to the spermathecal pores. Postclitellar genital markings on XVIII, one pair presetal and one pair postsetal, both ventrally to the male pore.

Internal characters. Septa 5/6–7/8 and 10/11–12/13 thickened, 8/9 absent. Tufted nephridia in V and VI. Gizzard in VIII-IX. Intestinal origin in XV, caeca absent. Last hearts paired in XIII. Spermathecae three pairs in VII, VIII and IX. Ampulla sac-shaped, diverticulum *ca*. third as short as the ampulla, with a basally bent thin stalk (Fig. 10). Holandric, testes in paired testis sacs in X, XI. Seminal vesicles paired in XI, XII, pseudovesicles in XIII. Prostatic glands paired in XVIII–XIX, racemose. Ducts muscular, hook-shaped (Fig. 11). Accessory glands absent. Excretory system meroic.

Remarks. Our specimen differs from the observations of Easton (1979) in the position of the preclitellar markings, which are on segment VII and VIII similarly to *P. annulata*.

DISCUSSION

The recent earthworm surveys carried out on Batanta Island resulted in recording the presence of five species. Among them, *Dichogaster annae* is a widely introduced circumtropical peregrine species, but the other four seem to possess more restricted ranges.

Michaelsen (1896) described *Amynthas halmaherae* from Halmahera Island, North Maluku, Indonesia together with six subspecies. The differences among these subspecies are very scanty, including mostly the size, colouration and the genital markings. Moreover, some of them were described on the basis of a single preadult specimen. Therefore, a thorough revision is needed to clarify the taxonomic status of these subspecies.

Ude (1905, 1932) recorded *A. halmaherae* from New Britain, Nissan Island and a small island near the Mussau Island, which suggests that it has a wider range stretching from North Maluku east to New Britain.

Amynthas hendersonianus was originally described from the Henderson Island (Cognetti 1914a). Later, Cognetti (1914b) described the varietas *coelogaster* – now treated as subpspecies – from Sungai Sermowai, West Papua. However, the slight differences raise the question whether it could be regarded as a separate taxon. Besides, as the Henderson Island is a relatively young atoll island emerged between 855–540 kyr (Blake 1995), the probability of occurrence of an endemic earthworm species there is quite low. Therefore, it was much likely to be introduced to the Henderson Island and has its origin elsewhere, covering the island of New Guinea and possibly Batanta as well.

There are a couple of species very close to *A. hendersonianus* and also to each other: *A. omtrekensis* (Cognetti, 1911), *A. misellus* (Cognetti, 1913), *A. miserus* (Cognetti, 1913) and *A. keianus* (Michaelsen, 1924). Unfortunately, some of them were described on the basis of a single specimen (*A. misellus*, *A. miserus*) so, their validity remains in question. Nevertheless, a revision cannot be accomplished without further collections from the type localities.

The two *Polypheretima* species, *P. annulata* and *P. fakfakensis*, are well recognizable by their segmental presetal spermathecal pores. The main difference between the two species is the number of spermathecae (2 pairs in *annulata* and 3 pairs in *fakfakensis*). According to Easton (1979), *P. fakfakensis* is the western species with its distribution covering Misool Island, Kepala Burung and the Fakfak region. *P. annulata* was previously found on the Aru Islands and Southwest New Guinea. Now the new data show that the two species' distributions overlap on Batanta Island.

Earthworms weren't the focal animal group of the recent surveys on Batanta and the collections were made in only a few parts of the island. A more thorough and focused sampling would probably result in finding more earthworms species. For comparison, the much smaller Lanyu (45.7 km^2), Kinmen (146.3 km^2) and Matsu islands (29.5 km^2) near Taiwan have much more species present and among them several are endemics (Chang *et al.* 2012, Shen 2018, Shen & Tsai 2002, Shen *et al.* 2013, 2014, 2015, Tsai *et al.* 2009).

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A new species of *Penaincisalia* (Lepidoptera: Lycaenidae) from Peru

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Abstract. The penelfin *Penaincisalia alina* sp. nov. is described from Department Apurímac, Peru on the basis of wing and genitalia characters. Spectral analysis of structural colours carried out on congeneric species is presented. A hitherto unnamed *Penaincisalia* species from the vicinity of the type locality is also documented.

Keywords. Andes, diversity, Eumaeini, genitalia, light reflectance, structural colour.

INTRODUCTION

The genus *Penaincisalia* was established by Kurt Johnson for 13 nominal species with the type species *Thecla culminicola* Staudinger, 1894 (Johnson 1990). Subsequently in a monograph of Andean Eumaeini Johnson elaborated the relatives of *Penaincisalia* and described additional species and established further genera (Johnson 1992). In a checklist, many species- and genus-group names proposed by Johnson for *Penaincisalia* and its relatives (= penelfins) were placed in synonymy but, amongst the 41 recognized “Penaincisalia” species there have been indicated 18 species as undescribed (Robbins 2004) .

In his doctoral thesis Carlos Prieto (2008) revised the whole assemblage on the basis of the biogeography, taxonomy and phylogeny of the group, and recognized many of the genera proposed by Johnson as monophyletic species-groups, including the *culminicola* species group (= *Penaincisalia* s. s.tr) (Prieto *et al.* 2008, 2011 and 2016). As the phylogeny of “Penaincisalia” was not fully resolved, the generic concept of Robbins has been used in most species descriptions subsequent to the checklist (Hall *et al.* 2005, Prieto 2007, 2010), but a different view of generic concept has also been expressed (Bálint *et al.* 2005, Bálint 2005, Prieto & Bálint 2007, Bálint *et al.* 2008a, 2008b). Although, since the publication of the checklist eleven new species group names have been proposed in *Penaincisalia* sensu Robbins, it is evident, that the species diversity of penelfins has been not fully documented yet.

In 2019, Vyacheslav Doroshkin (Russia, Chelyabinsk) sent a male specimen of *Penaincisalia* s. str. for investigation to the Hungarian Natural History Museum (HNHM; registered as loan 2019-37). In the HNHM there are 55 specimens (amongst them 11 have been dissected) representing *Penaincisalia* s. str. Comparing with this material and literature sources, on the basis of wing and genitalia characters the specimen collected by Mr. Doroshkin proved to be an undescribed species. In searching additional specimens Dr. Gerardo Lamas (Lima, Peru) sent information via personal communication that in the Museo de Historia Natural, Universidad Nacional Mayor de San Marcos (Lima, Peru) (MUSM), there are three male and one female *Penaincisalia* specimens probably from the same locality. It seems that these specimens represent a different species. The aims of the present paper are (1) to name the species collected by the

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Russian lepidopterist, (2) to describe the species, and (3) to discuss the characters of the new species and compare with the specimens of the MUSM.

TAXONOMY

Penaincisalia alina Bálint, sp. nov.

(Figures 1–3, 18–19)

Type material. Holotype, male (at the moment in HNHM, but will be deposited in MUSM), set dorsally, in good condition (right antenna missing, right wings slightly worn), labelled as "Peru Pass Abancay Cusco [//] H – 4000 [//] 10. 12. 2000. V. Doroshkin leg." (rectangular label, black print on white paper) (Figs. 1–2, 18–19). The holotype is dissected (HNHM Lepidoptera Bálint gen. prep. no. 1659).

Diagnosis. This species is unique in the genus in possessing the following combination of characters: (1) the dorsal wing surface is dark rufous brown with a violet reflection when viewed at a shallow angle (*P. perezi* Bálint, 2001 has a similar reflection, but the dorsal wing surface of that species is orange; see Figs. 18–19 and 22–23); (2) ventral wing surface is dark brown with a somewhat lighter area in the forewing below the cubital vein (*P. alatus* Druce, 1907 described from Ecuador has similarly dark underside but it is not brown but grey, and the dorsal wing surfaces of that species are deep violet blue; Figs. 6–7). Similar congeneric species are either dorsally blue, violet or orange, and ventrally somewhat differently coloured and patterned (*e.g.*, Figs. 8–17). (3) The male genitalia valva has the lower margin rectangular, a unique character in the *culminicola* species group, as all the other species have different valval shape (Fig. 3).

Description. Male. Head, thorax and abdomen black on dorsal side; thorax and abdomen with greyish pubescence on ventral side; antenna with 0.6 time length of forewing costa, clubs black. Forewing length 12 mm, measured from the base of cubital vein to vein R3 terminus, triangular in shape. Ground colour on dorsal surface dark rufous brown with violet iridescence (depending on the direction of illuminating light) (Figs. 18–19); margins with thin (< 2 mm) black border, broadening in apical areas in both wings; fringes lighter brown. Androconia present as scent pad trapezoid in shape in the apical part of the discal area, and as minute scent patch in the erection of vein M3. Forewing ventral surface warm brown with delicate discoidal patch and black, sharp and slightly ruptured postmedian line and somewhat lighter median area below the cubitus; hindwing basal and medial band black, ruptured and sharply marked; antemarginal line appearing as continuous intercellular black arrowhead marks bordered distally by lighter brown crescent pattern; fringes brown (Figs 1–2). In male genitalia tegumen and uncus large when seen from lateral and dorsal aspects; gnathos straight when seen from lateral but curved when seen from ventral side, with a formation appearing as rounded plate in dorso-ventral view before the pointed apex; valva slender, as long as tegumen, with straight upper and angled lower margins, length of narrow apical part one third the length of the valva; vinculum slender but well sclerotized, saccus membranous and short (with the length of narrow valval apical part); aedeagus slender with valva length slightly more than two times and two apical cornuti (Fig. 3). Female. Unknown.

Distribution. Geographic: Known only from the type locality "Abancay Pass" (= a high pass on the paved road between Abancay and Cusco, department Apurímac; the approximate coordinates of the collecting site are: 13°35'05.7"S 72°49'08.0" W) (Fig. 5). Spatial: The label data indicate that the type specimen was captured at 4000 m elevation. Temporal: The holotype was collected in the first half of December.

Bionomics. A series of *Yramea inca* (Staudinger, 1894) (Heliconiinae) was collected at the same time and place as the holotype.

Etymology. By request, this species is named after *Alina Doroshkin*, daughter of the collector. The name is treated as a feminine nominative noun in apposition.

Figures 1–2. *Penaincisalia alina* sp. nov. Holotype. 1 = recto; 2 = idem, verso. The violet sheen of the dorsal wingsurfaces was not caught by the camera because of the light conditions (for colour reflection see Figs. 8–9) (scale: 10 mm).

Figures 3–4. Male *Penaincisalia* genitalia capsule and aedeagus in dorsal view, in same magnification. 3 = *P. alina* sp. nov. (holotype; Bálint gen. prep. no. 1659) (a black arrow indicates the genitalia character of *P. alina*; white arrows point to gnathos before the pointed terminus, what showing a character state to be the supposed apomorphy of *Penaincisalia* s. str.) 4 = *P. aurulenta* K. Johnson, 1990 (Peru, Llanganuco; Bálint gen. prep. no. 1660) (scale bars = 0.8 mm).

