June 2024

VOL. 34 NO. 1

TROPICAL LEPIDOPTERA Research

TROPICAL LEPIDOPTERA RESEARCH

ASSOCIATION FOR TROPICAL LEPIDOPTERA
Founded 1989

VOLUME 34 NUMBER 1 **June 2024**

CONTENTS

Front Cover Photo - *Actinote pyrrhosticta* **n. sp.** (Nymphalidae), Ecuador, Loja, Jimbura-San Andrés road. Photo by Keith Willmott.
Back Cover Photo - *Erasmia pulchella* (Zygaenidae), India, Arunachal Pradesh, Upper Siang District. Photo by Sanjay Sondhi.

The Association for Tropical Lepidoptera, Inc. is a non profit organization for the support of research on the biology, systematics, and conservation of tropical and subtropical Lepidoptera of the world. Funding for the Association helps to support research projects, field studies, and publications on tropical and subtropical Lepidoptera. The Association for Tropical Lepidoptera, as organized in 1989 in Florida, is a tax exempt corporation under Section 501(c)3 of the IRS Code and is a publicly supported organization as defined in Sections 170(b)(1)(vi) and 509(a). Contributions are tax deductible.

TROPICAL LEPIDOPTERA RESEARCH (ISSN 1941-7659) is published semi-annually by the Association for Tropical Lepidoptera, Inc. Membership is open to all persons interested in Lepidoptera. Membership applications, dues, and other business should be sent to Association for Tropical Lepidoptera, P. O. Box 141210, Gainesville, FL 32614-1210, USA. Visit http://www.troplep.org for more information.

Send Manuscripts to: Dr. Keith R. Willmott, McGuire Center for Lepidoptera & Biodiversity, Florida Museum of Natural History, P. O. Box 112 710, University of Florida, Gainesville, FL 32611 kwillmott@flmnh.ufl.edu, fax: 352-392-0479, phone: 352-273-2012. Instructions to authors can be found at www.troplep.org.

Home Page: http://journals.fcla.edu/troplep; http://www.troplep.org June 2024

A new species and eight new subspecies of high elevation *Actinote* from Colombia, Ecuador and Peru (Nymphalidae, Heliconiinae, Acraeini)

Keith R. Willmott[1,2], Gerardo Lamas[3], Jason P. W. Hall[4], Pierre Boyer[5], Tomasz Pyrcz[6] and Klaudia Florczyk[7]

1. McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History, University of Florida, Gainesville, Florida, USA; kwillmott@flmnh.ufl.edu; 2. Instituto Nacional de Biodiversidad, Quito, Ecuador; 3. Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Lima, Perú; 4. Department of Entomology, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560-0127, USA; 5. Le Puy Sainte Réparade, France; 6. Department of Invertebrate Evolution, Institute of Zoology and Biomedical Research, Jagiellonian University, Gronostajowa 9, 30-387 Kraków, Poland; 7. Nature Education Centre, Jagiellonian University, Gronostajowa 5, 30-387 Kraków, Poland

Date of issue online: 27 October 2023
Zoobank Registered: urn:lsid:zoobank.org:pub:426852BA-EA23-4F2D-BBCD-25968FC91D69
Electronic copies (ISSN 2575-9256) in PDF format at: https://journals.flvc.org/troplep; https://zenodo.org; archived by the Institutional Repository at the University of Florida (IR@UF), http://ufdc.ufl.edu/ufir; **DOI**: 10.5281/zenodo.10027609.

Abstract: We describe one new species and eight new subspecies of high elevation *Actinote* Hübner, [1819] (Nymphalidae, Heliconiinae, Acraeini) from Colombia, Ecuador and Peru: *Actinote pyrrhosticta* Lamas, Willmott & Hall, **n. sp.**, *Actinote pyrrhosticta quintecocha* Lamas & Willmott, **n. ssp.**, *Actinote pyrrhosticta apurimac* Lamas & Willmott, **n. ssp.**, *Actinote pyrrhosticta alfamayo* Lamas & Willmott, **n. ssp.**, *Actinote eresia albesia* Lamas & Willmott, **n. ssp.**, *Actinote eresia canyaris* Pyrcz & Lamas, **n. ssp.**, *Actinote hilaris arcoiris* Willmott & Hall, **n. ssp.**, *Actinote hilaris sourakovi* Willmott & Lamas, **n. ssp.**, and *Actinote trinacria alegria* Boyer & Willmott, **n. ssp.** We treat *Actinote binghamae* Dyar, 1913 as a new synonym of *Actinote eresia eresina* (Hoffer, 1874) **n. syn.**, and treat *Altinote santamarta* Winhard, 2017 as a subspecies, *Actinote trinacria santamarta* **rev. stat.** We illustrate adult specimens of all described taxa of *A. pyrrhosticta* **n. sp.**, *A. eresia* (C. Felder & R. Felder, 1862) and *A. hilaris* Jordan, 1910, and representatives of *A. trinacria* (C. Felder & R. Felder, 1862). We also provide illustrations of male and female genitalia for select taxa, distribution maps, and a revised, annotated synonymic list for all four species.

Resumen: En este trabajo describimos una especie nueva y ocho nuevas subspecies altoandinas de *Actinote* Hübner, [1819] (Nymphalidae, Heliconiinae, Acraeini) encontradas en Colombia, Ecuador y Perú: *Actinote pyrrhosticta* Lamas, Willmott & Hall, **n. sp.**, *Actinote pyrrhosticta quintecocha* Lamas & Willmott, **n. ssp.**, *Actinote pyrrhosticta apurimac* Lamas & Willmott, **n. ssp.**, *Actinote pyrrhosticta alfamayo* Lamas & Willmott, **n. ssp.**, *Actinote eresia albesia* Lamas & Willmott, **n. ssp.**, *Actinote eresia canyaris* Pyrcz & Lamas, **n. ssp.**, *Actinote hilaris arcoiris* Willmott & Hall, **n. ssp.**, *Actinote hilaris sourakovi* Willmott & Lamas, **n. ssp.**, y *Actinote trinacria alegria* Boyer & Willmott, **n. ssp.** Consideramos a *Actinote binghamae* Dyar, 1913 como un nuevo sinónimo de *Actinote eresia eresina* (Hoffer, 1874) **n. syn.**, y a *Altinote santamarta* Winhard, 2017 como una subespecie, *Actinote trinacria santamarta* **rev. stat.** Ademas, ilustramos especímenes adultos de todos los taxa descritos de *A. pyrrhosticta* **n. sp.**, *A. eresia* (C. Felder & R. Felder, 1862) y *A. hilaris* Jordan, 1910, y algunos representantes de *A. trinacria* (C. Felder & R. Felder, 1862). También presentamos ilustraciones de las genitalias masculinas y femeninas de algunos taxones seleccionados, junto con mapas de distribución, y una lista de sinonimos revisada para las cuatro especies.

Key words: Andes; COI barcode; morphology; taxonomy.

INTRODUCTION

The Neotropical Acraeini comprises over 50 described species and a half-dozen or more known, undescribed species (Lamas, 2004; Francini *et al*., 2004; Paluch *et al*., 2006; Neild, 2008; Willmott *et al*., 2009; Winhard, 2017; Willmott *et al.*, 2017; Freitas *et al*., 2018). The generic classification of these butterflies has remained remarkably unstable in recent decades, with Pierre (1987) placing all Neotropical species within the pantropical genus *Acraea* Fabricius, 1807, and Lamas (2004) recognizing three genera for these species, *Actinote* Hübner, [1819], *Altinote* Potts, 1943, and *Abananote* Potts, 1943. Silva-Brandão *et al*. (2008) showed that neither *Altinote* nor *Abananote* was monophyletic and suggested treating all Neotropical species within a single genus, *Actinote,* a decision followed by Willmott *et al*. (2017) and Carvalho *et al.* (2021; albeit as a subgenus of *Acraea*), and formalized by Zhang *et al*. (2021) with the synonymy of Potts's generic names and recognition of *Actinote* as the sole genus of American Acraeini (see also Williams & Henning, 2023).

Actinote are relatively large, conspicuous, colorful and slow-flying butterflies, distributed throughout the Neotropics, mostly in forest habitats, from sea level to 4050 m. Although several species are very common, a number are very rare, and new species continue to be described from the two centers of diversity for the genus, the Atlantic forest (e.g., Francini *et al.*, 2004; Freitas *et al*., 2018) and the Andes (e.g., Neild, 2008; Willmott *et al*., 2009; Winhard, 2017; Willmott *et al.*, 2017). The uppermost forests of the Andes, in particular, contain several species that are poorly represented in most collections, with a number of distinctive populations scattered throughout this tropical montane region. To contribute to ongoing faunistic studies in the Andes, we here describe a new species and eight new subspecies of high Andean *Actinote*.

MATERIALS AND METHODS

Actinote specimens and information on distribution and natural history were collected by the authors and colleagues throughout Ecuador and Peru, and in numerous collections, over many years. Morphological and molecular methods follow Willmott *et al.* (2017), and are described only briefly here. The following collection acronyms are used: AWLW: Allan & Lesley Wolhuter collection, United Kingdom; CAS: California Academy of Sciences, San Francisco, USA; HAWA: Haydon Warren-Gash collection, Pressac, France; INABIO: Instituto Nacional de Biodiversidad, Quito, Ecuador; JEPE: Jean-Claude Petit collection, Ducy, France; MGCL: McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History, Gainesville, USA; MUSM: Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Lima, Peru; CEPUJ: Nature Education Centre, Jagiellonian University (formerly Zoological Museum, MZUJ); NHMUK: Natural History Museum, London, UK; PIBO: Pierre Boyer collection, Le Puy Sainte Réparade, France; RCCP: Research Collection of Carlos Prieto, Cali, Colombia; USNM: National Museum of Natural History, Smithsonian Institution, Washington, DC, USA.

