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Two new species of *Tachyphyle* Butler, 1881 from South America (Lepidoptera: Geometridae)

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Abstract

The Neotropical emerald geometrid genus *Tachyphyle* Butler, 1881 as revised by PITKIN (1996), consists of fifteen described species. This article is aimed at presenting descriptions of two additional species, *Tachyphyle nielseni* Viidalepp & Lindt, sp. n. from Argentina which is similar to *T. acuta* Butler, 1881 and *Tachyphyle selini* Viidalepp & Lindt, sp. n. from Costa Rica and Ecuador, which is similar with *T. undilineata* (Warren, 1900). The adults and their male genitalia are illustrated.
KEY WORDS: Lepidoptera, Geometridae, new species, Costa Rica, Nicaragua, Ecuador.

Dos nuevas especies de *Tachyphyle* Butler, 1881 de América del Sur (Lepidoptera: Geometridae)

Resumen

Los geométridos esmeralda del género Neotropical *Tachyphyle* Butler, 1881, revisados por PITKIN (1996), consistien en quince especies descritas. El objeto de este artículo es presentar la descripción de dos especies adicionales, *Tachyphyle nielseni* Viidalepp & Lindt, sp. n. de Argentina la cual es similar a *T. acuta* Butler, 1881 y *Tachyphyle selini* Viidalepp & Lindt, sp. n. de Costa Rica y Ecuador, que es similar a *T. undilineata* (Warren, 1900). Se ilustran los adultos y su genitalia del macho.
PALABRAS CLAVE: Lepidoptera, Geometridae, new species, Costa Rica, Nicaragua, Ecuador.

Introduction

BUTLER (1881) characterized the genus *Tachyphyle* and the typical species *T. acuta* Butler, 1881. Warren described two decades later *T. allineata* (Warren, 1900) (as *Dichorda allineata* Warren, 1900) from Venezuela and *T. undilineata* (Warren, 1900) from Guiana, *T. occulta* (Warren, 1901) from Colombia, *T. costiscripta* (Warren, 1906) from French Guiana, *T. fuscicosta* from Brazilian Amazonas and *T. albisparsa* (Warren, 1907) from Peru.

PROUT (1912) listed 15 species in this genus, but revised the genera *Tachychlora* Prout, *Tachyphyle* and *Phrudocentra* Warren anew in the Seitz volume (PROUT, 1932), adding brief descriptions of two further taxa (*T. antimima* Prout, 1932 from Peru and *T. apicibadia* Prout, 1932 from Colombia), and combining (*Phalaena*) *pigraria* Sepp, 1848 from Surinam and (*Geometra*) *basiplaga* Walker, 1861 from Brazil with the genus *Tachyphyle*. Additional species, *Tachyphyle hamata* Schaus, 1912 and *T. oleaster* Schaus, 1912 from Costa Rica, *T. aganapla* Dyar, 1913 from Mexico and *T. maiester* Dyar, 1914 from Panama were discussed as well by PROUT (1932-1938). PITKIN (1996) followed Prout's treatment of the genus but transferred to *Tachyphyle (Tachychlora*) *pretiosa* Thierry-

Meig, 1816 and listed the fifteen species in an alphabetical arrangement. The taxonomic structure of this heterogeneous genus is analyzed by VIIDALEPP (2017).

Material and methods

The present study was initiated by attempts to identify moths that have accumulated in the collection of the Estonian Museum of Natural History (EMNH, Tallinn) and in the IZBE insect collection which is deposited at the Estonian University of Life Sciences (IZBE, Tartu). The main material was collected between 1999 and 2013 and prepared for investigation by Aare Lindt. Additional material collected by T. Kesküla, V. Soon, V. Viidalepp and J. Viidalepp (in the IZBE collection), by A. Selin and T. Armolik (in the private collection of A. Selin) were used as well.