DISCUSSION

Characters

Prieto demonstrated for several *Penaincisalia* species groups that, although the male genitalia differences were quantitative, they were sufficient for species recognition (Prieto *et al.* 2008, 2016). This statement stands also for *Penaincisalia* s. str. (the *culminicola* species group). We had insufficient material to enable a statistically sound comparative analysis of the genitalia traits, but it seems that *P. alina* male genitalia is distinctive enough in having the lower valval margin angulated, a unique character in the group (Figs. 3–4; for comparison see the figures in Johnson 1990 and 1992, and Prieto 2008).

The differences in male dorsal wing colour seem to be the most distinctive, and on the basis of this character syntopic and synchronic species can be immediately discriminated even in the field. For example, in the Llanganuco valley (Cordillera Blanca, Ancash, Peru) the penelfins (*P. aurulenta* Johnson, 1990; *P. biophot* Bálint & Wojtusiak, 2008; *P. lamasi* Bálint, 2001 and *P. perezi*) were able to be distinguished by the observer in flight, when they were on wing on the same day (Bálint 1995 and 1997; *cf.* Bálint *et al.* 2008b).

Syntopic, closely related (congeneric) species having distinctive male dorsal coloration might be a general phenomenon in Lycaenidae, but when the colours are identical species are often allopatric or allochronic (*cf.* Bálint *et al.* 2012, 2014), and the phenomena discoloration (Biró *et al.* 2003) or reinforcement (Lukhtanov *et al.* 2005) play the role. This should be also the case for *Penanicisalia* s. str., when traits determined by

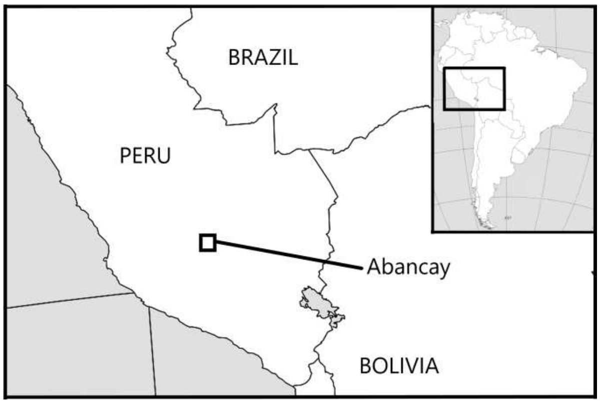
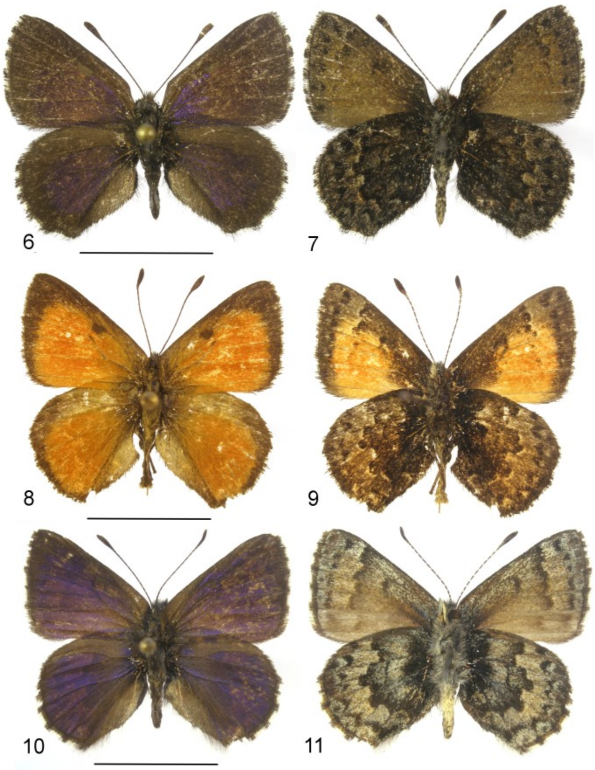


Figure 5. "Abancay", in department Apurímac, the type locality of *Penaincisalia alina* sp. n. as situated geographically in Peru.



Figures 6–11. Males of various *Penaincisalia* species from Peru for comparison. Scales: 10 mm. 6–7 = *P. alatus* (Druce, 1907) (dorsal wingsurfaces deep violet with wide black margin): 6 = recto, 7 = verso (Peru, Cordillera Blanca, above Huanuco); 8–9 = *P. aurulenta* K. Johnson, 1990 (dorsal wingsurfaces orange with goldish shade): 8 = recto, 9 = verso (Peru, Cordillera Blanca, Llanganuco); 10–11 = *P. biophot* Bálint & Wojtusiak, 2008 (dorsal wingsurfaces light deep violet): 10 = recto, 11 = verso (paratype, Peru, Cordillera Blanca, Llanganuco).

Figures 12–17. Males of various *Penaincisalia* species from Peru for comparison. Scales: 10 mm. 12–13 = *P. culminicola* (Staudinger, 1894) (dorsal wingsurfaces light violet with thin black margin): 12 = recto, 13 = verso (Peru, Apurímac, Saywite); 14–15 = *P. lamasi* Bálint, 2001 (dorsal forewingsurface black, hindwing forewingsurface light blue): 14 = recto, 15 = verso (Peru, Cordillera Blanca, Tingo Pampa); 16–17 = *P. perezi* Bálint, 2001 (dorsal wingsurface orange with pink shade): 16 = recto, 17 = verso (Peru, Cordillera Blanca, Llanganuco).

pigments and nanoarchitectures are lost or regained multiple times (*cf.* Bálint *et al.* 2005, 2008a, b).

Light reflectance and structural colours

The ground scales of the species *P. aurulenta* and *P. perezi* contain yellow pigment, whilst *P. alina* scales do not. The yellow colour is most distinctive in the measurement under normal incidence, and this is also distinctive in the Figures 18–23 and 24. The scales of the species *P. alina* and *P. perezi* possess photonic nanoarchitectures, and the identical spectra of the reflected blue colour suggest that their nanoarchitectures are identical. The spectra of these two species under normal incidence show difference in the region where the reflectivity of the pigments are (> 500 nm): *P. perezi* is yellow, whilst *P. alina* is

Figures 18–23. Male specimens of the known orange *Penaincisalia* species photographed under normal (90°) and 45° light incidence. 18–19 = *P. alina* sp. n., 20–21 = *P. aurulenta*, 22–23 = *P. perezi*. The direction of illumination is indicated by the black shadow situated under the specimens: 90° = there is shadow under the specimen, 45° = there is shadow only on the left side. Under 45° light incident the structural colour is not visible.

brown. Therefore the spectrum of *P. alina* is more similar to the spectra of blue *Penaincisalia* species investigated previously (Bálint *et al.* 2008b).

In the cases of *P. biophot* and *P. culminicola* we know that the ground scales are heavily packed with melanin producing brown colour, but the cover scales possess photonic architectures reflecting the light with much higher directionality.

Diversity

Members of *Penaincisalia* s. str. inhabit high altitudes in the Andes from central Colombia via Ecuador, Peru and Bolivia to northwest Argentina and northeast Chile. The adults of these species are small with structurally or pigmentally coloured dorsal and cryptically patterned ventral wing surfaces, and with a gnathos having a widening subterminal plate before the pointed apex in a state, what is probably the synapomorphy of the group (see Figs. 3–4) (Bálint, *in prep.*). Males possess a double androconial spot in the distal part of the forewing discalis. Because the habitats where these species dwell are difficult to access, the weather conditions are often unfavourable for sampling, and the flight periods of the species are short, this group is under-represented in museum collections. As a result, the taxonomy of *Penaincisalia* sensu Robbins remains rather poorly understood and the diversity of the species groups have yet to be adequately documented.

Based on records collected in the Llanganuco valley, Peruvian Cordillera Blanca, which is one of the best explored Andean valley in high altitudes from the aspect of butterfly faunistics (Lamas & Pérez 1983), it seems that five *Penaincisalia* species occur synchronically and syntopically (*cf.* Bálint 1995 and 1997) (see Figs. 8–17). These species differ in ventral wing pattern and genitalia morphology but the male dorsal wing surface coloration is the most distinctive (*cf.* Bálint 2001; see Fig. 24). Most recently Dr. Tomasz Pyrcz (Krakow, Poland) in June 2019 conducted faunistic surveys also in the Cordillera Blanca region where he was able to detect six *Penaincisalia* species, one of them seems to be undescribed.

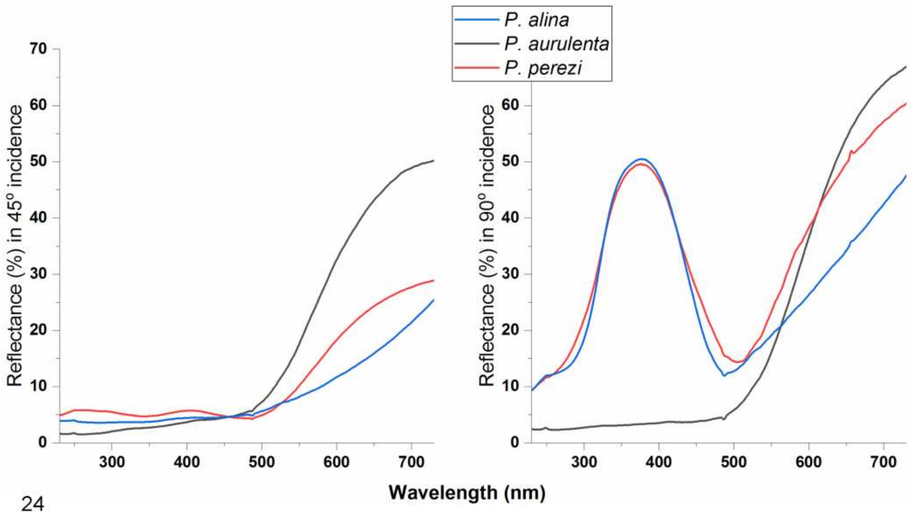


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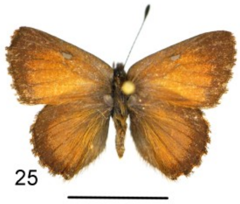
Figure 24. The spectral diagrams of the three *Penaincisalia* species as depicted in Figs. 18–23. Detailed explanation is given in the main text.



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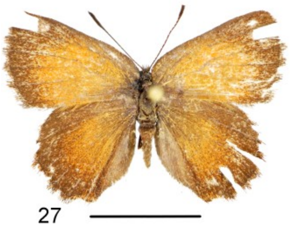

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Figures 25–28. Documentation of an undescribed orange *Penaincisalia* species from Apurímac, Peru. 25 = male, recto, 26 = idem verso, 27 = female, recto, 28 = idem, verso (courtesy: MUSM) (scale: 10 mm).

The *Penaincisalia* specimens, collected in or in the vicinity of *P. alina* type locality and deposited in MUSM, most probably represent a hitherto unnamed species. This species is close to *P. aurulenta*, but the representative specimens have no goldish hue on the dorsal wing surfaces, they are plain orange and the wing undersides somewhat differently coloured and patterned. The species cannot be described as at the moment we have no access to these specimens, but because of Dr. Lamas' kindness we can document the species in this paper (Figs. 25–28).

We do not know yet what other *Penaincisalia* s. str. species may occur there, but there are records for *P. culminicola* from department Apurímac, which is a species with violet male dorsal wingsurafces and yellowish forewing ventral wingsurface (Figs. 12–13).