Adult abdomens were soaked in hot 10% KOH for 10-15 minutes, dissected and subsequently stored in glycerine. Body morphology and dissections were studied using a binocular microscope at up to 100x magnification. The terminology for male genitalic and abdominal structures follows Scoble (1992), and nomenclature for venation follows Comstock & Needham (1898). We use the abbreviations DFW, VFW, DHW and VHW for dorsal and ventral forewing and hindwing, and HT and LT for Holotype and Lectotype, respectively.

For most specimens, genomic DNA was extracted from legs removed from *Actinote* specimens using Qiagen's DNeasy Blood & Tissue Kit following the manufacturer's protocol, incubating samples overnight (24 h) and using a final elution volume of 50 ul. We amplified the first half of the mitochondrial gene cytochrome oxidase I (COI), also known as the barcode region for animals (Hebert *et al.,* 2003), using primers and methods described by Willmott *et al*. (2017). Single strands of the PCR products were sequenced by the University of Florida's Interdisciplinary Center for Biotechnology Research Sanger Sequencing Group or by Eurofins Genomics, using the same primers as in the PCR. Two new sequences were obtained using methods described by Kawahara *et al*. (2023).

Where necessary, fragments were assembled into composite sequences and all 18 new sequences were aligned using BioEdit v. 7.1.3 (Hall, 1999), with 26 additional sequences obtained from GenBank (Appendix 1). The final aligned sequences were of length 633 bp, and new sequences are deposited in GenBank (Appendix 1). To examine relationships among taxa we conducted a phylogenetic analysis using the Maximum Likelihood (ML) method in MEGA11 (Tamura *et al.,* 2021). The best substitution model (lowest Bayesian Information Criterion score) was TN93+G+I, and this model was used in the ML search with 100 bootstrap replicates to estimate branch support. The tree was rooted with a sequence from *Telchinia issoria* (Hübner, [1819]), a member of the clade sister to *Actinote* (Carvalho *et al.,* 2021). We also calculated mean within-group and between-group genetic divergence using MEGA11, with partial deletion of missing data with 90% cut-off, p-distance as the substitution model, and other default options.

RESULTS AND DISCUSSION

DNA barcodes and relationships among *Actinote* taxa

The ML analysis of COI barcode sequences (Fig. 1) recovered three main clades as in Carvalho *et al.* (2021), with strong support (100% bootstrap) for a clade containing *A. pyrrhosticta* **n. sp.**, *A. eresia* (C. Felder & R. Felder, 1862) and *A. hilaris* Jordan, 1910, and with weak support (57% bootstrap) for *A. pyrrhosticta* being sister to the other two species. Although the relationships among the three main clades differ from those in Carvalho *et al.* (2021), in which *A. eresia*+*A. hilaris* were placed as sister to all other *Actinote*, this discrepancy likely reflects the lack of nuclear gene data in our analysis that would be needed to confidently resolve deeper nodes. In terms of species relationships, in our analysis *Actinote eresia canyaris* **n. ssp.** formed a strongly supported clade with *A. eresia eresia* and *A. eresia leptogramma* Jordan, 1913 (92% booststrap), and *A. hilaris arcoiris* **n. ssp.** and *A. hilaris sourakovi* **n. ssp.** formed a strongly supported clade with *A. hilaris desmiala* Jordan, 1913 (99% bootstrap; the nominate subspecies of *A. hilaris* was not sampled). *Actinote eresia eresina* (Hopffer, 1874) did not form a clade with other *A. eresia*, but instead was moderately well supported as sister to *A. hilaris*, a result discussed below in the annotated checklist.

Taxonomy

Actinote pyrrhosticta Lamas, Willmott & Hall, **new species**

Figs. 2A-C, 6A,D-H, 9A, 10A-D, 11A,B

Diagnosis and identification: Analysis of multiple nuclear and mitochondrial gene sequences showed that *A. eresia* and *A. hilaris* form a clade that is sister to all other Neotropical Acraeini (Carvalho *et al*., 2021; Chazot *et al*., 2021). Our analysis of COI sequence data shows that *A. pyrrhosticta* **n. sp.** is also a member of this clade, and sister to these two species (Fig. 1). These three species share a distinctive VHW pattern, with a thin, only slightly kinked brown discal line bordered distally by a pale postdiscal band (Figs. 2-5). The definition of the discal line and the expression of the pale postdiscal band are rather variable,

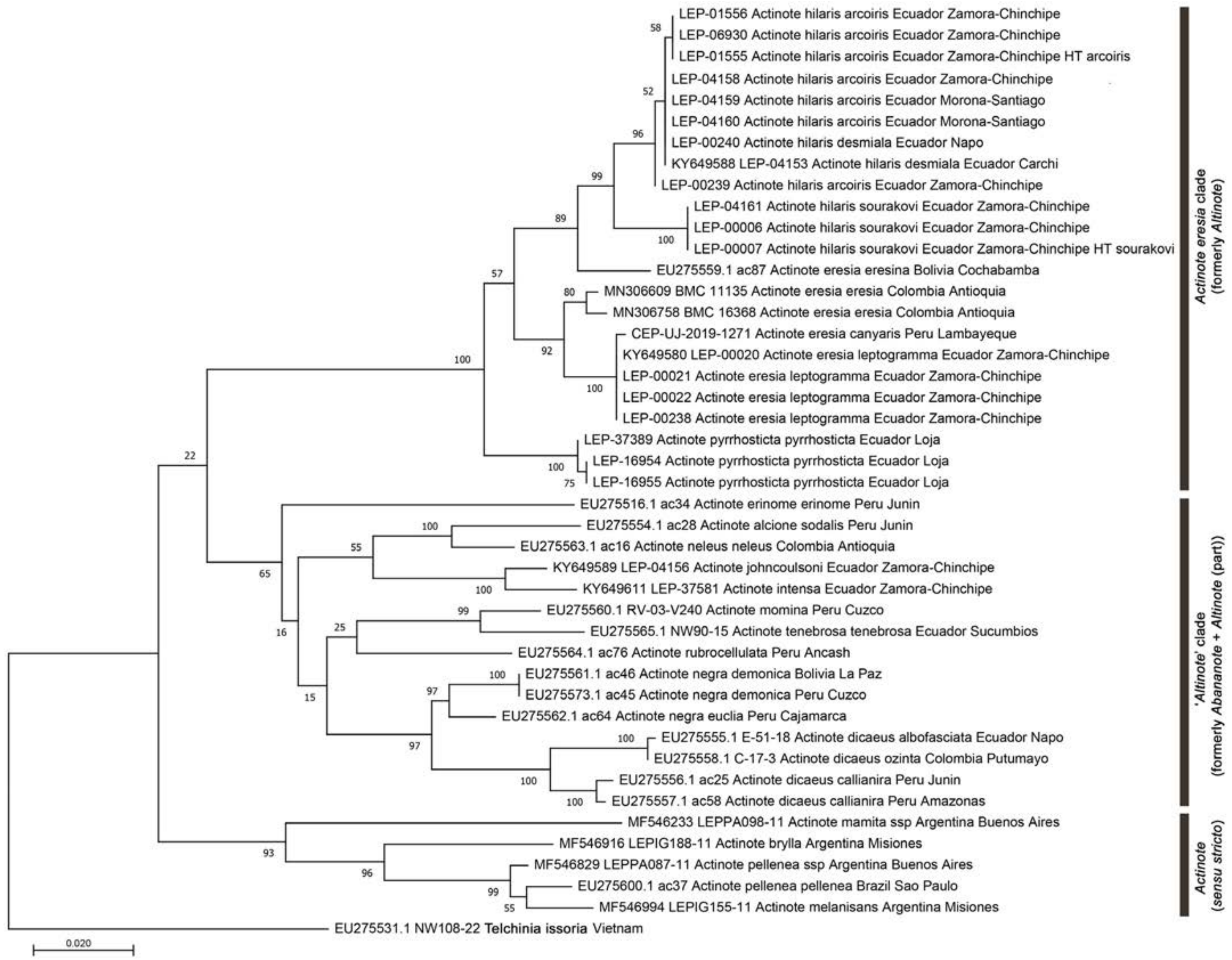


Figure 1. Maximum-Likelihood tree for the *Actinote eresia* clade and exemplar species of *Actinote* based on 663 bp of COI (barcode region). Numbers by nodes indicate bootstrap support based on 100 replicates. Black vertical bars at right indicate the three main clades of *Actinote* referred to in the text.

but together they nevertheless enable ready recognition of almost all specimens of these three species, in comparison with all other Neotropical Acraeini. Perhaps the most superficially similar species are *A. rubrocellulata* Hayward, 1960 (central Peru) and *A. mamita* (Burmeister, 1861) (Atlantic forest), but the former lacks the brown VHW discal line and pale postdiscal band, while the latter has a brown VHW discal line but it is more strongly kinked, as in other *Actinote sensu* Lamas (2004), and lacks the pale postdiscal band. Both *A. rubrocellulata* and *A. mamita* were included in recent molecular phylogenetic studies (Carvalho *et al*., 2021) and were not recovered as being closely related to the *A. eresia* clade.