The mounting of emerald green moths is a complicated process and the method that was used was to inject some water into the thorax of a specimen, followed by keeping the moth in a container with high air moisture environment for 1-2 hours, finally desiccating the mounted sample at around 60°C for about 12 hours. Such a treatment prevents the green moths from further fading in collection. Palpi, antennae, legs and details of wing venation were measured using an ocular micrometer and binocular microscopes, using 40x magnification. The genital slides of males and females were treated using established procedures (HARDWICK, 1950), inspected in glycerol, embedded in Euparal and photographed in ventral view. Moths were photographed prior to investigation of the genital structures using a Canon 300D digital camera, while the genital slides were photographed with an Olympus SZ60 microscope and Leica M165C digital camera. The photographs obtained were augmented using Adobe Photoshop Elements v. 7 in order to clarify their resolution.

We thank Erki ÕUNAP for his attempts for DNA barcode analysis; however, these results were not encouraging. Dr G. BREHM has kindly taken over the COI barcoding of the new species *T. selini* and *T. undilineata,* for his Geometridae phylogeny project.

Description of new species

Tachyphyle nielseni Viidalepp & Lindt, sp. n. (Figures 1, A-E)

Type material: Holotype, ♂: Argentina, [prov.] Neuquen 15: Piedra del Aguila, 19-XII-1978, Mision Cientifica Danesa. Gen. prep. 88/2001 (JV/ZMUC). Paratypes, 3 ♂, the same data as Holotype. The Holotype and paratypes are deposited in the collection of the Zoological Museum of University of Copenhagen (ZMUC), Denmark.

Remark: The collection site "Neuquen 15" (Figure 1D) lies at Rio Limay between Neuquen and S. C. de Bariloche (40º 03'S, 70º 04'W); biotope: transition between bush steppe and Patagonian steppe (SCHMIDT-NIELSEN *in* MADSEN *et al*., 1980).

Additional material: *T. acuta* Butler: Paraguay (slide 7590); Peru (slide7266); Ecuador (slides 6602, 6630); Fr. Guiana; Costa Rica (slides 7065, 7266); Nicaragua (slides 8044, 8531). *T. olivia* Schaus, 1901: A male specimen from Brazil, Espiritu Santu, labelled as *T. olivia* in coll. Herbulot in ZSM, Munich, and a male specimen in the BMNH collection with the slide Geo 14185 examined.

Diagnosis. The new species is similar to *Tachyphyle acuta* in facies, differing in the forewing apex less acute and distal margin of forewing convex (Figure 1A); male hind leg has proximal spurs and tibial hairpencil entirely lost. Male genitalia (Figure 1B): uncus short and bidentate (triangular, pointed in *T. acuta*), sacculus not produced distally, and aedeagus (Figure 1C) provided with two distal prongs (one sclerite in *T. acuta* and one wide based cornutus in *T. olivia* Schaus). *T. olivia* shares a bifid uncus and a bifid last abdominal sternite with *T. nielseni* but differs in the shape of cornutus which is single, wide based and thick, and in forewing costa speckled yellowish and dark grey.

Description. Wing span of males 20-22 mm (Figure 1A). The frons is flat and smooth, white, with a green line in its middle. The upper edge of the frons has a pair of flat tufts of white scales ventral to the bases of antennae; the fillet is broad, white. The palpus is whitish, its third segment 0.12 mm long.

The antennae are bipectinate in the basal 2/3 and filiform in apical third, the longest pectinations 0.4 mm long or four times the diameter of the shaft. The forewing veins M_1 and M_3 are free ($R_{2+}M_1$ and M_3+CuA_1 being short-stalked in *T. acuta*). The apex of the discal cell appears concave, produced towards the wing apex. The hindwing veins Rs+M_1 and M_3+CuA_1 are short-stalked. The male hind tibia is slightly shorter than the tarsus, slender, without a distal projection and without a hair pencil, the proximal spurs being completely reduced. The apex of the forewing is not extended or angulate, without a black apical spot. The hindwing tornus is angulate but not extended (the forewing apex being angulate, and the hindwing tornus extended in *T. acuta*). The ground colour of wings upperside is apple green, the fringe green (the ground colour being darker, the fringe lighter green in *T. acuta*). The postmedial line is thin, straight, whitish.