The descriptions of the undescribed species from Peruvian Cordilleara Blanca and Ampay regions will be the task of the next study on *Penaincisalia*. This will be another step for having a better understanding of this peculiar high Andean group of lycaenid butterflies.

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New earthworm records from several Indian Ocean islands (Clitellata, Megadrili)

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Abstract. Elaboration of the earthworm material collected on the Seychelles, Mauritius, Réunion, Mayotte and Sri Lanka islands resulted in recording 20 species altogether. Among them, the ocnerodrilid *Maheina braueri* (Michaelsen, 1897) endemic to Mahé (Seychelles) and the megascolecid *Nellogaster bahli* (Stephenson, 1925) endemic to Sri Lanka were reported for the first time since their original description. The material also contained some enigmatic juvenile specimens from Mayotte, most resembling the genus *Diporochaeta*.

Keywords. Oligochaeta, Ceylon, Seychelles, Mauritius, Reunion, Mayotte.

INTRODUCTION

The Indian Ocean is the third largest ocean on the globe bordered by Africa, Asia, Australia and Antarctica (Fatima & Jamshed 2015). It has numerous small and several larger islands of different origin from continental (*e.g.* Madagascar, Seychelles) to true oceanic ones (*e.g.* Reunion, Mauritius) (Walker *et al.* 2005). Madagascar, with the other Indian Ocean Islands, represents one of the Earth's 35 biodiversity hotspots (Mittermeier *et al.* 2011). However, except Madagascar of which the earthworm fauna has recently been intensively studied (Csuzdi *et al.* 2012, 2016, 2017a, Hong *et al.* 2018, Razafindrakoto *et al.* 2010, 2011, 2017) earthworms of the other islands of this hotspot are almost unknown. Apart from some sporadic records (Michaelsen 1897a, 1907a) there are just a few comprehensive publications from the region including the summary of the earthworms in the Seychelles Islands by Gerlach (2011) and that of Mauritius by Ljungström (1971).

Gerlach (2011) listed 11 earthworm species from the families Eudrilidae, Megascolecidae, Acanthodrilidae and Octochaetidae. Apart from the obviously erroneous placements of the megascolecid *Lampito mauritii* Kinberg, 1866 to Octochaeatidae and the glossoscolecid (now rhinodrilid) *Pontoscolex corethrurus* (Müller, 1857) to Acanthodrilidae he also listed several strange lumbricid species (with 20–25, 25–33 and 10–15 setae per bundle (*sic*!)). The native *Maheina braueri* (Michaelsen, 1897) described from Mahé Island was listed in Acanthodrilidae but have not been re-collected during the collections conducted in the early 1970s and 2000s.

Ljungstöm's (1971) checklist of the earthworms of Mauritius lists ten species; all are well-known peregrine ones with *Amynthas* species prevailing (listed in the genus *Pheretima*).

Sri Lanka, with its some 65,000 km^2 territory represents the second largest island in the region after Madagascar. It is a continental island lying on the Indian Plate and, together with the Western Ghats represents an independent biodiversity hotspot in the Indian Ocean region (Katz 2000, Mittermeier *et al.* 2011). Due to the works of Michaelsen (1897b, 1903, 1907b, 1908, 1910) and Stephenson (1913, 1915, 1923, 1925) its earth-

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worm fauna is quite well studied recording 63 earthworm species for the island including 48 endemics.

Here we provide new earthworm records collected in the early 2000's years in Mauritius, Mayotte, Reunion, Seychelles and Sri Lanka. A small collection by the USSR Zoological Expedition to Seychelles was also elaborated.

MATERIAL AND METHODS

Earthworms were collected with the diluted formalin method (Raw 1959) supplemented by digging and searching under stones, barks of fallen logs and mosses. The specimens collected were killed in 75% ethanol, fixed in 4% formalin and after several days transferred into 75% ethanol. The gathered specimens are deposited in the earthworm collection of the Hungarian Natural History Museum (HNHM).

TAXONOMY

Family Acanthodrilidae Claus, 1880

Dichogaster (Diplothecodrilus) annae (Horst, 1893)

Benhamia annae Horst, 1893: 32.
Dichogaster (Diplothecodrilus) annae: Csuzdi 2010: 191. (for complete synonymy)

Material examined. HNHM/AF5171 5 ex., Mayotte, Grande Terre, along River Bandrani, S12°42’26” E45°05’36”, 160 m, 07.10.2005, leg. T. Pavlíček. HNHM/AF5177 2 ex., Mayotte, Grande Terre, along Longoni River, S12°44’ E45°10’, 95 m, 05.10.2005, leg. T. Pavlíček. HNHM/AF5735 2 ex., Seychelles, Mahé, Copolia, the beginning of the road, under bark, 16.06. 2000, leg. Cs. Csuzdi.

Family Eudrilidae Calus, 1880

Eudrilus eugeniae (Kinberg, 1867)

Lumbricus eugeniae Kinberg, 1867: 98.
Eudrilus eugeniae: Blakemore 2008a: 452 (for complete stynonymy).

Material examined. HNHM/AF5192 3 ex., Mayotte, Grande Terre, along the river above the Gîtes de Kwalé, S12°48’30” E45°09’40”, 185 m, 06.10.2005, leg. T. Pavlíček.

Family Lumbricidae Rafinesque-Schmaltz, 1815

Aporrectodea caliginosa (Savigny, 1826)

Enterion caliginosum Savigny, 1826: 180.
Aporrectodea caliginosa: Csuzdi & Zicsi 2003: 75 (for complete synonymy).

Material examined. HNHM/17515 2 ex., Réunion, Piton des Neiges, *ca*. 2000 m asl., 16.09. 2002.

Bimastos rubidus (Savigny, 1826)

Enterion rubidum Savigny, 1826: 182.
Bimastos rubidus: Csuzdi *et al.* 2017b: 20.

Material examined. HNHM/17516 2 ex., Réunion, Piton des Neiges, *ca*. 2000 m asl., 16.09.2002.

Family Megascolecidae Rosa, 1891

Amynthas corticis (Kinberg, 1867)

Perichaeta corticis Kinberg, 1867: 102.
Amynthas corticis: Blakemore 2008a: 272 (for complete synonymy).

Material examined. HNHM/AF5717 1 ex., Réunion, the bottom of the moss forest, *ca*. 1000 m, 22.06.2000, leg. Cs. Csuzdi. HNHM/AF5720 2 ex., Réunion, Forêt de Bébour, 1310 m, moss forest, 22.06.2000, leg. Cs. Csuzdi.

Amynthas gracilis (Kinberg, 1867)

Nitocris gracilis Kinberg, 1867: 102.
Amynthas gracilis: Blakemore 2008a: 284 (for complete synonymy).

Material examined. HNHM/AF5723 3 ex., Mauritius, Petrin, Brise Fer, forest reserve, behind the Gerald Durrell Endemic Wildlife Sanctuary, 625 m, S20°22’1” E57°26’5”, 26.06.2000, leg. Cs. Csuzdi.

Amynthas minimus (Horst, 1893)

Perichaeta minima Horst, 1893: 66.
Amynthas minimus: Blakemore 2008a: 302 (for complete synonymy).

Material examined. HNHM/AF5713 9 ex., Mauritius, Montagne Cocotte, moss forest, under moss, 750 m, S20°26'5" E57°28'3", 26.06.2000, leg. Cs. Csuzdi. HNHM/AF5721 1 ex., Mauritius, Petrin, Brise Fer, forest reserve, behind the Gerald Durrell Endemic Wildlife Sanctuary, 625 m, S20° 22'1" E57°26'5", 26.06.2000, leg. Cs. Csuzdi. HNHM/AF5751 1 ex., Seychelles, Silhouette, 23. 08.1984, USSR Zoological Expedition.

Amynthas rodericensis (Grube, 1879)

Perichaeta rodericensis Grube, 1879: 554.
Amynthas rodericensis: Blakemore 2008a: 319 (for complete synonymy).

Material examined. HNHM/AF5169 1 ex., Mayotte, Grande Terre, along River Bandrani, S12°42'26" E45°05'36", 160 m, 07.10.2005, leg. T. Pavlíček. HNHM/AF5179 4 ex., Mayotte, Grande Terre, along Longoni River, S12°44' E45°10', 95 m, 05.10.2005, leg. T. Pavlíček. HNHM/AF5185 2 ex., Mayotte, Grande Terre, near Longoni, S12°43'43" E45°07'46", 35 m, around mangrove forest, 04.10.2005, leg. T. Pavlíček. HNHM/AF5712 1 ex., Mauritius, Montagne Cocotte, moss forest, under moss, 750 m, S20°26'5" E57°28'3", 26.06.2000, leg. Cs. Csuzdi. HNHM/AF5718 2 ex., HNHM/AF5716 1 ex., Réunion, the bottom of the moss forest, *ca*. 1000 m, 22.06.2000, leg. Cs. Csuzdi. HNHM/AF5722 3 ex., Mauritius, Petrin, Brise Fer, forest reserve, behind the Gerald Durrell Endemic Wildlife Sanctuary, 625 m, S20°22'1" E57°26'5", 26.06.2000, leg. Cs. Csuzdi. HNHM/AF5728 3 ex., Mauritius, Black River Peak, 600−700 m, 27.06.2000, leg. Cs. Csuzdi.

Amynthas robustus (Perrier, 1872)

Perichaeta robusta Perrier, 1872: 112.
Amynthas robustus: Blakemore 2008a: 315 (for complete synonymy).

Material examined. HNHM/AF5711 3 ex., Mauritius, Montagne Cocotte, moss forest, under moss, 750 m, S20°26'5" E57°28'3", 26.06.2000, leg. Cs. Csuzdi. HNHM/AF5716 1 ex., Réunion, the bottom of the moss forest, *ca*. 1000 m, 22.06. 2000, leg. Cs. Csuzdi. HNHM/AF5727 1 ex., Mauritius, Black River Peak, 600-700 m, 27.06.2000, leg. Cs. Csuzdi.

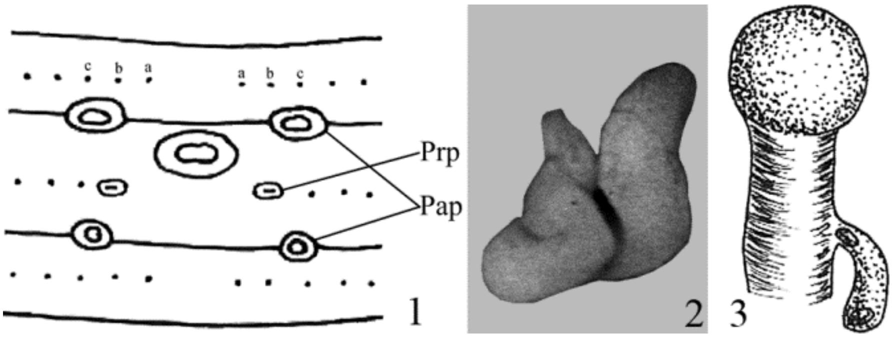
?*Diporochaeta* sp.