Actinote pyrrhosticta **n. sp.** can be consistently distinguished from *A. eresia* by the following characters: **1)** The black 'S'-shaped discocellular bar on the FW extends as a continuous line through the base of vein Cu_2 to the anal margin; in *A. eresia*, the line is more distally placed in the discal cell, and the black marking in cell 2A-Cu_2 is reduced to a small spot or absent, not meeting the discocellular line (Figs. 2-4). **2)** The black postdiscal line in VFW cell Cu_2-Cu_1 in *A. pyrrhosticta* is placed directly in a line with that in cell Cu_1-M_3, while in *A. eresia* it is displaced distally or absent; overall, the curving black postdiscal line on the VFW of *A. pyrrhosticta* is more basally positioned than it is in *A. eresia* (Figs. 2-4). **3)** The distinct block of pale scaling in *A. pyrrhosticta* at the base of the VHW in cell Rs-Sc+R_1 contrasts with the darker coloring of the anterior half of the discal cell; in *A. eresia*, the anterior half of the discal cell is similarly pale-colored. In *A. hilaris*, the black FW postdiscal line and cell-end bar are fused, forming a broad black band in the middle of the wing (Figs. 2-5). **4)** A series of orange dorsolateral spots is present along the abdomen in *A. pyrrhosticta* (a single lateral spot in the middle of each tergite, e.g. Figs. 2J, 11A,F,H,I), which is absent or, at most, barely visible in only some tergites (e.g., *A. e. eresia*) in the two related species (e.g., Fig. 11J,L). **5)** The sphragis of *A. pyrrhosticta* barely protrudes beyond the ventral edge of the abdomen (Fig. 2J), in contrast to the protruding sphragis of *A. eresia* (Fig. 2K) and *A. hilaris* (Fig. 2L). The tapering male genitalic valva of *A.*

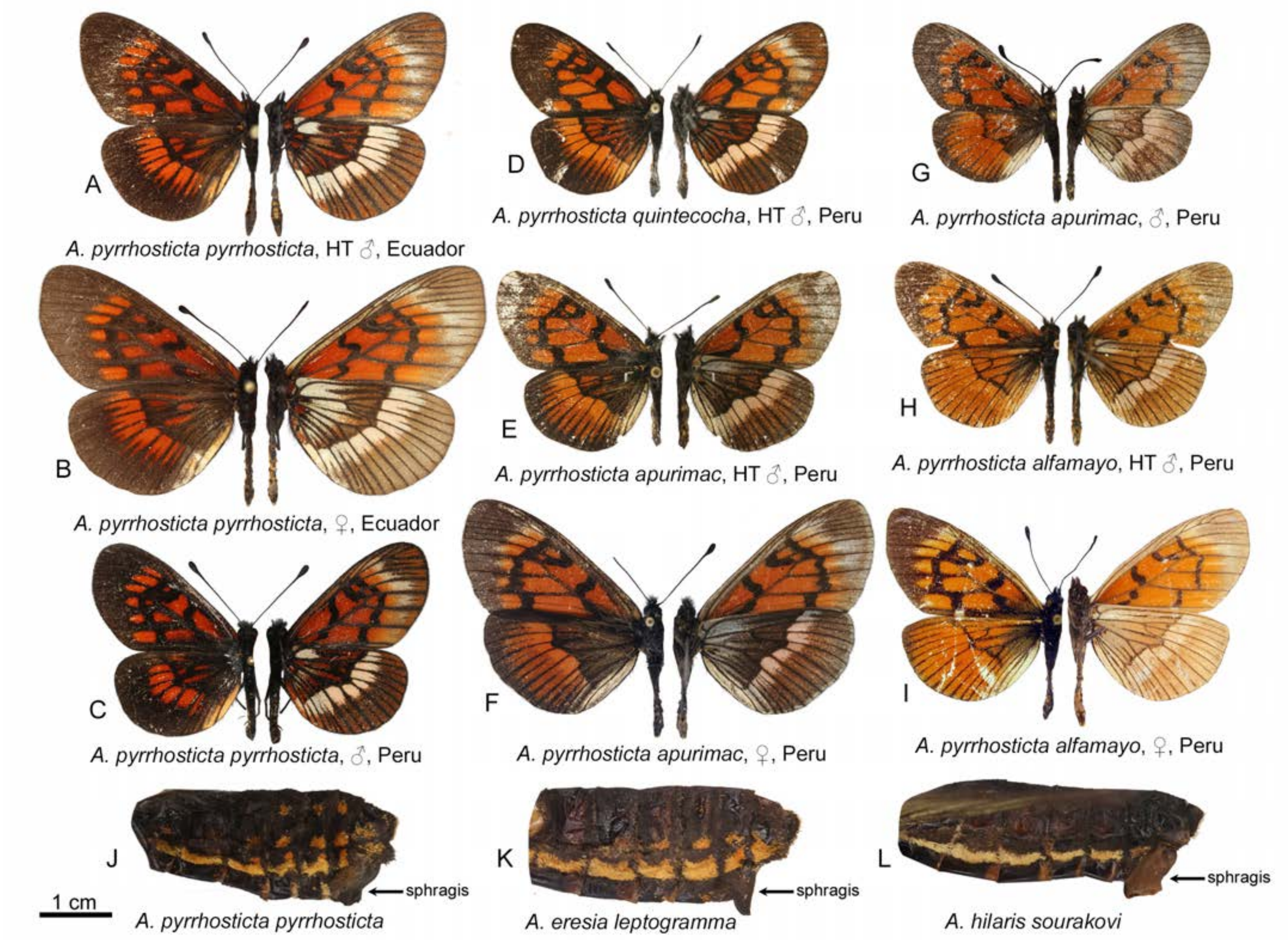


Figure 2. *Actinote* specimens (A-F), left half dorsal surface, right half ventral surface. **A)** *A. pyrrhosticta* **n. sp., HT** ♂, Ecuador, Loja, km 13.2 Jimbura-San Andrés rd. (FLMNH-MGCL-209919); **B)** *A. pyrrhosticta* **n. sp.**, ♀, Ecuador, Loja, km 13.2 Jimbura-San Andrés rd. (FLMNH-MGCL-209929); **C)** *A. pyrrhosticta* **n. sp.**, ♂, Peru, Cajamarca, N El Pargo (MZUJ); **D)** *A. pyrrhosticta quintecocha* **n. ssp., HT** ♂, Peru, Amazonas, Quintecocha (MUSM-ENT-007883); **E)** *A. pyrrhosticta apurimac* **n. ssp., HT** ♂, Peru, Apurímac, Laguna Angascocha (MUSM-ENT-007885); **F)** *A. pyrrhosticta apurimac* **n. ssp.**, ♀, Peru, Apurímac, Laguna Uspacocha (MUSM); **G)** *A. pyrrhosticta apurimac* **n. ssp.**, ♂, Peru, Apurímac, vía Huanipaca km 8 (MZUJ); **H)** *A. pyrrhosticta alfamayo* **n. ssp., HT** ♂, Peru, Cuzco, Río Santa María (MUSM-ENT-007887); **I)** *A. pyrrhosticta alfamayo* **n. ssp.**, ♀, Peru, Cuzco, 'Kiteni', (PIBO). *Actinote* ♀ abdomen, lateral view (J-L). **J)** *A. pyrrhosticta pyrrhosticta* (FLMNH-MGCL-109926); **K)** *A. eresia leptogramma* (FLMNH-MGCL-119804); **L)** *A. hilaris sourakovi* (FLMNH-MGCL-145578).

pyrrhosticta (Fig. 6A-C) is distinct from the broader, blunter valva of *A. eresia leptogramma* (Fig. 7B), but similar to that of *A. eresia eresina* (Fig. 7C) and *A. hilaris* (Fig. 7E,F). Other characters distinguishing subspecies of *A. pyrrhosticta* from those of *A. eresia* occurring in the same region are discussed under the accounts of each taxon.

Description: MALE (Fig. 2A,C): Forewing length of HT 24.5 mm (23-25 mm, mean 23.9 mm, n=10). *Wings*: as illustrated. VHW with long, black hair-like scales ('bristles' of Jordan (1913) and Potts (1943)) along veins, including location of vestigial vein 1A (vein visible in distal fifth of wing). *Head*: eyes black, bare; antennae black with sparse black needle-like scales dorsally, 35 antennomeres with terminal 9 antennomeres comprising club; labial palpi with sparse, long, black, hair-like scales ventrally (much shorter, similar scales dorsally) on basal and middle segment, sparse black scales laterally on middle and terminal segment; top of head black, frons with sparse, long, black, hair-like scales, two tufts of orange hair-like scales dorsolaterally on patagia. *Thorax*: black with sparse, long black and brown hair-like scales, except ventrally with lateral orange spot on meso- and metathorax approximately in region of epimeron and katepisternum, forelegs, mid- and hindlegs black. *Abdomen*: dorsal surface black except for orange spot in middle of each tergite laterally, ventral surface black except for spots of orange scaling in middle of each sternite in anterior half, laterally with line of orange scaling dorsal of sternites and orange dashes ventral of tergites. *Genitalia* (Fig. 6A): as illustrated, notable features include broad-based, upwardly tapering valva with indented basal edge, and relatively broad aedeagus. Juxta is a rather elongate, approximately 'V'-shaped plate.