Male genitalia (Figures 1 B, C. E). The uncus is flat, apically bidentate, converging towards the tips, 0.37 mm long, (conical, pointed, 0.7 mm long in *T. acuta*). The socii are tiny, membranous; the gnathos is a broad loop with a cochlear (medial projection) present, triangular, short (slenderer, with the hooked cochlear tapering to the tip in *T. acuta*). The valvae are well fused, with a small crista in the middle, bearing some setae (the sacculus is projecting a free arm, about 0.4 mm long in *T. acuta*). The juxta as a small rounded plate, distally fused to aedeagus. The saccus is conical (rounded or oval in shape in *T. acuta*). The aedeagus is straight, with its basal third sclerotized, the distal part membranous, with two long (ca 1.0 mm) prongs which are tapering distally (without long prongs, slightly pistol-shaped in *T. acuta*). The sternite A8 with two triangular distal projections (Figure 1E). The coremata are absent (small coremata pencils are attached to the bases of valvae in *T. acuta*).

Remarks: *T. acuta* (identified according to the images of male genitalia from the lectotype (Pitkin, 1996, Figs 130, 179; the image of a male moth by L. Pitkin (1996: Figure 53) has forewing apex acute and distal margin concave, and it may be not conspecific) has its palpi longer (0.22 mm, while 0.12 mm in *T. nielseni*, sp. n.), and hind tibiae provided with a thin hair pencil and with the proximal spurs reduced to their black tips visible at the base of distal spurs. *T. nielseni,* sp. n. has lost both the hair pencil and distal spurs of the hind tibia.

T. olivia differs from the new species *T. nielseni* sp. n. in dark tipped forewing with its distal margin slightly concave, and in genitalia as described above. The combination of a forked uncus and the absence of sacculus projection is shared by *T. nielseni*, sp. n. and *T. olivia* Schaus, 1901, but the shape of triangular projections of the sternite A 8 (wide spaced in *T. olivia*), and the presence of a wide-based cornutus on vesica of *T. olivia* allow to distinguish between these species. *T. olivia* has also its ground colour darker and the forewing apex slightly projecting.

Etymology: The species name is derived from Dr. Ebbe Schmidt Nielsen's family name, gender masculine.

Tachyphyle selini **Viidalepp & Lindt, sp. n.** (Figures 1 F, 2 A-E)

Type material: Holotype: ♂, Costa Rica, Bri Bri, 278 m, 12-II-2007, 09º 35' 31"N, 82º 53' 55"W (IZBE0121228) (A. Lindt). Paratypes: 1 ♂, Costa Rica, Golfito, 50 m, 14-II-2007, 10º 36' 58"N, 84º 01' 15"W (IZBE0121230) (A. Lindt); 1 ♂, Costa Rica, Playa Hermosa, 135 m, 07-II-2007, (gen. 8335) (IZBE0121231) (A. Lindt); 1 ♂, Costa Rica, Siquirres, 550 m, 09-II-2007, 10º 03' 33"N, 83º 26' 35"W (A. Lundt) (IZBE0121232); 2 ♂♂, Costa Rica, Esquipulos, 400 m, 20-II-2007, (IZBE 0121233) (A. Lindt); 1 ♂, Costa Rica, Laguna de Arenal, 700 m, 16-III-2007, 10º 33' 44"N, 84º 34' 54"W (A. Lindt) (gen. 8045) (DNA voucher 947 Õunap) (IZBE0121234); 4 ♂♂, Costa Rica, Cariari, 03-V-2001, 10º 34' 49"N, 83º 42' 11"W (Selin & Armulik); 5 ♂♂, 1 ♀, Costa Rica, Limon, Bri Bri, 60 m, 14-IV-2001 (gen. 6853, 7037, 7059); 1 ♀, Costa Rica, Ciudad Cortes, 8º 59' 29"N, 83º 32' 36"W, 21-IV-2001 (Selin & Armulik) (gen. 6853) (IZBE 0121235) (coll. A. Selin); 3 ♂♂, Ecuador, Manabi prov., Beche, 50 m, 15-V-2007, 0º.12' 32"N, 79º 54' 04"W (gen. 8467) (IZBE0121236, IZBE 0121238, IZBE 0121239) (A. Lindt); 1 ♂, Ecuador, Esmeraldas prov., San Javier, 97 m, 6-V-2007 (gen. 8468) (IZBE 0121237) (A. Lindt); 1 ♂, Ecuador, Arajuno, 540 m, 8-II-2008, 01º 09' 49"S, 77º 39' 28"W (gen. 329) (IZBE 0121223) (A. Lindt).