(Figures 1–3)

Material examined. HNHM/AF5172 4 ex., Mayotte, Grande Terre, along River Mro, NE of Dzoumonyé, S12°41'58" E45°05'22", 200 m, natural forest, 08.10.2005, leg. T. Pavlíček. HNHM/ AF5193 1 ex., Mayotte, Grande Terre, along the river above the Gîtes de Kwalé, S12°48'30" E45°09'40", 185 m, 06.10.2005, leg. T. Pavlíček.

Description. External characters. All specimens juvenile. Length around 60 mm, diameter 2.5 mm. Colour alive unknown, conserved pale. Prostomium epilobic, dorsal pores lacking. Segments simple, setae perichaetin in irregular rows with ventral and dorsal interruption, aa = 1.5 zz. Setal number on segment III = 22, VI = 26, X = 22, XIII = 20, XVII = 16, XXVI = 14. Spermathecal pores paired small slits in the intersegmental furrows VII/VIII, VIII/IX in setal line *b*. Clitellum lacking. Female pores in XIV, presetal before setae *a*. One pair of combined male and prostatic pores on XVIII in setal line b. Paired genital markings on XVIII outside of the prostatic pores and in XVII/XVIII and XVIII/XIX in setal line *b,* furthermore a single midventral papilla in XVIII between the prostatic pores (Fig. 1).

Internal characters. No septa notably thickened. Muscular gizzard lacking. Dorsal vessel single throughout, the last pair of hearts in XIII. Excretory system holoic, avesiculate. Calciferous glands lacking. Intestine begins in XVI, typhlosole lacking. Holandric. Two pairs of testes and iridescent male funnels in X, XI. Seminal vesicles two pairs in XI, XII. One pair of ovaries in XIII. One pair of small tubular prostates in XVIII,



Figures 1–3. *Diporochaera* sp. 1 = male field; 2 = prostate gland; 3 = spermatheca. *Prp* = prostatic pore, *Pap* = papillae.

slightly coiled and confined to its own segment (Fig. 2). Penial setae lacking. Two pairs of spermathecae in VIII and IX. Ampulla elongated sac-shaped, duct wide, *ca*. 1/3 as long as the ampoule. A small, unilocular, finger-shaped diverticulum joins to the ental part of the duct. (Fig. 3).

Remarks. We have several juvenile specimens from this interesting species. With its non-lumbricine setal arrangement, holoic avesiculate excretory system and tubular prostates, these specimens seem to be most close to the Australian genus *Diporochaeta* Beddard, 1890. However, our specimens do not fit clearly to *Diporochaeta* because they lack muscular gizzard. To clear the position of this interesting species further clitellate material is needed.

Lampito mauritii **Kinberg, 1867**

Lampito mauritii Kinberg, 1867: 103, Blakemore 2008a: 238 (for complete synonymy).

Material examined. HNHM/AF5748 3 ex., Sri Lanka, Colombo district, Dehiwala-Mount Lavinia, moist area, 09.03.2000, leg. S. Mahunka, L. Mahunka-Papp. HNHM/AF5749 1 ex., Amirantes, Poivre Atoll, coconut plantation, 05–09.08.1984, USSR Zoological Expedition.

Megascolex insignis **Michaelsen, 1910**

Megascolex insignis Michaelsen, 1910: 78, Stephenson 1923: 250.

Material examined. HNHM/AF5737 7 ex., Sri Lanka, Kalutara district, Matugama, stream bank near the city, 12.03.2000, S. Mahunka, L. Mahunka-Papp. HNHM/AF5741 2 ex., Sri Lanka, Kalutara district, Wadduwa, moist meadow near the city, 11.03.2000, leg. S. Mahunka, L. Mahunka-Papp. HNHM/AF5745 6 ex., Sri Lanka, Kalutara district, Moratuwa, near the shore of Bolgoda Lake, 10.03.2000, leg. S. Mahunka, L. Mahunka-Papp.

Metaphire bahli **(Gates, 1945)**

Pheretima bahli Gates, 1945: 85.
Metaphire bahli: Blakemore 2008a: 338.

Material examined. HNHM/AF5740 2 ex., Sri Lanka, Kalutara district, Wadduwa, a moist meadow near the city, 11.03.2000, leg. S. Mahunka, L. Mahunka-Papp. HNHM/AF5743 1 ex., Sri Lanka, Kalutara district, Kalutara, bare, weedy area at the edge of the city, from cow droppings and soil, 06.03.2000, leg. S. Mahunka, L. Mahunka-Papp. HNHM/AF5746 1 ex., Sri Lanka, Colombo district, Dehiwala-Mount Lavinia, moist area, 09.03.2000, leg. S. Mahunka, L. Mahunka-Papp.

Metaphire californica **(Kinberg, 1867)**

Pheretima californica Kinberg, 1867: 102.
Metaphire californica: Blakemore 2008a: 343 (for complete synonymy).

Material examined. HNHM/AF5719 1 ex., Réunion, the bottom of the moss forest, *ca*. 1000 m, 22.06.2000, leg. Cs. Csuzdi

Nellogaster bahli **(Stephenson, 1925)**

Woodwardiella bahli Stephenson, 1925: 888.

Nellogaster bahli: Gates, 1938: 428, 1945: 75.

Material examined. HNHM/AF5739 2 ex., Sri Lanka, Kalutara, 08.03.2000, leg. S. Mahunka, L. Mahunka-Papp.

Remarks. Gates (1938) separated *Woodwardiella bahli* Stephenson, 1925, into a new genus *Nellogaster* due to its lumbricine setal arrangement and presence of open enteroic megameronephridia in the postclitellar segments. Blakemore (2007) places this species into *Notoscolex* Fletcher, 1886 characterized by lumbricine setae and open exoic megameronephridia. Until a thorough revision of the Indian megascolecids is done we retain Gates' (1938) combination.

Pithemera bicincta (Perrier, 1875)

Perichaeta bicincta Perrier, 1875: 1044.
Pithemera bicincta: Blakemore 2008a: 419 (for complete synonymy).

Material examined. HNHM/AF5167 1 ex., Mayotte, Grande Terre, along River Bandrani, S12°42'26" E45°05'36", 160 m, 07.10.2005, leg. T. Pavlíček. HNHM/AF5173 1 ex., Mayotte, Grande Terre, along River Mro, NE of Dzoumonyé, S12°41'58" E45°05'22", 200 m, natural forest, 08.10.2005, leg. T. Pavlíček. HNHM/AF5181 6 ex., Mayotte, Grande Terre, along River Mro, NE of Dzoumonyé, S12°42'55" E45°06'06", 115 m, natural forest, 11.10.2005, leg. T. Pavlíček. HNHM/AF5184 2 ex., Mayotte, Grande Terre, near Longoni, S12°43'43" E45°07'46", 35 m, around mangrove forest, 04.10.2005, leg. T. Pavlíček. HNHM/AF5732 5 ex., Réunion, lowland rain forest, 24.06.2000, leg. Cs. Csuzdi.

Polypheretima elongata (Perrier, 1872)

Perichaeta elongata Perrier, 1872: 124.
Polypheretima elongata: Blakemore 2008a: 428 (for complete synonymy).

Material examined. HNHM/AF5160 2 ex., Mayotte, Grande Terre, along River Mroni Bé, N of Dapani, S15°57'57" E45°09'28", 40 m, 08.10.2005, leg. T. Pavlíček. HNHM/AF5162 5 ex., AF5163 3 ex., Mayotte, Grande Terre, Tsimkoura, fruit plantation, S12°55'50" E45°07'25", 16.10.2005, leg. T. Pavlíček. HNHM/AF5164 1 ex., Mayotte, Grande Terre, Kwalé, S12°47'42" E45°09'57", 330 m, 20.10.2005, leg. T. Pavlíček. HNHM/AF5168 3 ex., Mayotte, Grande Terre, along River Bandrani, S12°42'26" E45°05'36", 160 m, 07.10.2005, leg. T. Pavlíček. HNHM/AF5174 2 ex., Mayotte, Grande Terre, along River Mro, NE of Dzoumonyé, S12°41'58" E45°05'22", 200 m, natural forest, 08.10.2005, leg. T. Pavlíček. HNHM/AF5178 3 ex., Mayotte, Grande Terre, along Longoni River, S12°44' E45°10', 95 m, 05.10.2005, leg. T. Pavlíček. HNHM/AF5180 6 ex., Mayotte, Grande Terre, Dembéni, CIRAD station, 12.10.2005, leg. T. Pavlíček. HNHM/AF5182 2 ex., AF5183 2 ex., Mayotte, Grande Terre, along River Mro, NE of Dzoumonyé, S12°42'55" E45°06'06", 115 m, natural forest, 11.10.2005, leg. T. Pavlíček. HNHM/AF5186 1 ex., Mayotte, Grande Terre, near Longoni, S12°43'43" E45°07'46", 35 m, around mangrove forest, 04.10.2005, leg. T. Pavlíček. HNHM/AF5189 5 ex., Mayotte, Grande Terre, along Longoni River, S12°44' E45°10', 40 m, 05.10.2005, leg. T. Pavlíček. HNHM/AF5191 1 ex., Mayotte, Grande Terre, along the river above the Gîtes de Kwalé, S12°48'30" E45° 09'40", 185 m, 06.10.2005, leg. T. Pavlíček. HNHM/AF5715 2 ex., Mauritius, Yemen Grosse Roche, 270 m, grassy meadow, stream bank, 28.06.2000, leg. Cs. Csuzdi.

Polypheretima taprobanae (Beddard, 1892)

Perichaeta taprobanae Beddard, 1892: 163.
Polypheretima taprobane: Blakemore 2008a: 435 (for complete synonymy).

Material examined. HNHM/AF5738 1 ex., Sri Lanka, Kalutara district, Matugama, stream bank near the city, 12.03.2000, S. Mahunka, L. Mahunka-Papp. HNHM/AF5752 1 ex., Seychelles, tropical mist forest, on a ridge, above La Passe, 540-590 m, 23.08.1984, USSR Zoological Expedition.

Family Ocnerodrilidae Beddard, 1891

Maheina braueri (Michaelsen, 1897)

(Figures 4–6)

Acanthodrilus braueri Michaelsen, 1897a: 22.
Maheina braueri: Michaelsen 1899: 237.
Notiodrilus braueri: Beddard, 1912: 78.

Material examined. HNHM/AF5710 1 clitellate adult (tail missing) 2 aclitellate adult ex. and one juvenile ex., Seychelles, Mahé, Congo Rouge, moss forest, under fallen log, stones and moss, 19.06.2000, leg. Cs. Csuzdi.

Description. External characters. Length of the aclitellate adult specimens 75–95 mm, diameter 3–3.5 mm, segment No. 215–253–192. Colour alive green, conserved reddish-grey. Prostomium epilobic, dorsal pores lacking. Segments simple, setae eight per segment in widely paired regular rows. Setal formula after clitellum *aa*:*ab*:*bc*:*cd*:*dd* = 4.5:1:3:2:5.5. Setae of XVII, XIX present, penial setae and genital setae lacking. Spermathecal pores paired, small slits in the intersegmental furrow VII/VIII, VIII/IX in setal line *b*. Clitellum saddle-shaped on XIV–XX. Female pores in XIV, presetal before setae *b*. Two pairs of prostatic pores on two pairs of glandular elevation in XVII, XIX just at the base of setae *b*, joined by curly braces-like seminal grooves, running in setal line *b*. Male pores minute, externally not visible on XVIII, within the seminal grooves. Genital marking are lacking (Fig. 4).