FEMALE: (Fig. 2B,J): Forewing length mean 28.1 mm (26.5-29.5 mm, n=7). *Wings*: similar to male except FW slightly broader. *Dorsal surface*: similar to male. *Ventral surface*: similar to male except whitish scaling in basal third of VHW more extensive, reaching posteriorly to vein 3A. *Head, thorax, abdomen*: similar to male in coloration. Out of six examined females, all possessed a sphragis, a curving, rectangular plate closely appressed to tip of abdomen, not protruding ventrally beyond terminal sternite (Fig. 2J). *Genitalia* (Fig. 6D-H): Notable features include strongly sclerotized eighth tergite with invaginated antero-ventral corner, lamella antevaginalis forming a roughly U-shaped, curving plate, with a separate, horseshoe-shaped lamella postvaginalis that protrudes postero-ventrally (Fig. 6E); ductus bursae very short, broad, merging into amorphous, small corpus bursae, similar in size to lamella antevaginalis plus lamella postvaginalis (Fig. 6F), ductus seminalis narrow; subpapillary glands similar in size to papillae anales (Fig. 6G,H).

Types: HOLOTYPE ♂: **ECUADOR**: *Loja*: nr. Amaluza, km 13.2 Jimbura-San Andrés rd., [4°42'32"S,79°26'47"W], 2970 m, (Willmott, K. R., J. I. R., J. C. R.), 12 Jun 2014, [FLMNH-MGCL-209919; LEP-37390; dissection, KW-15-164], (MGCL, to be deposited in INABIO).

PARATYPES (18 ♂, 13 ♀): **ECUADOR**: *Loja*: 'Cordillera Lagunillas, E Jimbura', 2600-3000 m, (Jasinski, A.), 14 May 1998, 1 ♂, (CEPUJ); 'Cordillera Lagunillas, E Jimbura', 3300 m, (Jasinski, A.), 1 ♂, (CEPUJ); nr. Amaluza, km 13.2 Jimbura-San Andrés rd., [4°42'32"S,79°26'47"W], 2900 m, (Willmott, K. R., J. I. R., J. C. R.), 12 Jun 2014, 1 ♂ [FLMNH-MGCL-209921], (MGCL); 'Nord de Laguna Negra, Jimbura-Zumba 3060m', [4°42'32"S,79°26'47"W], 3030 m, (Boyer, P.), 4-6 Aug 2017, 2 ♀, (PIBO), (Petit, J.-C.), 4-6 Aug 2017, 1 ♂, 1 ♀, (JEPE); nr. Amaluza, km 13.2 Jimbura-San Andrés rd., [4°42'32"S,79°26'47"W], (Willmott, K. R., J. I. R., J. C. R.), 12 Jun 2014, 1 ♂ [FLMNH-MGCL-195746], 1 ♂ [FLMNH-MGCL-209918], 1 ♂ [FLMNH-MGCL-209920], 1 ♂ [FLMNH-MGCL-209922], 1 ♂ [FLMNH-MGCL-209923], 1 ♂ [FLMNH-MGCL-209924], 1 ♂ [FLMNH-MGCL-209925], 1 ♀ [FLMNH-MGCL-195747], 1 ♀ [FLMNH-MGCL-209926], 1 ♀ [FLMNH-MGCL-209927], 1 ♀ [FLMNH-MGCL-209928], 1 ♀ [FLMNH-MGCL-209929], 1 ♀ [FLMNH-MGCL-209930], (MGCL), 4 ♂, 2 ♀, (INABIO), (Boyer, P.), 4 Aug 2017, 1 ♀, (PIBO). **PERU**: *Cajamarca*: Llama-'Uambos' [=Huambos], N 'Pargo' [=El Pargo], [6°27'20"S,79°4'2"W], 3000-3050 m, (Pyrcz, T. W.), 9 Jun 2018, 1 ♂, (CEPUJ); *Piura*: Ayabaca, Ramos, [4°42'S,79°28'W], 2900 m, (Zelada, W.), 2 Jun 2007, 1 ♂, (MUSM), 4 Jul 2007, 1 ♀ [dissection, MUSM-2010-11-26-06], (MUSM), 5 Jul 2007, 1 ♂ [dissection, MUSM-2010-11-26-05], (MUSM).

Etymology: The species name is derived from the Latinized Greek words *pyrrhos*, meaning flame-colored, and *stiktos*, meaning spotted, in reference to the coloration of the wings and orange dorsal abdominal spots that are distinctive for this species. The name is treated as a feminine adjective.

Taxonomy and variation: This species is geographically variable and four subspecies are recognized. These four taxa are grouped on the basis of the diagnostic wing and abdominal color pattern characters discussed above, in the absence of molecular data for all but the nominate subspecies, and the lack of clear morphological differences to separate *A. eresia* from *A. pyrrhosticta* **n. sp.** The three species in the *A. eresia* clade are broadly sympatric from southern Ecuador to southern Peru, but they appear typically to replace one another from lower to higher elevations in the order *A. hilaris*, *A. eresia*, and *A. pyrrhosticta*, and are rarely collected in microsympatry.

DNA sequence data would be useful to test the taxonomic hypothesis proposed here, given the large gap between the currently known locations of *A. pyrrhosticta* in southern Ecuador and northern Peru, and southern Peru (Fig. 9A).That gap seems most likely to represent a sampling artifact resulting from the rarity and restricted elevational range of this species. Mean sequence divergence within sampled *A. pyrrhosticta* was 0.1%, with mean divergence between *A. pyrrhosticta* and *A. eresia* being 3.6%, and between *A. pyrrhosticta* and *A. hilaris* being 4.5%.

No notable differences were observed between the genitalia of the male holotype from Ecuador and a dissected specimen from Peru (MUSM-2010-11-26-05).

Distribution and natural history: The nominate subspecies is known from the western slope of the Andes in extreme southern Ecuador, within a few km of the Peru border, to northwestern Peru (Cajamarca, Piura) (Fig. 9A). The taxon was first collected in Ecuador by A. Jasinski, during his pioneering trips to the Jimbura-San Andrés road (e.g., Jasinski, 1996, 1998a,b), but his two specimens, now in the CEPUJ, were labeled with imprecise data. We made a number of visits to the same road before finally observing the species flying along the edge of undisturbed forest from 2900-3030 m on the west Andean slope. On 12 June, 2014, both sexes were observed in approximately equal numbers, flying in the vicinity of a small stream (Fig. 10A) on a sunny morning from 10:20-11:30. Individuals of both sexes were observed flying over the low forest canopy and repeatedly descending to 1-2 m above the ground, with males occasionally landing on the ground. A pair was observed *in copula* from 11:20 to 15:00, resting on the ground on rocks along the stream and road edge (Fig. 11A,B); additional males and females were observed to fly frequently down to within 0.5 m of the mating pair before flying off. In August 2017, PB observed this species at the same stream, in a short period of bright sun at 13:30. Several individuals were seen flying over the canopy, and two females were observed resting near water. The species was only seen during a few minutes with bright sun and was not abundant, and was neither observed subsequently, nor seen again during visits to the stream over a 4-5 day period.

The lack of previous observations coupled with the abundance of the species during our observations on 12 June 2014, when multiple individuals were visible at any one time, are consistent with a synchronous emergence of adults from gregarious immature stages along with a relatively short adult life span (see also notes under *A. pyrrhosticta apurimac* **n. ssp.**).

Actinote pyrrhosticta quintecocha Lamas & Willmott, **new subspecies**

Figs. 2D, 6B, 9A

Diagnosis and identification: This taxon differs from the nominate in having paler, less reddish orange dorsal markings, which are also expanded in each cell, with a notably thin black postdiscal line on the DHW (Fig. 2D). The DFW orange marking at the base of cell Cu_2-Cu_1 is broader and the similarly colored postdiscal markings in this cell and cell Cu_1-M_3 are reduced or absent.