Additional material: *T. undilineata*: Ecuador (slides 6611, 328); Fr. Guyana (slides 7036, 7060, 7103, 7104, 7105, 7106); Nicaragua: San Juan prov., Bartola (slide 8321). Additonal samples are deposited in the private collections of the collectors A. Lindt, A, Selin, in the insect collections of EMNH (Tallinn) and IZBE (Tartu). *T. occulta*: 2 ♂♂, Ecuador: Occidente: Esmeraldas, Maldonado 50 m, 07-V-2007, 01º 08' 51"S, 78º 48' 31"W (slide 8336) (IZBE0121239, IZBE 0121240); Ecuador, Esmeraldas prov., San Javier 94 m (slide 8468); Holotype and genital slide in BMNH compared (VIIDALEPP *et al*., 2011); 2 ♂♂, Nicaragua, San Juan prov., Bartola, 2-6-VI-2008 (slides 8034, 8043) (Viidalepp leg.), in coll. IZBE, Tartu.

Diagnosis. Very alike to *Tachyphyle undilineata* Warren and *T. occulta* Warren in its wing pattern but distinct in the structure of male genitalia: the harpe of *T. selini* consists of one single, straight, stick-shaped process which is directed outward. The harpe of *T. undilineata* consists of 2-4 (usually 3) stout horns which are directed dorsally, while more than a dozen small, flat thorns, curved distally, characterize *T. occulta.* The distal projection of sacculus is short (absent in *T. occulta*, longer in *T. undilineata*) and antennal pectinations are up to 0.5-0.55 mm long in males; sterigma of *T. selini* appears less sclerotised than in females of *T. umdilineata*.

Description. Wing span 21-25 mm in males, 26 mm in females (Figure 1F). The frons is flat, green, with a broad white stripe above and two white spots at lower margin. The fillet is white, broad. There are two flat tufts of white scales to antennae bases as an extension of the white interantennal fillet. The third segment of palpus is 0.25 mm long in males and 0.4 mm long in females. The antennae are bipectinate in the basal two-thirds and filiform in the apical third in both sexes, the length of the external pectinations reaching 0.55-0.6 mm in males, 0.4-0.5 mm in females. The forewing has the veins R_2-M_1 stalked, M_3 free, the hindwing has the veins M_1 and M_3 stalked with nearby veins (Rs and CuA1, respectively). The hind tibia has the proximal spurs reduced and hidden in scaling, with black tips only hardly visible, distanced 0.25 mm from the base of distal spurs. The male hind tarsus is longer than the tibia (as about 4: 3). The distal margin of the forewing is slightly concave, the wing apex acute, the hindwing tornus being produced like in *T. acuta* and *T. undilineata* (Figure 1G). The ground colour of wings is dull green, gradually tending paler towards the distal margin of wings, with sparse fuscous transverse irroration just as in *T. undilineata.* The costa of the forewing is sparsely mottled with fuscous, tending blackish towards the apex. The fringe has a black spot at forewing apex. The antemedial and postmedial lines are inconcrete, being marked by denser fuscous striation. The discal spots are fuscous in forewings but sometimes tiny or absent in hindwings. The underside of wings is pale green with the discal spots fuscous, the pale distal area of wings more contrasting than above. *T. undilineata* and *T. occulta* share this wing pattern.

Male genitalia (Figures 2 A-E): The entire genital armature is very similar to that in *T. undilineata* (Figures 2 F-G) in overall build but differing in the short (0.1 mm) and relatively broad projection of the sacculus, in the harpe consisting of a single straight spine, pointing ventrally. The spines of the harpe are thinner, more numerous, and curved towards the apex of the valva in *T. occulta* (Figure 2H).