Internal characters. No septa notably thickened. One large oesophageal gizzard in VI. Dorsal vessel single throughout, the last pair of hearts in XI. Excretory system holoic, avesiculate. Two pairs of downward oriented, aubergine-shaped calciferous glands in IX, X (Fig. 5). Intestine begins in XIV, real typhlosole lacking, but a shallow bulging can be seen dorsally from segment XXIV. Metandric. One pair of testis and iridescent male funnel in XI. A single pair of seminal vesicles in XII. One pair of moderate-sized ovaries in XIII. Two pairs of small tubular prostates of similar size in XVII and XIX, slightly coiled and confined to their own segment. Penial

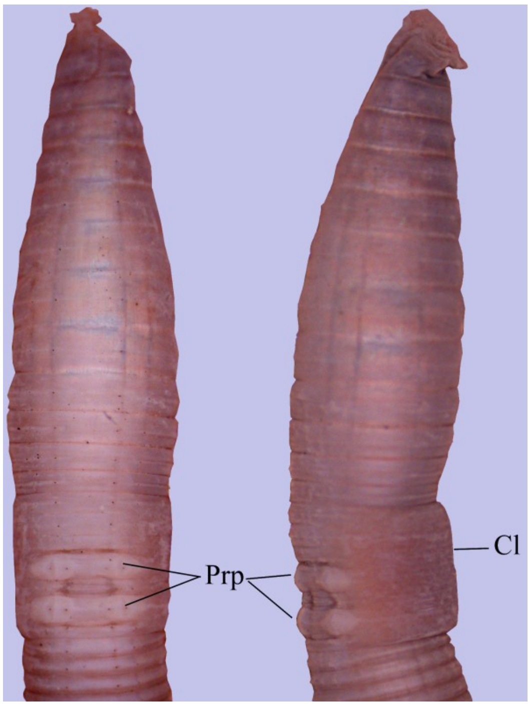


Figure 4. *Maheina braueri* (Michaelsen, 1897) ventral and ventro-lateral view. *Prp* = prostate pores, *Cl* = clitellum.

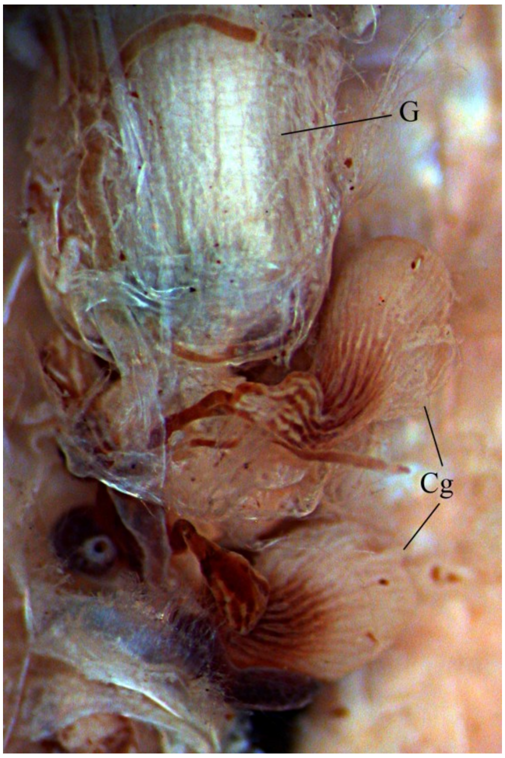


Figure 5. *Maheina braueri* (Michaelsen, 1897) *G* = gizzard, *Cg* = calciferous glands.

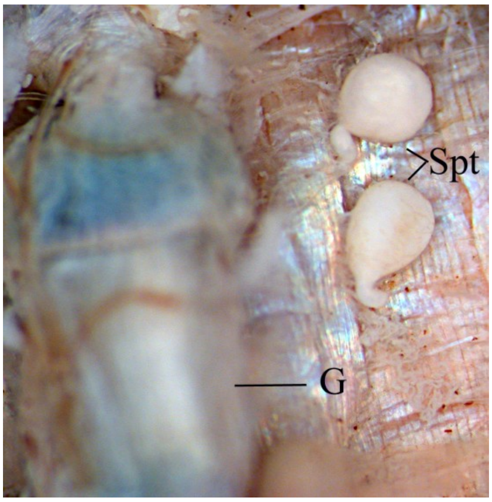


Figure 6. *Maheina braueri* (Michaelsen, 1897) *G* = gizzard, *Spt =spermathecae*

setae lacking. Two pairs of spermathecae in VIII and IX. Ampoule spherical, duct slightly curved, almost as long as the ampoule. Diverticulum lacking. (Fig. 6).

Remarks. This is the first recollection of this interesting species described as *Acanthodrilus braueri* from Mahé (Seychelles). Later (Michaelsen 1899) relegated it into a new genus *Maheina* Michaelsen, 1899 of the subfamily Megascolecidae (Acanthodrilinae). After a thorough examination of the paired calciferous glands in X, XI of *Maheina* Michaelsen (1922) proposed its close relationship to the ocnerodrilid *Curgia* Michaelsen, 1921 genus (now *Curgiona* Gates, 1941) possessing unpaired calciferous glands in the very same segments, and transferred *Maheina* to the subfamily Megascolecidae (Ocnerodrilinae). However, recently, the Drilobase database (http://taxo.drilobase.org) lists it in the family Acanthodrilidae as well as Blakemore (2008b, 2013) and Gerlach (2011). According to the vascular system (last pair hearts in XI) and the paired ocnerodrilid like calciferous glands in IX, X *Maheina* Michaelsen, 1899 belongs to Ocnerodrilidae and seems to be related to the metandric Southern Indian ocnerodrilid genera *Aphanascus* Stephenson, 1924 and *Curgiona* Gates, 1941p.

Family Rhinodrilidae Benham, 1890

Pontoscolex corethrurus (Müller, 1857)

Lumbricus corethrurus Müller, 1857: 113.
Pontoscolex corethrurus: Blakemore 2008a: 444. (for complete synonymy)

Material examined. HNHM/AF5161 5 ex., Mayotte, Grande Terre, near the road between Combani and Kahani, under a mango tree, S12°48’43” E45°07’35”, 16.10.2005, leg. T. Pavlíček. HNHM/AF5165 5 ex., Mayotte, Grande Terre, Kwalé, S12°47’42” E45°09’57”, 330 m, 20.10.2005, leg. T. Pavlíček. HNHM/AF5166 3 ex., Mayotte, Grande Terre, near road Combani-Kwalé, S12°46’59” E45°08’52”, 280 m, 20.10. 2005, leg. T. Pavlíček. HNHM/AF5170 7 ex., Mayotte, Grande Terre, along River Bandrani, S12°42’26” E45°05’36”, 160 m, 07.10.2005, leg. T. Pavlíček. HNHM/AF5175 4 ex., Mayotte, Grande Terre, along River Mro, NE of Dzoumonyé, S12°41’58” E45°05’22”, 200 m, natural forest, 08.10.2005, leg. T. Pavlíček. HNHM/ AF5176 2 ex., Mayotte, Grande Terre, lower station of the monte-charge to Mlima Combani, forest reserve, S12°48’00” E45°09’14”, 440 m, 14.10.2005, leg. T. Pavlíček. HNHM/ AF5187 7 ex., Mayotte, Grande Terre, near Longoni, S12°43’43” E45°07’46”, 35 m, around mangrove forest, 04.10.2005, leg. T. Pavlíček. HNHM/ AF5188 1 ex., Mayotte, Grande Terre, along Longoni River, S12°44’ E45°10’, 40 m, 05.10. 2005, leg. T. Pavlíček. HNHM/AF5190 5 ex., Mayotte, Grande Terre, along river above the Gîtes de Kwalé, S12°48’30” E45°09’40”, 185 m, 06.10.2005, leg. T. Pavlíček. HNHM/AF5714 7 ex., Mauritius, Montagne Cocotte, moss forest, under moss, 750 m, S20°26’5” E57°28’3”, 26.06.2000, leg. Cs. Csuzdi. HNHM/AF5724 4 ex., Mauritius, Petrin, Brise Fer, forest reserve, behind the Gerald Durrell Endemic Wildlife Sanctuary, 625 m, S20°22’1” E57°26’5”, 26.06.2000, leg. Cs. Csuzdi. HNHM/AF5725 2 ex., Seychelles, Mahé, N side of Le Niol, along the road, under leaf litter, 16.06.2000, leg. Cs. Csuzdi. HNHM/AF5726 1 ex., Seychelles, Mahé, cloud forest, 500 m, under *Pterocarpus indicus*,

Table 1. Earthworm species found on the different Indian Ocean Islands

	Mayotte	Mauritius	Reunion	Seychelles	Sri Lanka
Acanthodrilidae					
Dichogaster (Dt.) annae (Horst, 1893)	+			+	
Eudrilidae					
Eudrilus eugeniae (Kinberg, 1867)	+				
Lumbricidae					
Aporrectodea caliginosa (Savigny, 1826)			+		
Bimastos rubidus (Savigny, 1826)			+		
Megascolecidae					
Amynthas corticis (Kinberg, 1867)			+		
Amynthas gracilis (Kinberg, 1867)		+			
Amynthas minimus (Horst, 1893)		+		+	
Amynthas rodericensis (Grube, 1879)	+	+	+		
Amynthas robustus (Perrier, 1872)		+	+		
?*Diporochaeta* sp.	+				
Lampito mauritii Kinberg, 1867					+
Megascolex insignis Michaelsen, 1910					+
Metaphire bahli (Gates, 1945)					+
Metaphire californica (Kinberg, 1867)			+		
Nellogaster bahli (Stephenson, 1925)					+
Pithemera bicincta (Perrier, 1875)	+		+		
Polypheretima elongata (Perrier, 1872)	+	+			
Polypheretima taprobanae (Beddard, 1892)				+	+
Ocnerodrilidae					
Maheina braueri (Michaelsen, 1897)				+	
Rhinodrilidae					
Pontoscolex corethrurus (Müller, 1857)	+	+	+	+	+
	7	6	8	5	6

16.06.2000, leg. Cs. Csuzdi. HNHM/af5729 1 ex., Mauritius, Black River Peak, 600-700 m, 27.06. 2000, leg. Cs. Csuzdi. HNHM/5730 1 ex., Seychelles, Mahé, N side of Le Niol, along a small stream, 350 m, 16.06.2000, leg. Cs. Csuzdi. HNHM/AF5731 1 ex., Réunion, lowland rain forest, 24.06.2000, leg. Cs. Csuzdi. HNHM/ AF5736 9 ex., Sri Lanka, Kalutara district, Matugama, stream bank near the city, 12.03.2000, S. Mahunka, L. Mahunka-Papp. HNHM/5742 6 ex., Sri Lanka, Kalutara district, Wadduwa, moist meadow near the city, 11.03.2000, leg. S. Mahunka, L. Mahunka-Papp. HNHM/AF5744 2 ex., Sri Lanka, Kalutara district, Moratuwa, near the shore of Bolgoda Lake, 10.03.2000, leg. S. Mahunka, L. Mahunka-Papp. HNHM/AF5747 3 ex., Sri Lanka, Colombo district, Dehiwala-Mount Lavinia, moist area, 09.03.2000, leg. S. Mahunka, L. Mahunka-Papp. HNHM/AF5750 1 ex., Seychelles, Mahé, Morne Blanc, 350 m, secondary tropical rain forest, 01.08.1984, USSR Zoological Expedition. HNHM/AF5753 1 ex., Seychelles, Silhouette, near La Passe, 22–25.08.1984, USSR Zoological Expedition.