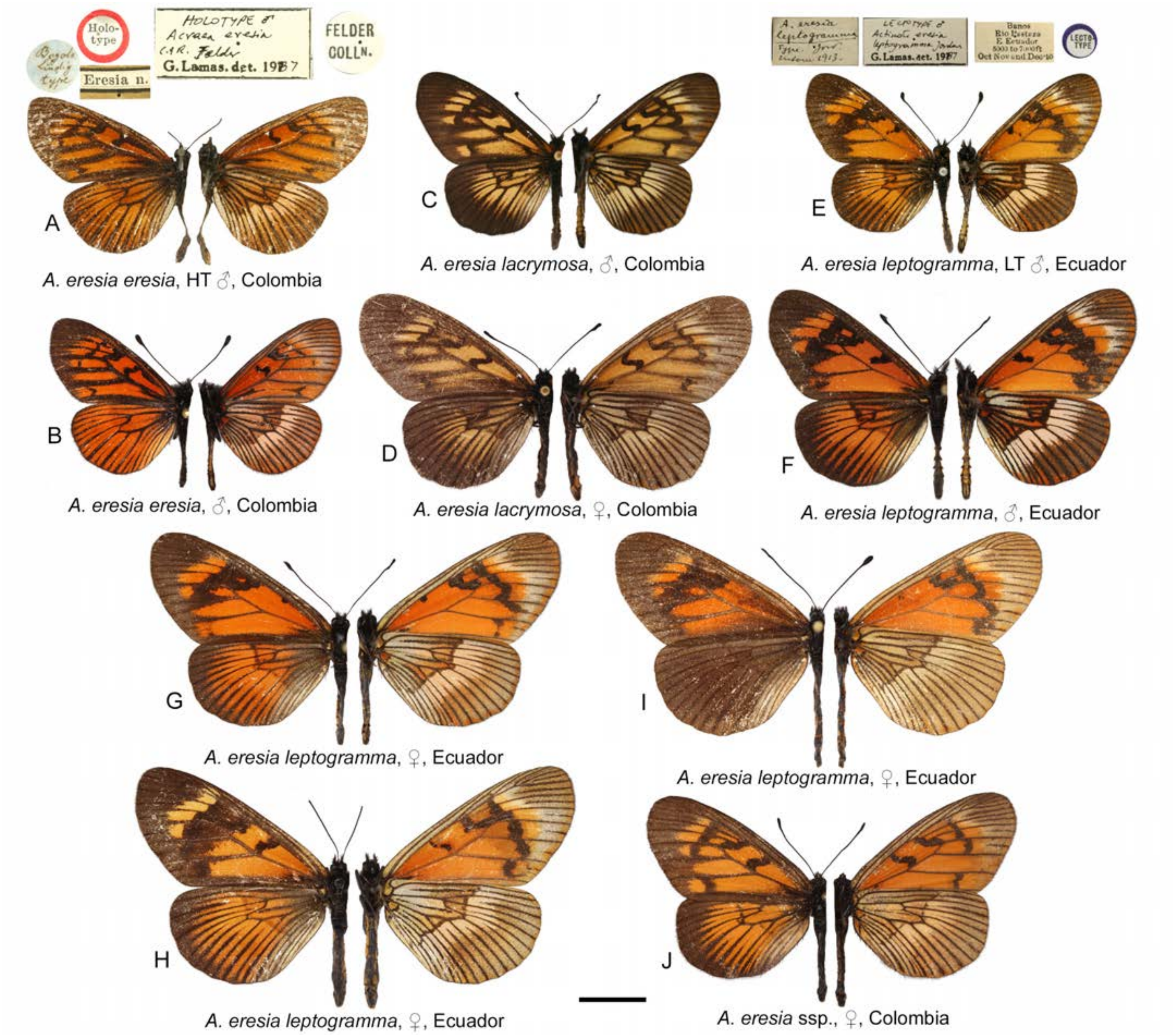
Description: MALE (Fig. 2D): Forewing length 21.0 mm (n=1). *Wings*: as illustrated. *Head, thorax, abdomen* as in nominate subspecies. *Genitalia* (Fig. 6B): similar to nominate subspecies.

FEMALE: unknown.

Types: HOLOTYPE ♂: **PERU**: *Amazonas*: Quintecocha, [6°51'30"S,77°42'W], 3150 m, (Gallusser, S.), 20 Nov 2003, [MUSM-ENT-007883], (MUSM).

PARATYPES (3 ♂): **PERU**: *Amazonas*: Quintecocha, [6°51-52'S,77°42'W], 3150 m, (Gallusser, S.), 20 Nov 2003, 1 ♂ [MUSM-ENT-007884; dissection, MUSM-2010-11-26-07], (MUSM); same collection data, but 20 Sep 2004, 2 ♂, (MUSM).

Etymology: The name is derived from that of the type locality, and it is treated as a feminine noun in apposition.



A. eresia eresia, HT ♂, Colombia

A. eresia lacrymosa, ♂, Colombia

A. eresia leptogramma, LT ♂, Ecuador

A. eresia eresia, ♂, Colombia

A. eresia lacrymosa, ♀, Colombia

A. eresia leptogramma, ♂, Ecuador

A. eresia leptogramma, ♀, Ecuador

A. eresia leptogramma, ♀, Ecuador

A. eresia leptogramma, ♀, Ecuador

A. eresia ssp., ♀, Colombia

Figure 3. *Actinote eresia* specimens, left half dorsal surface, right half ventral surface. **A)** *A. eresia eresia*, **HT** ♂, Colombia, 'Bogotá' (NHMUK); **B)** *A. eresia eresia*, ♂, Colombia, Cundinamarca, La Floresta (CEPUJ); **C)** *A. eresia lacrymosa*, ♂, Colombia, Caldas, Manizales (MUSM); **D)** *A. eresia lacrymosa*, ♀, Colombia, Caldas, Manizales (MUSM); **E)** *A. eresia leptogramma*, **LT** ♂, Ecuador, Tungurahua, Baños (NHMUK); **F)** *A. eresia leptogramma*, ♂, Ecuador, Zamora-Chinchipe, Quebrada Navidades (FLMNH-MGCL-113370); **G)** *A. eresia leptogramma*, ♀, Ecuador, Zamora-Chinchipe, Quebrada Navidades (FLMNH-MGCL-113360); **H)** *A. eresia leptogramma*, ♀, Ecuador, Zamora-Chinchipe, Casa Simpson (JR-07-2A); **I)** *A. eresia leptogramma*, ♀, Ecuador, Zamora-Chinchipe, Quebrada Navidades (FLMNH-MGCL-113359); **J)** *A. eresia* ssp., ♀, Colombia, Cauca, Tambito (CEPUJ).

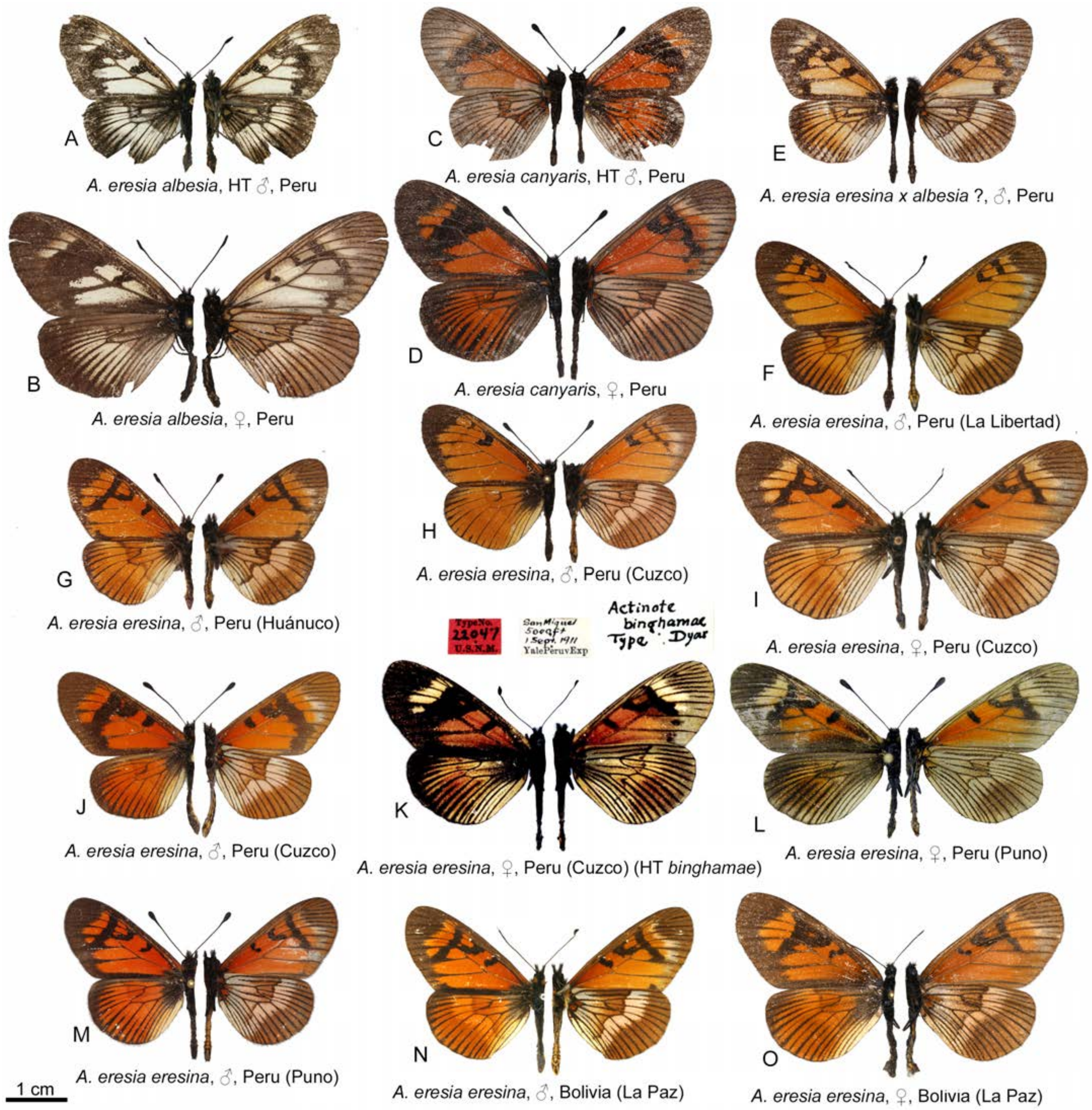
Taxonomy and variation: Characters supporting recognition of this taxon as conspecific with *A. p. pyrrhosticta* **n. sp.** are discussed under the description of the nominate subspecies. It was not possible to assess variation in this subspecies since only four specimens are known. Nevertheless, the stability of the diagnostic characters of the nominate subspecies in the relatively large series examined, from multiple sites, supports recognition of *A. p. quintecocha* **n. ssp.** as a distinct taxon.

Distribution and natural history: This subspecies is known only from four specimens collected at the type locality at 3150 m in the Department of Amazonas in northern Peru (Fig. 9A).