T. selini has the longest (>0.6 mm), sharp-tipped and the deepest (0.35-0.4 mm) split uncus while the uncus is shorter than 0.5 mm in *T. undilineata* and *T. occulta*, with rounded tips and shorter (<0.2 mm) medial incision. However, one dissected male from Ecuador has a shorter uncus combined with one thin rod-likea harpe.

Female genitalia: The bursa copulatrix is oblong, membranous, without a signum. The sterigma is bordered by a slightly sclerotized fold posteriorly only (2 slides studied). The sterigma is broad, rounded-triangular in *T. undilineata*, bordered anteriorly by wrinkled, sclerotized folds.

Etymology: The new species is named in honour of the collector, Mr. Allan Selin.

Remarks: *T. undilineata* (15 ♂♂, 2 ♀♀ from French Guiana and 1 ♂ from Ecuador for comparison, male genitalia (compared to the slide 12934 in the British Museum) differs from *T. selini*, sp. n. in the distal projection of the sacculus, which is slenderer, about 0.25 mm long in average, and in the harpe consisting of two to four (usually three) stout, tubular, horn-shaped, parallel-lying spines curved dorsal (Figures 2, F-G). The male antennal pectinations appear shorter (not exceeding 0.55 mm) in *T. selini*, if compared to those in *T. undilineata.* The third segment of palpus is short (0.2 mm in males, 0.32 mm in

females of *T. selini*). The male hind tibia has the proximal spurs reduced to tips visible at the base of distal spurs.

Tachyphyle occulta Warren, 1901 (Figures 2, H-I)

The species was described from Colombia a year after the publication of *T. undilineata*. Prout (1912) listed the both species, but later (PROUT, 1932-1938) synonymized the names. The facies of the both, *T. occulta* ana *T. undilineata* (and *T. selini* described above) is similar indeed. Dr. M. Scoble, Mr. M. Honey and Mr. G. Martin kindly put photos of the primary type of *T. occulta* at the author's disposal.

WARREN (1901: 451) characterized this species as follows. "Forewings: dull green, with scattered purplish striae; cell-spot large, purplish; first line represented by a purplish streak at costa and a spot on median and submedian veins respectively; outer line obsolete, except towards inner margin, where it is marked by a spot on the submedian; a purplish streak at apex… Hindwings: with reddish cell-spot, and faintly marked reddish central line which is slightly bent in below the median vein. Underside yellow-green, with all the margins whitish, except costal margin of forewing, which remains greenish yellow; cell-spots red-brown. Collar, thorax and abdomen yellow-green; vertex, face and palpi white; these last with a slight ochreous flush. Expanse of wings: 31 mm."

The original description is to be supplemented as follows: Facies like in related species *T. undilineata* and *T. selini*. The difference in the forewing pattern, the antemedial band outcurved and the postmedial band incurved in the anal fold, seems inconstant.

Male genitalia (Figures 2, H-I) The uncus is bifid in its distal half; the sacculus is not protruding distally but smoothly fused to the valvula (projecting free in two allied species); the harpe is more complex, consisting of 7-12 thin spines in a row, pointing to the ventral margin of the valva (1-4 tubular thorns in a row, pointing to the costal margin of a valva in *T. selini* and *T. undilineata*); the saccus is projecting knob-shaped (rounded in related species).

Genitalically different from allied species *T. undilineata* and *T. selini*, *T. occulta* is restored from synonymy with *T. undilineata*.