DISCUSSION

This small scale survey resulted in recording 20 earthworm species on the investigated five islands (Table 1). According to our expectation, the peregrine earthworms dominated on both oceanic and continental islands. The three endemic species found were present only in the continental islands (*Maheina braueri* in Seychelles and *Megascolex insignis*, *Nellogaster bahli* in Sri Lanka) in a contrast to the oceanic ones. Among the peregrine species the well-known pantropical pheretimoids were the most frequent (10 spp.). To our surprise, the only species occurring in all the investigated islands was the rhinodrilid *Pontoscolex corethrurus*. Amazingly, at higher elevations in Réunion two peregrine lumbricid species were also collected (*Aporrectodea caliginosa* and *Bimastos rubidus*).

The present survey resulted in recording the type species of the monotypic genera *Maheina* (*M. braueri*) and *Nellogaster* (*N. bahli*) for the first time since their original description and also an enigmatic ?*Diporochaeta* species. The genus *Diporochaeta* is mainly distributed in Australia and New Zealand (Jamieson 2000) with two doubted records in Southern India (Blakemore 2007). However, these two *Diporochaeta* species (*D. montanus* (Gates, 1940) and *D. pellucida* (Bourne, 1894)) differs markedly from our specimens having strong gizzard in segment V and last pair of hearts in XII (in our specimens there is no gizzard and the last pair of hearts are in XIII).

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Scopula orientalis (Alphéraky, 1876) (Lepidoptera: Geometridae, Sterrhinae) in the Carpathian Basin

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Abstract. The material of *Scopula* spp. specimens (n = 1181) in the Hungarian Natural History Museum is revised in the light of recent publications. The museum hosts vouchers of three species from the white-coloured taxa of the "*ornata* species-group" from the Carpathian Basin and six species from the Palaearctic Region. A historical specimen of *S. orientalis*, undoubtedly collected in the Carpathian Basin, was found amongst Palaearctic material. This is the first record of this species from the area and its most inland occurrence in Europe. A key to the identification of the three species recorded from the Carpathian Basin is given. With eight figures.

Keywords. Collection, distribution, Frivaldszky, genitalia, *Scopula decorata*, *Scopula ornata*.

INTRODUCTION

Scopula orientalis (Alphéraky, 1876) is a handsome, rare and local geometrid moth, with a disjunct distribution pattern from Macedonia to Northern Iran throughout coastal Ukraine, Asia Minor, Caucasus and the southern Urals (Hausmann 2004). This range was recently extended by the Albanian records of Beshkov (2017) and by Dincă & Székely (2018), who found the species in Dobrogea (Romania).

The latter work inspired us to revise the material of the white-coloured taxa of the "*ornata* species-group" (Hausmann 2004) *i.e.* this group without *S. submutata* (Treitschke, 1828) and *S. vigilata* (Wagner, 1826) originated from the Carpathian Basin and the Palaearctic Region, preserved in the Hungarian Natural History Museum (HNHM).

The aim of our article is to present a brief review on the material of this species-group of HN HM, to give the first record of *S. orientalis* from the Carpathian Basin and to facilitate its identification by publishing a brief identification key.

MATERIAL AND METHODS

Specimens of *Scopula concinnaria* (Duponchel, 1842) (Fig. 1), *S. ornata* (Scopoli, 1763) (Fig. 2), *S. honestata* (Mabille, 1869) (Fig. 3), *S. orientalis* (Fig. 4), *S. decorata* ([Denis & Schiffermüller], 1775) (Fig. 5) and *S. subtilata* (Christoph, 1867) (Fig. 6) from the Palaearctic Region are located in the drawers Nos 8F/15 and 8F/16 of HNHM. Drawers Nos 38A/19 and 38A/20 contain the *S. ornata* specimens from the Carpathian Basin and the drawer No. 38A/21 contains the *S. decorata* specimens, also from that territory. Altogether 1181 specimens were examined and their identity checked. The material has been recurated according to geographical regions.

All the specimens are dried, pinned, set and labelled. Dissections were performed where necessary (slide Nos TB1847m, TB1851m, TB1852f, TB1853m, TB1854m, TB1855f, TB1861m, TB1862f, TB1863m), using traditional method with maceration in KOH solution, staining in eosine and mounting in Euparal on standard microscopic slides.

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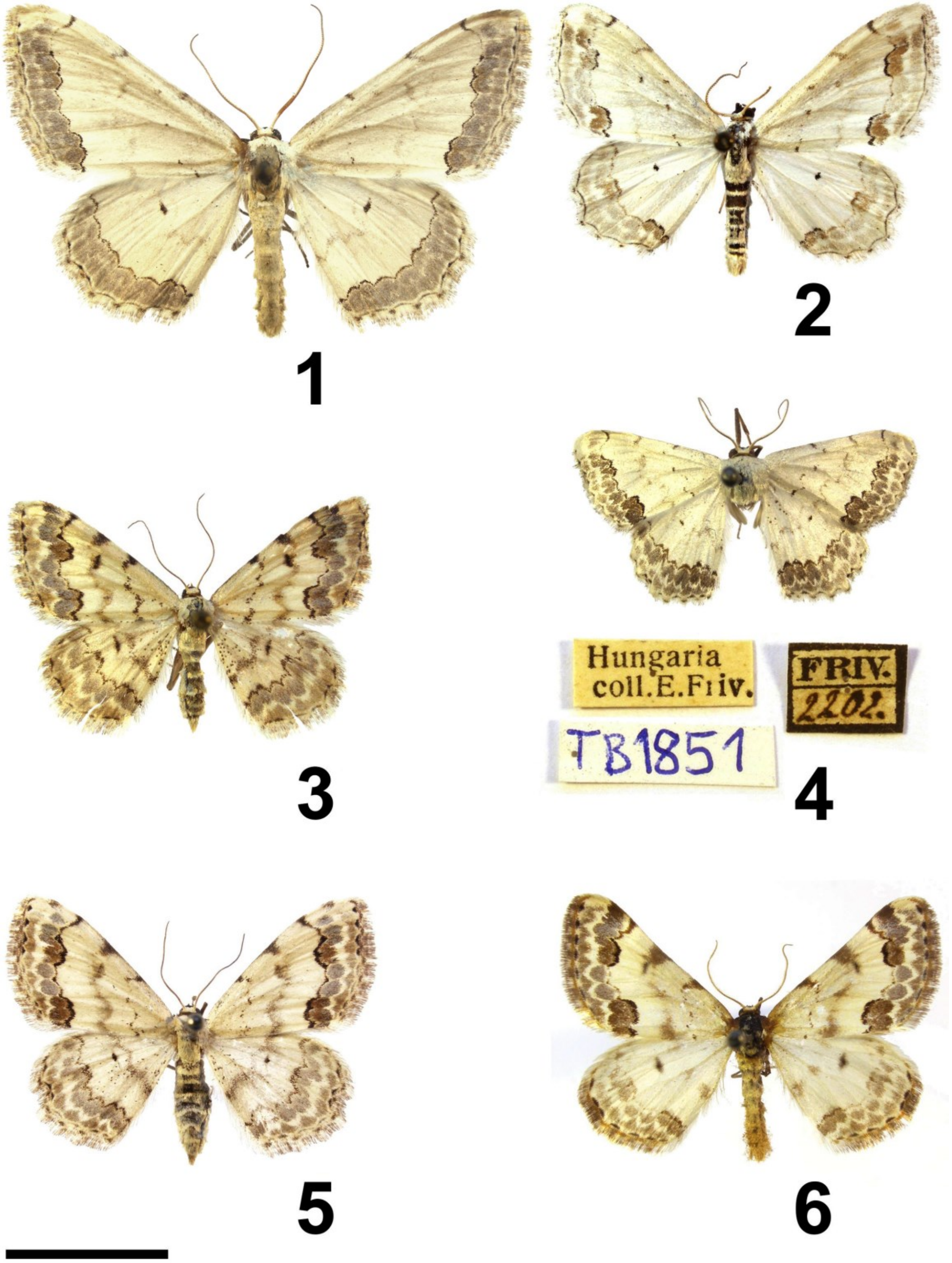


Figures 1–6. *Scopula* adults, museum specimens in dorsal view. 1 = *Scopula concinnaria* (Duponchel, 1842) male, Spain, Andalusia. 2 = *S. ornata* (Scopoli, 1763) male, Northern Macedonia, Babuna Mts. 3 = *S. honestata* (Mabille, 1869) female, Corsica, Col de Vergio. 4 = *S. orientalis* (Alphéraky, 1876) male and its labels. 5 = *S. decorata* ([Denis & Schiffermüller], 1775) female, Kosovo, Rudnik. 6 = *S. subtilata* (Christoph, 1867) male, Russia, Sarepta. Scale bar: 10 mm.

Adults and genitalia slides were digitalised in the HNHM working stations with Olympus C-7070 camera and Olympus SZx12 binocular microscope supplemented by an Olympus DP70 camera. The program Adobe Photoshop CS2 was used to adjust images and prepare tables for this article.

RESULTS

In the national (Carpathian Basin) main collection 608 *S. ornata* specimens and 343 *S. decorata* specimens were identified. According to the material *S. ornata* is widespread and frequent while *S. decorata* is more locally distributed than the former species but can also be frequent. There was no *S. orientalis* specimen amongst the specimens studied.

In the systematic (worldwide) collection eight *S. concinnaria* specimens, 84 *S. decorata* specimens, 17 *S. honestata* specimens, three *S. orientalis* specimens, 117 *S. ornata* specimens and one *S. subtilata* specimen were identified. Most of them were mixed. Amongst them we located five *S. decorata* specimens and four *S. ornata* specimens from "Hungaria", and surprisingly one of the located *S. orientalis* specimens is also labelled as from "Hungaria".

The labels of this *S. orientalis* specimen (Fig. 4) are as follows ("|" stands for the end of a line): (1) "Hungaria | coll. E. Frivaldszky" [thick yellowed paper due to ageing, text printed]; (2) "FRIV. | 2202." [thin, square-shaped paper with broad black edge, letters printed, numbers handwritten with black ink]. This specimen is a male, and has been dissected (slide No. TB1851m). The genitalia structures (Fig. 7) have characteristic features which enable unambiguous identification: posterior margin of sternum A8 is more concave, left ceras is much longer than in *S. decorata* and tips of cerata are spinulose, while they are smooth in *S. decorata*. In the clasping apparatus the fibula is shorter and the ventro-lateral processes of juxta are much shorter than in *S. decorata*.