Actinote pyrrhosticta apurimac Lamas & Willmott, **new subspecies**

Figs. 2E-G, 6C, 9A, 11C-H

Diagnosis and identification: This subspecies is distinguished from *A. p. quintecocha* **n. ssp.** by having broader dorsal orange markings on both wings, with postdiscal spots present in cells Cu$_2$-M$_3$ on the FW, and a much broader postdiscal band on the DHW, extending almost to the distal margin near the tornus (Fig. 2E-G). Conversely, the orange markings basal of the thin, dark postdiscal line on the DHW are reduced in the discal cell and anal margin area, with this area of the wing mostly dark



A. eresia albesia, HT ♂, Peru

A. eresia canyaris, HT ♂, Peru

A. eresia eresina x albesia ?, ♂, Peru

A. eresia albesia, ♀, Peru

A. eresia canyaris, ♀, Peru

A. eresia eresina, ♂, Peru (La Libertad)

A. eresia eresina, ♂, Peru (Cuzco)

A. eresia eresina, ♂, Peru (Huánuco)

A. eresia eresina, ♀, Peru (Cuzco)

A. eresia eresina, ♂, Peru (Cuzco)

A. eresia eresina, ♀, Peru (Cuzco) (HT *binghamae*)

A. eresia eresina, ♀, Peru (Puno)

A. eresia eresina, ♂, Peru (Puno)

A. eresia eresina, ♂, Bolivia (La Paz)

A. eresia eresina, ♀, Bolivia (La Paz)

Figure 4. *Actinote eresia* specimens, left half dorsal surface, right half ventral surface (reverse for C). **A)** *A. eresia albesia* **n. ssp.**, **HT** ♂, Peru, Amazonas, Quebrada Chido (MUSM); **B)** *A. eresia albesia* **n. ssp.**, ♀, no data (CEPUJ); **C)** *A. eresia canyaris* **n. ssp.**, **HT** ♂, Peru, Lambayeque, vía 'Kañaris' (CEPUJ); **D)** *A. eresia canyaris* **n. ssp.**, ♀, Peru, Lambayeque, vía 'Kañaris' (CEPUJ); **E)** *A. eresia eresina,* transitional to *albesia* **n. ssp.**?, ♂, Peru, Amazonas, Molinopampa (CEPUJ); **F)** *A. eresia eresina*, ♂, Peru, La Libertad, Tayabamba-Ongón (MUSM-ENT-07483); **G)** *A. eresia eresina*, ♂, Peru, Huánuco, Diez Canseco (MUSM-ENT-07489); **H)** *A. eresia eresina*, ♂, Peru, Cuzco, Quebrada Toccohuayco-Pillahuata (CEPUJ); **I)** *A. eresia eresina*, ♀, Peru, Cuzco, San Pedro (MUSM-ENT-07526); **J)** *A. eresia eresina*, ♂, Peru, Cuzco, Abra Malaga-Santa María (Quillabamba road) (PIBO); **K)** *A. eresia eresina*, ♀, Peru, Cuzco, San Miguel (USNM; **HT** of *binghamae*); **L)** *A. eresia eresina*, ♀, Peru, Puno, Río Jerusalén, Río Sina (PIBO; left-right wings reversed for easier comparison); **M)** *A. eresia eresina*, ♂, Peru, Puno, 3 km E Sina (PIBO); **N)** *A. eresia eresina*, ♂, Bolivia, La Paz, Coroico (NHMUK); **O)** *A. eresia eresina*, ♀, Bolivia, La Paz, Unduavi (CEPUJ).

brown (instead of orange). The paler orange color of the dorsal markings, broad DHW postdiscal band, and reduced orange in the basal half of the DHW, are the most obvious characters distinguishing this taxon from the nominate subspecies.

Description: MALE (Fig. 2E,G): Forewing length 23.1 mm (n=1). *Wings*: as illustrated. *Head, thorax, abdomen*: as in nominate subspecies. *Genitalia* (Fig. 6C): similar to nominate subspecies.

FEMALE: (Fig. 2F): Forewing length 28.4 mm (n=1). *Wings*: as illustrated, differing from male most notably in having broader white scaling in basal third of VHW, as in other subspecies. *Head, thorax, abdomen*: similar to male. *Genitalia*: not examined.

Types: HOLOTYPE ♂: **PERU**: *Apurímac*: S[antuario]. N[acional]. Ampay, Laguna Angascocha, [13°35'S,72°53'W], 3200 m, (Curo, J. L.), 21 Jul 2001, [MUSM-ENT-007885], (MUSM).

PARATYPES (9 ♂, 2 ♀): **PERU**: *Apurímac*: S[antuario]. N[acional]. Ampay, vía Huanipaca km 8, [13°32'12"S,72°51'56"W], '3800' m, (Pyrcz, T. W.), 7 Sep 2008, 1 ♂, (CEPUJ), 3950 m, (Boyer, P.), 7 Sep 2008, 5 ♂, (PIBO); S[antuario]. N[acional]. Ampay, Laguna Angascocha, [13°35'S,72°53'W], 3200 m, (Curo, J. L.), 21 Jul 2001, 1 ♂ [MUSM-ENT-007886; dissection, MUSM-2010-11-26-08], (MUSM); S[antuario]. N[acional]. Ampay, Explana[da], 3600 m, (Curo, J., Mayorga, R., Samanez, O., Astete, C.), 25 Jul 2007, 1 ♂, (MUSM); S[antuario]. N[acional]. Ampay, Laguna Uspacocha, [13°34'38"S,72°53'10"W], 3750 m, (Curo, J., Mayorga, R., Samanez, O., Astete, C.), 25 Jul 2007, 1 ♂, 1 ♀, (MUSM); S[antuario]. N[acional]. Ampay, 3350 m, (Baiker, J.), 19 Apr 2009, 1 ♀, (MUSM).

Other records (photographs of live specimens): **Peru**: *Cuzco*: above Mollepata, [13°24'53"S,72°34'7"W], 3600 m, (Geale, D.), 20 Jul 2021, 1 ♀, (https://www.inaturalist.org/observations/97049333), 1 ♀, (https://www.inaturalist.org/observations/97049334), 1 ♂, (https://www.inaturalist.org/observations/97049336), 1 ♂, (https://www.inaturalist.org/observations/97049339), 1 ♂, (https://www.inaturalist.org/observations/97049345), 27 Jun 2013, 1 ♂, (https://www.inaturalist.org/observations/97049346); Soraypampa, [13°24'4"S,72°34'22"W], 3850 m, (Galiano, W.), 25 Jul 2010, 1 ♂, (Galiano, W. (17 Nov 2011, pers. comm. to KRW, with photo)).

Etymology: The name is derived from that of the type locality, and it is treated as a masculine noun in apposition.

Taxonomy and variation: Characters supporting recognition of this taxon as conspecific with *A. p. pyrrhosticta* **n. sp.** are discussed under the description of the nominate subspecies. In comparison with the holotype from Apurímac, male specimens from Cuzco have slightly more extensive orange in the basal area of the DHW, with only a narrow black line separating that area from the broader orange in the remainder of the wing.

Distribution and natural history: This taxon is known from 3200-3950 m in southern Peru, in the headwaters of the Apurímac valley in the department of that name and adjacent Cuzco (Fig. 9A), where it occurs in the uppermost cloudforest, with records of adults from April to September. David Geale (see iNaturalist references above) photographed both sexes nectaring on two Asteraceae species (Fig. 11F-H), as well as a single moribund larva (Fig. 11C) and clusters of hundreds of pupae (Fig. 11D,E), assumed to be this species based on the abundance of adults, lack of other species, and a freshly emerged adult female (Fig. 11D). PB also observed males nectaring on Asteraceae along the Huanipaca road.

Actinote pyrrhosticta alfamayo Lamas & Willmott, new subspecies

Figs. 2H,I, 9A

Diagnosis and identification: This subspecies is distinguished from *A. p. apurimac* **n. ssp.** by the more extensive orange dorsal markings, including postdiscal markings on the FW in cells Cu_2-M_3 that are broader than the orange marking at the base of cell Cu_1-M_3, and orange covering almost the entire DHW, except for the veins in the basal half of the wing, a dark postdiscal line, and black intervenal stripes intruding from the distal margin (Fig. 2H,I).

Description: MALE (Fig. 2H): Forewing length 22.1 mm (n=1). *Wings*: as illustrated. *Head, thorax, abdomen*: as in nominate subspecies. *Genitalia*: somewhat intermediate between those of *A. pyrrhosticta quintecocha* **n. ssp.** (Fig. 6B) and *A. pyrrhosticta apurimac* **n. ssp.** (Fig. 6C), in other words not showing notable differences from either taxon.

FEMALE: (Fig. 2I): Forewing length 22 mm (n=1). *Wings*: as illustrated. *Head, thorax, abdomen*: similar to male. *Genitalia*: not examined.

Types: HOLOTYPE ♂: **PERU**: *Cuzco*: Río Santa María, 7-14 km E Alfamayo, [13°5'S,72°23'W], 2700-3000 m, (Lamas, G.), 6 Oct 1981, [MUSM-ENT-007887], (MUSM).

PARATYPES (1 ♂, 1 ♀): **PERU**: *Cuzco*: Río Santa María, 7-14 km E Alfamayo, [13°5'S,72°23'W], 2700-3000 m, (Lamas, G.), 6 Oct 1981, 1 ♂ [MUSM-ENT-007888; dissected], (MUSM); 'Kiteni', (Weiss, J.-C.), [19-22] Jul 1978, 1 ♀, (PIBO).