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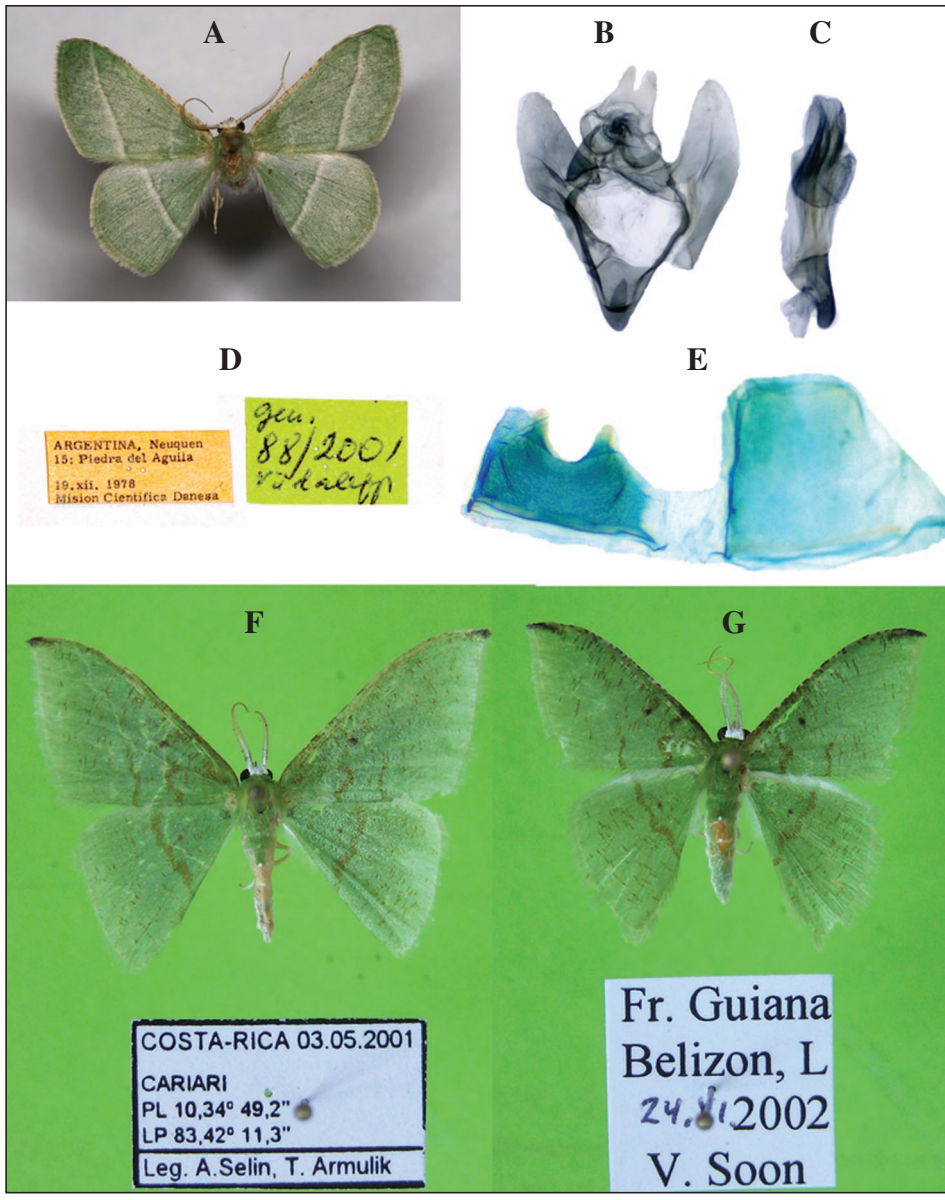
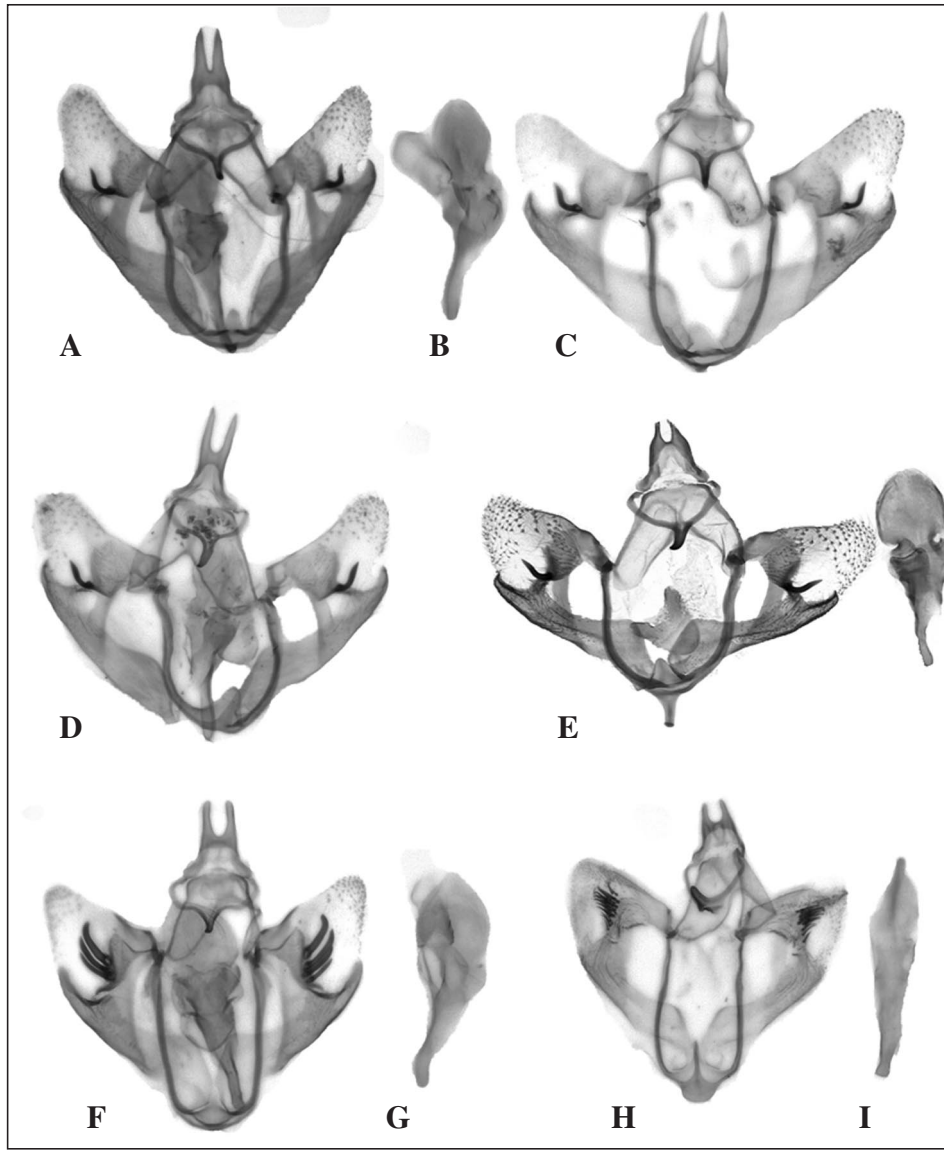