Figure 7. Genitalia of the *Scopula orientalis* specimen depicted as Fig. 3 (TB1851m). Scale bar: 1 mm.

DISCUSSION

Labels of the historical Scopula orientalis *specimen*

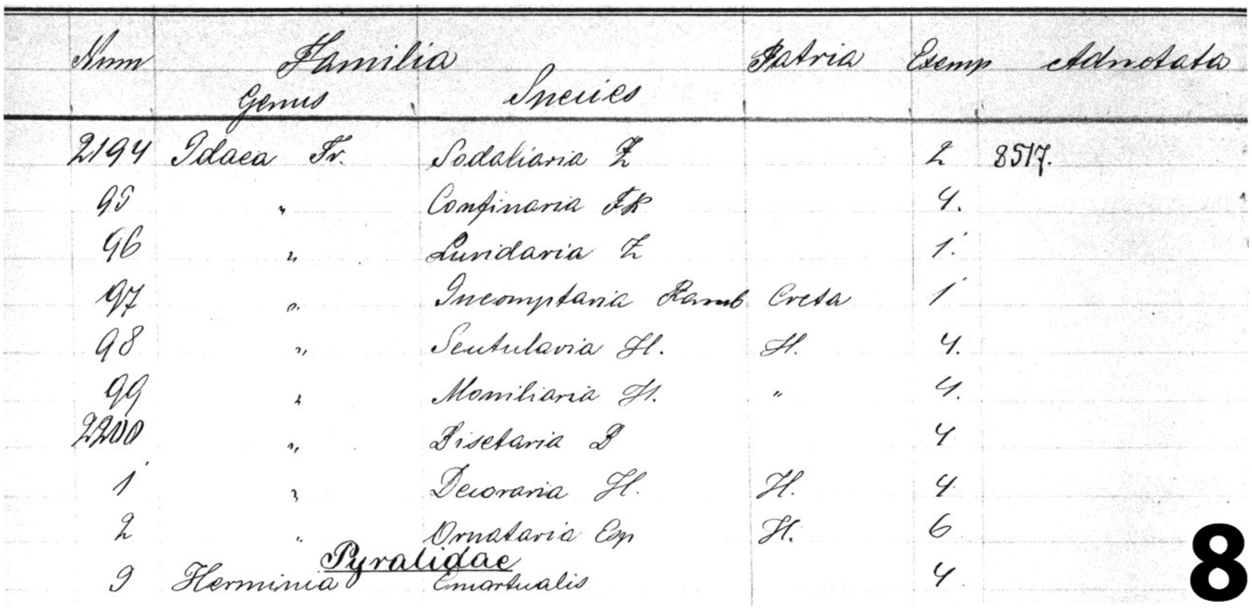
Like his contemporaries, Imre Frivaldszky (1799–1870) assigned serial numbers to his specimens, and gave the appropriate location to each number in a catalogue (Frivaldszky 1864). In this register the species names matched to serial numbers, and in these relevant numbered lines the quantity of the specimens with the places of origin were also indicated – thus providing a tool for tracing back some crucial information. Later on, in the 1950ies additional labels with location were assigned to Frivaldszky's specimens (Bálint 2008).

Accordingly the label no. 1 of the specimen is the recent one as testified the style of labels used after the 2nd World War staff in the museum, whilst the label no. 2. is the original Frivaldszky label, containing the serial number indicating the relevant numbered line in the catalogue. The place of origin of the *S. orientalis* specimens is "H." (= Hungarian Kingdom, Hungary) (Fig. 8).

Collecting localities

As it was the general practice in the 18–19th centuries Frivaldszky did not write precise collecting date on the labels of his specimens. The standard of Frivaldszky's era was giving large regions as collecting localities in catalogues, but exact localities could be traced back by diaries, field notes or published accounts on the expeditions. In the case of Frivaldszky it is a difficult task to trace back the exact collecting sites as the personal diaries could survive the centuries only in fragments, and only documentation of the Balkan expeditions remained intact (Bálint & Frivaldszky 2009).

The term "Hungaria" of Frivaldszky era means the Carpathian Basin but without Transylvania. The closest parts of this area to the known range of *S. orientalis* are the Banat (at present Northern Serbia and Southwestern Romania) and the vicinity of Băile Herculane (Romania). These are the most probable collecting sites of Frivaldszky's *S. orientalis* specimen but unfortunately nothing can be stated precisely. However, we cannot see any reason to raise doubts either on the origin of the specimen or the pertinence of the collecting area.



Num	Familia Genus	Species	Patria	Exemp	Adnotata
2194	Idaea Tr.	Sodaliaria L.		2	8517.
95	"	Confinaria HS		4.	
96	"	Lunidaria L.		1.	
97	"	Incomptaria Ramb.	Creta	1	
98	"	Scutularia H.	H.	4.	
99	"	Moniliaria H.	"	4.	
2200	"	Bisetaria D.		4	
1	"	Decoraria H.	H.	4	
2	"	Ornataria Esp	H.	6	
3	Pyralidae Herminia	Emortualis		4.	

8

Figure 8. Scanned page of the relevant part of the Frivaldszky's catalogue, showing the numbered lines for *Scopula ornata*, *S. orientalis* (both as "Idaea Ornataria") and *S. decorata* (as "Idaea Decoraria").

Further Frivaldszky specimens

According to the catalogue, No. 2202 refers to "Idaea Ornataria" [= *S. ornata*], from "Hungaria", present in the collection by six specimens. We found five of them; four specimens were identified as *S. ornata*. One of these specimens was the *S. orientalis* mentioned above. We found a further *S. ornata* specimen, mislabelled by Zsigmond Velez (locality: Italy, Piemont). This can be the sixth specimen of Frivaldszky, judging by the style of mounting as well as shape and quality of the pin, which are identical to those of Frivaldszky and it is known that Velez relabelled many museum specimens, often with false data (Bálint 2009).

No. 2201 of Frivaldszky stands for four specimens of "Idaea Decoraria" [= *S. decorata*] also from "Hungaria". We found all of them.

In general the Frivaldszky collection specimens were kept in the Palaearctic material by the previous curators. In the time of its acquisition (1864) the Frivaldszky Lepidoptera collection was one magnitude larger than the collection of the National Museum and contained large amount of species not native in the Carpathian Basin. Consequently all the new exotic (= "non Hungarian") material were incorporated to the Frivaldszky collection which had grown into the main collection. Whilst an extensive development of the national collection had been started from the 1950ies, the Frivaldszky specimens were left in their place. Recent curatorial policy is that the Frivaldszky specimens should be assembled together keeping as a distinct body, curated similarly as the collections of Tobias Koy, Ferdinand Ochsenheimer and Friedrich Treitschke, with great historical interest (Bálint 2008).

The **Scopula ornata** *species group diversity in the Carpathian Basin*

The first review of the *Scopula* fauna of the Carpathian Basin was provided by Abafi-Aigner (1907) presenting short descriptions and figuring the most common species. Subsequently Kovács (1965) monographed the Hungarian fauna and provided a key for the 16 species he recorded. Later Fajčik (2003) provided an overview and documented the occurrence of 20 species for Central Europe. Székely (2013) monographed the Sterrhinae fauna. None of the mentioned works discussed or figured *Scopula orientalis*. Therefore below we provide a key for the white-coloured taxa of the *Scopula ornata* species-group (sensu Hausmann 2004) to distinguish the three taxa recorded in the Carpathian basin.

1. Forewing with two, hindwing with at least one (often two) distinct brown patches in the marginal field; this field without bluish grey or lead-grey band (Fig. 2)..................*Scopula ornata*

– Forewing with two brown, often bluish grey patches in the marginal field, hindwing without distinct patch; all wings with lead-grey or bluish grey band in marginal fields…..............................2

2. Grey band of forewing reaching costa or at least vein R4; row of terminal grey spots confluent (Fig. 5).......................*Scopula decorata*

– Grey band of forewing reaching vein R5 only; apically from this vein the band either disappearing or vanishing to an isolated light grey dot; terminal grey spots separated (Fig. 4)… ....*Scopula orientalis*

Acknowledgements – We are grateful to Levente Székely (Săcele/Braşov) for sharing his article on *Scopula orientalis*.

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Opusc. Zool. Budapest, 2019, 50(2): 163–188

Hydrobiological bibliography of Lake Fertő/Neusiedler See – Hanság/Waasen — 1972–2017

Results of the research coordinated by the Danube-Research Institute (earlier: Hungarian Danube Research Station) CER Hungarian Academy of Sciences

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Abstract. A bibliography of the Fertő/Neusiedler See and Hanság/Waasen research coordinated by the Danube-Research Institute between 1972 and 2017 is presented. The bibliography lists 198 publications on the Fertő/Neusiedler See region and 28 on the Hanság/Waasen and furthermore, detailes of 19 projec reports are presented. Alphabetic lists of authors with references to their contributions to the research of both regions were also compiled.

Kewords. Shallow lakes, reed stands, hydrobiology, publications, Fertő Tó, Hanság.

PREFACE – ANTECEDENTS

The overall limnological, hydroecological research of Lake Fertő /Neusiedler See started fairly late compared to that of other lakes; by doing this research an old debt was paid off. Lake Fertő /Neusiedler See – the westernmost steppe-lake in Eurasia – used to be situated in Hungary, but after the Treaty of Trianon [Versailles 1920], due to the new state borders, the middle and northern parts of the lake (234 km^2) were annexed to Austria, whereas the southern 75 km^2 part still belonged to Hungary.

During the years between the two World Wars (1918 – 1939) no organized research was encouraged in the countries around the lake. The ’Iron Curtain’ (the political and technical barrier between the Soviet bloc and western Europe) built after the Second World War, after 1945, made research on the Hungarian territory of the lake impossible for decades; the limited but organized hydrobiological research could only be started from the 1970s due to the more relaxed political atmosphere. *This delay was regrettable for both scientific and practical reasons, as by then in Austria significant results had been produced in research and regional development.*

After our regular and coordinated research of more than three decades so much published material had been gathered, that it became justified to compile and publish a bibliography (edited by M. Dinka in 1999 and 2007).

In 2012 the research network of the Hungarian Academy of Sciences was reorganized and then the Danube Research Institute (earlier called Hungarian Danube Research Station) of the Hungarian Academy of Sciences became a member institute of the newly established Centre for Ecological Research. The new leadership of the Research Centre abolished the long ongoing organized research of Lake Fertő and did not intend any form of reorganization. From a scientific aspect that was all the more harmful because the serious consequences of the climate change on the shallow lakes (like water budget, thermic conditions, significantly increased instability) could not be assessed and no mitigation proposals could be made. Considering our more than 40 year successful research completed, we are publishing

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our replenished bibliography including the latest results.