Etymology: The name is derived from that of the type locality, and it is treated as a masculine noun in apposition.

Taxonomy and variation: Characters supporting recognition of this taxon as conspecific with *A. p. pyrrhosticta* are discussed under the description of the nominate subspecies. Obviously it would be desirable to obtain additional material of this taxon and *A. pyrrhosticta apurimac*, to better assess geographic variation. Available data show these taxa to be allopatric and consistently different in the small series examined. To our knowledge, no specimens of *A. pyrrhosticta alfamayo* have been collected in the last 42 years, and thus we prefer to name this taxon now rather than wait in the hope that further material might become available for study.

Distribution and natural history: Label data for this taxon suggest that it occurs from 2700-3000 m, at lower elevations than the neighboring *A. p. apurimac* **n. ssp.**, in the upper headwaters of the Río Urubamba (Fig. 9A). The collector of the female specimen, Jean-Claude Weiss, reported to PB (pers. comm.) that he collected at Kiteni on 20-21 July 1978, and thus the specimen was most likely collected between Abra Málaga and Quillabamba on his way to or from Kiteni, the elevation of which (approximately 600 m) is clearly too low for this taxon.

Actinote eresia albesia Lamas & Willmott, new subspecies

Figs. 4A,B, 9B

Diagnosis and identification: This subspecies is distinguished from all other *A. eresia* subspecies by the typically orange wing areas instead being very pale whitish gray (Fig. 4A,B). In wing pattern, it is perhaps most similar to *A. e. leptogramma*, except for having slightly broader dark borders on the DHW.

Description: MALE (Fig. 4A): Forewing length 22.0 mm (n=1). *Wings*: as illustrated. *Head, thorax, abdomen*: similar to *A. pyrrhosticta* **n. sp.** except with tufts of hair-like scales dorso-laterally on patagia yellowish, lacking conspicuous orange subdorsal spots on abdomen, and with pale yellowish (instead of orange) spots ventrally on thorax. *Genitalia*: not examined.

FEMALE: (Fig. 4B): Forewing length 29.5 mm (n=1). *Wings*: as illustrated. *Head, thorax, abdomen*: similar to male. *Genitalia*: not examined.

Types: HOLOTYPE ♂: **PERU**: *Amazonas*: Quebrada ‘Chiro’ [=Chido], [ca. 5°49'S,78°02'W], 2300-2500 m, (Lamas, G.), 24 Aug 1998, (MUSM).

PARATYPES (8 ♂, 1 ♀): **PERU**: *Amazonas*: Alto Nieva, [ca. 5°40'S,77°47'W], 2000-2500 m, (local collector), Apr 2005, 2 ♂, (PIBO); Quebrada Chido, [5°50'S,78°00'W], 2300-2500 m, (Calderón, B.), Nov 1999, 1 ♂, (MUSM); San Lorenzo, [5°48'S,77°58'W], 2300 m, (Pintado, J.), Feb 2011, 1 ♂, (MUSM); Oso Perdido, [5°43'S,77°50'W], 2125 m, (Pintado, J.), Apr 2015, 2 ♂, (MUSM); Pomacochas, [5°49'S,77°58'W], 2200 m, (Pyrcz, T. W.), 17 Aug 1998, 2 ♂, (CEPUJ); **Country unknown**: *Not located*: no data, 1 ♀, (CEPUJ).

Etymology: The name is an amalgam of the feminine Latin adjective *alba*, meaning white, and the species name *eresia*, and it is treated as a feminine noun in apposition.

Taxonomy and variation: Characters supporting recognition of this taxon as conspecific with *A. eresia eresia* are discussed under the description of *A. pyrrhosticta* **n. sp.** A male specimen from Peru, Amazonas, Molinopampa, in the CEPUJ has a narrow black DHW border (as in *A. eresia eresina*) but washed-out orange markings, especially in FW cell 2A-Cu$_2$ (Fig. 4E), and perhaps represents a transitional phenotype between *A. e. albesia* **n. ssp.** and *A. eresia eresina*.

Distribution and natural history: This taxon is known only from northeastern Peru in Amazonas (Fig. 9B), where label data suggest it occurs from 2000-2500 m.

Actinote eresia canyaris Pyrcz & Lamas, **new subspecies**

Figs. 4C,D, 7A, 9B

Diagnosis and identification: This subspecies differs from *A. eresia leptogramma* by having darker dorsal orange markings, a broader black area separating the basal orange area of the DFW from the orange postdiscal band (resulting from loss of the orange postdiscal spots that are present in *A. e. leptogramma* in the basal part of cell Cu$_1$-M$_3$ and just distal of the discocellular veins), no dark spot in the middle of the FW discal cell orange area, a very indistinct dark discal line within the DHW orange area, and less contrasting ventral coloration (Fig. 4D,E).

Description: MALE (Fig. 4C): Forewing length 22.5 mm (n=1). *Wings*: as illustrated. *Head, thorax, abdomen*: as in *A. eresia albesia* except with dark orange scale tufts on patagia and ventral thorax spots orange. *Genitalia* (Fig. 7D): similar to nominate subspecies (Fig. 7A) except valva broader and blunter, as in *A. eresia leptogramma*.

FEMALE: (Fig. 4D): Forewing length 26.2 mm (n=1). *Wings*: as illustrated. *Head, thorax, abdomen*: similar to male. *Genitalia*: not examined.

Types: HOLOTYPE ♂: **PERU**: *Lambayeque*: Pucará, vía ‘Kañaris’ [=Cañaris], [6°3'43"S,79°15'8"W], 2700-2800 m, (Pyrcz, T. W.), 14 Jun 2018, [dissection, prep. genit. 1910, 15/12/2019 K. Florczyk], (CEPUJ, to be deposited in MUSM).

PARATYPES (1 ♀): **PERU**: *Lambayeque*: Pucará, vía ‘Kañaris’ [=Cañaris], [6°3'43"S,79°15'8"W], 2700-2800 m, (Pyrcz, T. W.), 14 Jun 2018, 1 ♀, (CEPUJ).

Etymology: The subspecies name is derived from that of the type locality and is treated as a feminine noun in apposition.

Taxonomy and variation: Characters supporting recognition of this taxon as conspecific with *A. eresia eresia* are discussed under the description of *A. pyrrhosticta* **n. sp.**, and this hypothesis is supported by analysis of DNA barcode sequence data (Fig. 1). With only two specimens known it is not possible to reasonably assess variation.

Distribution and natural history: This is the only representative of *A. eresia* so far known from the western Andes in Peru (Fig. 9B), where it is known only from the type locality from 2700-2800 m.

Actinote hilaris arcoiris Willmott & Hall, **new subspecies**

Figs. 5C-H, 7E, 9B, 11J

Diagnosis and identification: This new subspecies (Fig. 5C-H) is perhaps superficially most similar to the nominate subspecies (Fig. 5K,L), which occurs from central Peru (Pasco) to the northern Andes of Bolivia. It may be distinguished from that subspecies by having slightly paler orange coloration, and, in the male, by the basal half of the VHW being dark orange, rather than being predominantly yellowish white. Females may be superficially similar to those of *A. eresia leptogramma*, but can be distinguished by the broad, even black band separating the basal orange area from the orange postdiscal band on the VFW, instead of having a thin, irregular black line which appears to fork at the costa. Although this taxon is also superficially similar to other less closely related Andean *Actinote*, the whitish band through the middle of the VHW distinguishes this species.

Description: MALE (Fig. 5C): Forewing length of HT 27.5 mm (22.0-27.7 mm, mean 25.8 mm, n=10). *Wings*: as illustrated. *Head, thorax, abdomen*: as in *A. pyrrhosticta* **n. sp.**, except with 39 antennomeres, frons with dense, long, black, hair-like scales, patagia black, ventral spots on thorax orange, mesothorax meron with patch of very long, yellow, hair-like scales, abdomen black except for scattered ventral orange scaling in middle of sternites and thin lateral line of yellow scales just dorsal of sternites. *Genitalia* (Fig. 7E): similar to nominate subspecies (pers. obs.).

FEMALE: (Fig. 5D-H): Forewing length mean 30.5 mm (26.3-32.5 mm, n=4). *Wings*: as illustrated, variable with respect to color of basal half of DFW and width and color of DFW postdiscal band. *Head, thorax, abdomen*: similar in color to male, sphragis present in two examined specimens as a broad, blunt rectangular plate extending beyond ventral edge of sternites, similar to *A. hilaris sourakovi* **n. ssp.** (Fig. 2L). *Genitalia*: not examined.

Types: HOLOTYPE ♂: **ECUADOR**: *Zamora-Chinchipe*: km 24 Loja-Zamora rd., San Francisco, casa de Arcoiris, [3°59'18"S,79°5'42"W], 2100 m, (Willmott, K. R.), 25 Nov 2003, [DNA voucher LEP-01555; Genitalic dissection KW-19-065], (MGCL, to be deposited in INABIO).