Figures 1 A-G.– A. Adult of *Tachyphyle nielseni* Lindt & Viidalepp, sp. n. (male, paratype). **B**. Male genitalia of *T. nielseni* Lindt & Viidalepp, sp. n. (paratype). **C**. Aedeagus of *T. nielseni* Lindt & Viidalepp, sp. n. (paratype). **D**. Labels of the paratype of *T. nielseni*. **E**. Last abdominal sternite and tergite of male *T. nielseni* Lindt & Viidalepp, sp. n. (paratype). **F**. Adult of *Tachyphyle selini* Lindt & Viidalepp, sp. n. (male, holotype). **G**. Adult of *T. undilineata* Warren.



Figures 2 A-I.– A. Male genital armature of *Tachyphyle selini* Lindt & Viidalepp, sp. n. (paratype from Costa Rica) (aedeagus not ectracted). **B**. Aedeagus of *T. selini* Lindt & Viidalepp, sp. n. (paratype from Costa Rica). **C**. Male genital armature of *T. selini* Lindt & Viidalepp, sp. n. (paratype from Costa Rica). **D**. Male genital armature of *T. selini* Lindt & Viidalepp, sp. n. (paratype from Ecuador) (aedfeagus not extracted). **E**. Male genital armature of *T. selini* Lindt & Viidalepp, sp. n. (paratype from Ecuador) (with aedeagus extracted). **F**. Male genital armature of *Tachyphyle undilineata* Warren (from French Guiana) (aedeagus not extracted). **G**. Aedeagus of T. undilineata Warren from Ecuador. H. Male genital armature of *T. occulta* Warren (from Nicaragua). **I**. Aedeagus of *T. occulta* Warren (from Nicaragua).