The Basis Characteristics of Lake Fertő/ Neusiedler See and a Short Survey of its Research

The sodic and extremely shallow (120 cm) Lake Fertő/Neusiedler See, situated in the temperate zone and having a large surface (309 km^2) has been in the centre of special international scientific interest concerning Europe. Due to its shallowness the surface of the lake is divided into reed stands in a mosaic-like way. Another consequence of this shallowness is that the external effects are very strong, like that of the wind on the current conditions and the fluctuation of the water and sediment thermal conditions. These make the existential- and biological processes of the lake very changeable, inconstant and to a great extent instable. From an economic aspect the different branches of utilization with an increasing importance are significant (like reed- and fish farming, recreation, ecotourism, regional development); all of which have to be done in accordance with the conditions of nature conservation. (The high level of natural and cultural protection of the lake and the joint areas will be discussed later.)

The 14the Congress of the International Limnological Society was held in Vienna, Austria in 1959. At this congress significant international scientific interest was shown in Lake Fertő and the Austrian scientists presented the results of some valuable series of examinations. Later, they joined the International Biological Program (IBP), the International Hydrological Decade (IHD) and the UNESCO Man and Biosphere (MAB) Program carrying out their assignments which was supported by the Austrian Academy of Sciences encouraging a more coordinated limnological research concerning the Lake Fertő's Austrian part (234 km^2). Including also the previous scientific reports on this area, a monograph was edited by Prof. H. Löffler in 1979 (Neusiedlersee: The limnology of a shallow lake in Central Europe – Dr. W. Junk bv Publ., The Hague-Boston-London) which is the summary of the work of 24 researchers in 549 pages.

In Hungary, Sopron, situated very near Lake Fertő and at the Hungarian – Austrian border since 1945, is a town of rich cultural past, still deemed to decay. The civic population of the town established the Sopron Fertő Committee of the Hungarian Hydrobiological Society already in 1958. The government of the Hungarian People's Republic passed a resolution in 1968 which gave directives for the complex development of the Fertő Landscape. It was the assignment of the Hungarian Academy of Sciences to provide the scientific background of this development. One of its main tasks was the basic hydrobiological assessment of Lake Fertő's Hungarian part in order to protect the natural values and to lay the foundations of a harmonized utilization. Both the Hungarian and the Austrian Academy of Sciences organized and carried out a long-term research cooperation by agreement. This research work became highlighted among the Hungarian tasks of the UNESCO MAB program. This Hungarian-Austrian cooperation was conducted by the Austrian Prof. H. Löffler, Member of the Academy, professor at the University of Vienna, as well as the Hungarian Prof. E. Dudich, Member of the Academy, professor at the University ELTE (Budapest) and his successor Prof. Á. Berczik, from the same university. The continuity of this cooperation was supported by the Austro-Hungarian UNESCO Fertő Committee directing the above named and involving leading researchers in the project (among them M. Dinka, M. Pannonhalmi, L. Kárpáti, A. Herzig, H. Waidbacher, F. Titz). On the initiative and supported by UNESCO a scientific round table discussion was organized both in Austria and in Hungary. The results of the research were presented in both countries on several national and international forums and we are continuously represented in different water management and regional developmental committees.

The first research task was starting the assessment of the basic hydrobiological conditions in the Hungarian part of Lake Fertő with 75 km^2 extension. *The investigations tried to reveal two large groups from the main habitats of Lake Fertő/Neusiedler See: 1/ the open water areas* *(open waters, bays, ponds within the reed stands, canals) and 2/ the reed stands (stands near the shoreline either with several km width, as well as reed stands).* The following investigations were carried out:

- ***Water chemistry*** – (the whole Hungarian part of the lake, altogether at 50 sampling sites, regarding 5–30 parameters, continuously between **1990 and 2006, later occasionally until 2015**),
- ***Sediment chemistry*** – (the whole lake area, 61 sampling sites, 6-20 parameters, between **1984–1992** intensively, since then in certain cases **until 2015**),
- ***Sediment interstitial water*** – (physical and chemical parameters regarding the reed stands and the interaction with sediment and connected water areas, between **1998–2002**),
- ***Sediment matter cycle*** based on the sediment ETS-activity (**2000–2001** and **2006***),*
- ***Water and sediment thermal conditions*** (the whole lake area, 20 investigation sites, sediment layer measurements from cm to cm max. until 30 cm, **between 1987–1990**, in the Hungarian part online measurement of temperature: in measuring points marked between the surface of the water and the sediment, on the surface of the sediment and 20 cm below the sediment in both open waters, in the inner lake and in the reeds as well between **2012 and 2017**),
- *Phytoplankton-algology* (the whole lake area, detailed and planned investigation series on the Hungarian part, between **1980–1990** and **2003–2004**),
- ***Zooplankton*** – Rotatoria, Crustacea assemblies (detailed and planned investigation series on the Hungarian part of the lake continuously **between 2002–2006**),
- ***Periphyto****n* (primarily in the inner ponds of the Hungarian part of lake, between **1985–1987**),
- ***Macrophyte assemblies*** (comparative stands record regarding to the Hungarian part, between **1987–1988**),
- ***Reed ecology*** (production site conditions of different reed stand areas at the Hungarian part of the lake, reed stand structure, reed-growth, production, nutrient content, nutrient stock, the carbohydrate-stock of the reed rhizome, the effect of harvesting and investigation of the reed decomposition, in the frame of EU-EUREED with the cooperation of 10 European countries, between **1992–1999** and NKFP, between **2002–2005** program),
- ***Macroinvertebrate assemblies*** (seaweeds between **1972–1980**, reed remains between **1995–2001**),
- ***Fish biology*** (fish faunistic records **1975** resp. **1987** and **2000**.),
- ***Anthropogenic effects*** (the effect of reed harvesting on the Hungarian part of the lake between **1995–1999**, the effect of reed burning between **2001–2002**),
- ***Nature conservation*** (regular contribution to attaining the different levels of conservation: by becoming a *UNESCO Biosphere Reserve (1987), a National Park (1991), an International National Park Crossing Countries (1994) and a member of the UNESCO World Heritage (2001)* the economic and social value of the Fertő landscape was significantly raised; directives on the maintenance of the values of the inner ponds, reed protection **between 1990–2006**).

Examinations have been expanded on the basic assessment of the Hanság wetland area which is hydrographically connected to Lake Fertő (1998–2001); furthermore on the exploration of *Nyirkai Hany és Keleti Mórrétek wetland areas* and the evaluation how effective the reconstructional intervention had been on nature conservation.

The present bibliography includes about 200 works about research results between 1972 and 2017 carried out with the direction, support and coordination of the Hungarian Danube Research Station (now called Hungarian Danube Research Institute) of the Hungarian Academy of Sciences.

The organized research work was financially made possible by the Hungarian Academy of Sciences, the UNESCO (Paris), the tender EU-

EUREED and by further projects like AKP of the Hungarian Academy of Sciences, OTKA, OKTKP, KAC, MTA KvVM, NKFP under the direction of Prof. Á. Berczik and ass. Prof. M. Dinka.

In 2012 the Danube Research Institute, Centre for Ecological Research of the Hungarian Academy of Sciences was reorganized and then the general director of the Centre ended the 40 year long organized field- and laboratory research of Lake Fertő with an oral statement, without any previous consultation. He interrupted the new research project started not long before, which meant to explore the impact of climate change on this territory, being especially endangered due to the extreme shallowness of Lake Fertő. This put an end to our ongoing research.

MATERIAL AND METHODS

The present literature is cimpiled from different sources. In the literature of the Neusiedler See/Fertő the authors' names of collaborators working at the Hungarian Danube Research Station of the Hungarian Academy of Sciences are written with capital letters. The name written in bold refer to articles, the normal letter symbolize the abstracts and the italics refer to manuscripts. In the alphabetic list of authors the publication numbers are in brackets when the listed author is not the first author of the publication.

NEUSIEDLER SEE (FERTŐ)

LIST OF PUBLICATIONS

1972

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1973

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1974 —

1975

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1976

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1977 —

1978

7. **Andrikovics, S. (1978):** Series of hydro-ecological data to the zoological evaluation of the pondweed fields of Lake Fertő. *Opuscula Zoologica, Budapest*, 15: 23–29.

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1979

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1980

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1981

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16. **Padisák, J. (1981):** Seasonal changes of phytoplankton communities in the Hungarian part of Lake Fertő. *Biologisches Forschungsinstitut für Burgenland – Bericht*, 42: 39–50.

1982

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1983

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MsC and PhD dissertations

Research activities at Lake Fertő/Neusiedler See resulted in:

1 MsC (77) and

4 PhD dissertations (10, 63, 149, 151).

Research activities at Hanság/Waasen resulted in:

MsC (4) and

1 PhD dissertation (22).

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Fertő/Neusiedler See

Fundamental characteristics:

latitude: 47°37' – 47°57' N

l*ongitude*: 16°41' - 16°°52' E

altitude above the Adriatic see level: 115 m

mean water depth: 110 cm

chemical character of the water: sodium-magnesium-hydrogencarbonate-sulfate.

	Surface km^2	***Open Water*** km^2	***Reed stand*** km^2	***Reed stand*** *%*
Austria	234	124	110	47
Hungary	75	11	64	86
Total	**309**	**135**	**174**	**56**

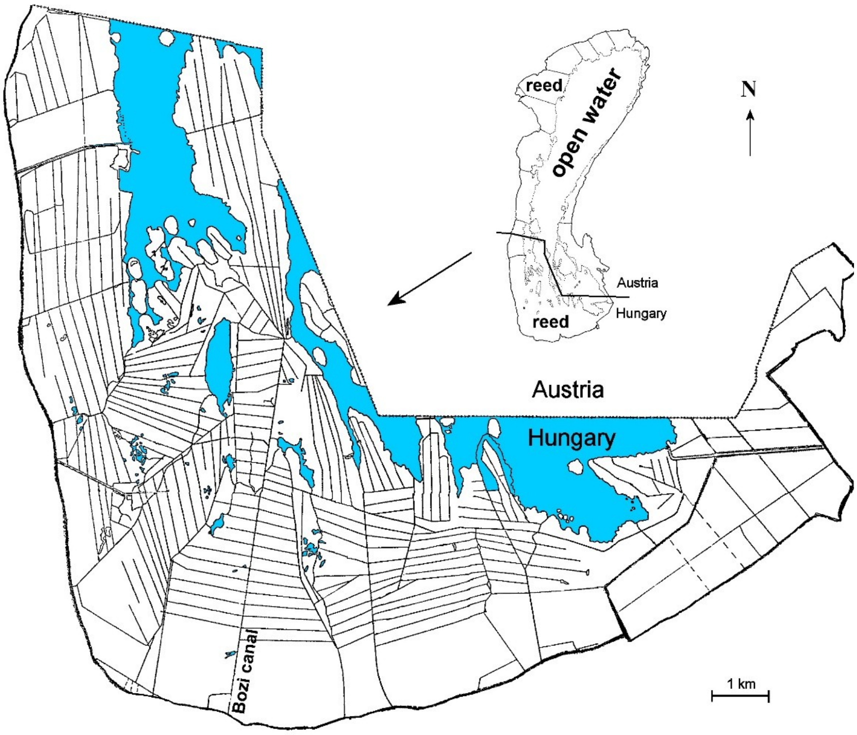

Figure 1. Overviwe of the Hungarian part of the Laske Fertő.

Figure 2. Mosaic reed-stands in the lake Fertő.

Figure 3. A wealthy reed-stand with sighn of water lewel fluctuation.