PARATYPES (12 ♂, 12 ♀): **ECUADOR**: *Morona-Santiago*: Guarumales/Hidropaute, [2°34'34"S,78°30'46"W], 1800 m, (Petit, J.-C.), 29 Oct 2009, 1 ♀, (JEPE); km 22 Limón-Gualaceo rd., [3°0'30"S,78°32'20"W], 2100 m, (Willmott, K. R.), 10 Nov 2010, 1 ♂ [FLMNH-MGCL-146472], 1 ♀ [FLMNH-MGCL-145576], 1 ♀ [FLMNH-MGCL-145577], (MGCL); km 50-60 Gualaquiza-Chigüinda rd., (Boyer, P.), 3 Dec 1998, 1 ♀, (PIBO); Quebrada Nueve de Octubre, [2°15'42"S,78°12'54"W], 1600 m, (Petit, J.-C.), 26 Oct 2008, 1 ♂, (JEPE); *Zamora-Chinchipe*: km 18 Yacuambí-Saraguro rd., Cascada Hampik Yaku, [3°33'56"S,78°58'6"W], 2000 m, (Willmott, K. R., J. I. R., J. C. R.), 21 Jun 2013, 1 ♀ [FLMNH-MGCL-157856], (MGCL); km 24 Loja-Zamora rd., San Francisco, casa de Arcoiris, [3°59'18"S,79°5'42"W], 2000-2100 m, (Willmott, K. R.), 28 Nov 2003, 1 ♂, (MGCL), (Willmott, K. R., Aldaz, R.), 9 Nov 2006, 1 ♀ [FLMNH-MGCL-119805], (MGCL); km 24 Loja-Zamora rd., San Francisco, casa de Arcoiris, [3°59'18"S,79°5'42"W], 2100 m, (Willmott, K. R.), 25 Nov 2003, 3 ♂, (MGCL); km 25 Loja-Zamora rd., [3°59'18"S,79°5'42"W], 2000 m, (Boyer, P.), 21 Nov 1996, 1 ♂, (PIBO); km 32 Loja-Zamora rd., Quebrada Zurita, [3°58'18"S,79°6'12"W], 1900

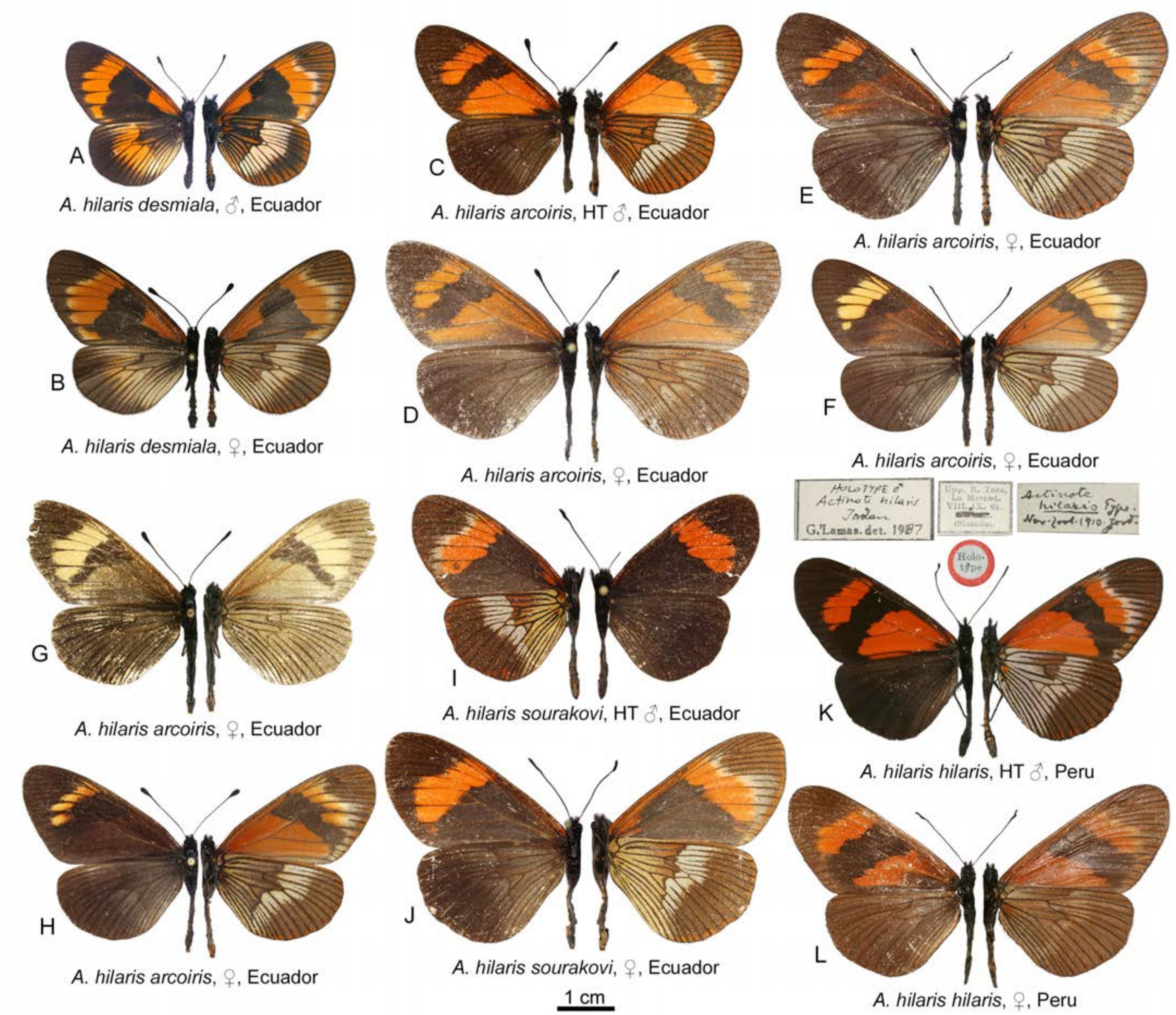


Figure 5. *Actinote hilaris* specimens, left half dorsal surface, right half ventral surface (reverse for I). **A)** *A. hilaris desmiala*, ♂, Ecuador, Napo, Río Jatun Tinahua (MGCL); **B)** *A. hilaris desmiala*, ♀, Ecuador, Napo, Yanayacu (CEPUJ); **C)** *A. hilaris arcoiris* **n. ssp.**, **HT** ♂, Ecuador, Zamora-Chinchipe, San Francisco (MGCL, LEP-01555); **D)** *A. hilaris arcoiris* **n. ssp.**, ♀, Ecuador, Zamora-Chinchipe, Cascada Hampik Yaku (FLMNH-MGCL-157856); **E)** *A. hilaris arcoiris* **n. ssp.**, ♀, Ecuador, Zamora-Chinchipe, San Francisco (FLMNH-MGCL-119805); **F)** *A. hilaris arcoiris* **n. ssp.**, ♀, Ecuador, Morona-Santiago, km 22 Limón-Gualaceo rd. (FLMNH-MGCL-145577); **G)** *A. hilaris arcoiris* **n. ssp.**, ♀, Ecuador, Zamora-Chinchipe, Loja-Zamora old rd. (PIBO); **H)** *A. hilaris arcoiris* **n. ssp.**, ♀, Ecuador, Morona-Santiago, Guarumales (PIBO); **I)** *A. hilaris sourakovi* **n. ssp.**, **HT** ♂, Ecuador, Zamora-Chinchipe, Quebrada Honda (FLMNH-MGCL-111075); **J)** *A. hilaris sourakovi* **n. ssp.**, ♀, Ecuador, Zamora-Chinchipe, above Valladolid (MGCL); **K)** *A. hilaris hilaris*, **HT** ♂, Peru, Junín, upper Río Toro (NHMUK); **L)** *A. hilaris hilaris*, ♀, Peru, Pasco, Cushi (NHMUK).

m, (Willmott, K. R.), 14 Nov 2010, 1 ♂ [FLMNH-MGCL-145575], 1 ♂ [FLMNH-MGCL-146469], 1 ♂ [FLMNH-MGCL-146470], 1 ♂ [FLMNH-MGCL-146471], (MGCL); Loja-Zamora old rd., [3°58'30"S,79°7'30"W], 2000-2700 m, (Boyer, P.), Jun 1998, 1 ♂, (PIBO); Loja-Zamora old rd., [3°58'30"S,79°7'30"W], 2200-2700 m, (Boyer, P.), 25 Nov 1998, 2 ♀, (PIBO), Jun 1998, 1 ♀, (PIBO); 'Zamora valley', (Los, K.), May 1997, 1 ♀, (CEPUJ); *Not located*: 'Ecuador', 1 ♀ ['Ecdr'], 1 ♀ ['Ecuador'], (NHMUK).

Other records: **Ecuador**: *Morona-Santiago*: Alshi, [2°13'47"S,78°13'11"W], (Wolhuter, A. & L.), 19 Sep 2002, 1 ♂, (AWLW) (Wolhuter, A. & L. (pers. comm. with CD of images to KRW)); Guarumales/Hidropaute, [2°34'16"S,78°30'56"W], 2000 m, (Petit, J.-C.), 1 ♂, (JEPE) (http://www.sangay.eu, no 1508), 1 ♀, (JEPE) (http://www.sangay.eu, no 734), 1 ♂, (JEPE) (http://www.sangay.eu, no 897); Guarumales/Hidropaute, [2°34'34"S,78°30'46"W], (Petit, J.-C.), 1 ♀, (JEPE); *Loja*: c. 3 km ESE Loja, Escuela Amauta, [4°2'38"S,79°10'24"W], 2300 m, (Piedra, V.), 30 Apr 2022, 1 ♂, (photograph of live specimen) (https://www.inaturalist.org/observations/114043083).

Etymology: The subspecies name is derived from that of the type locality and is also the Spanish word for 'rainbow'. It is treated as a masculine noun in apposition.

Taxonomy and variation: Characters supporting recognition of this taxon as conspecific with *A. hilaris hilaris* are discussed

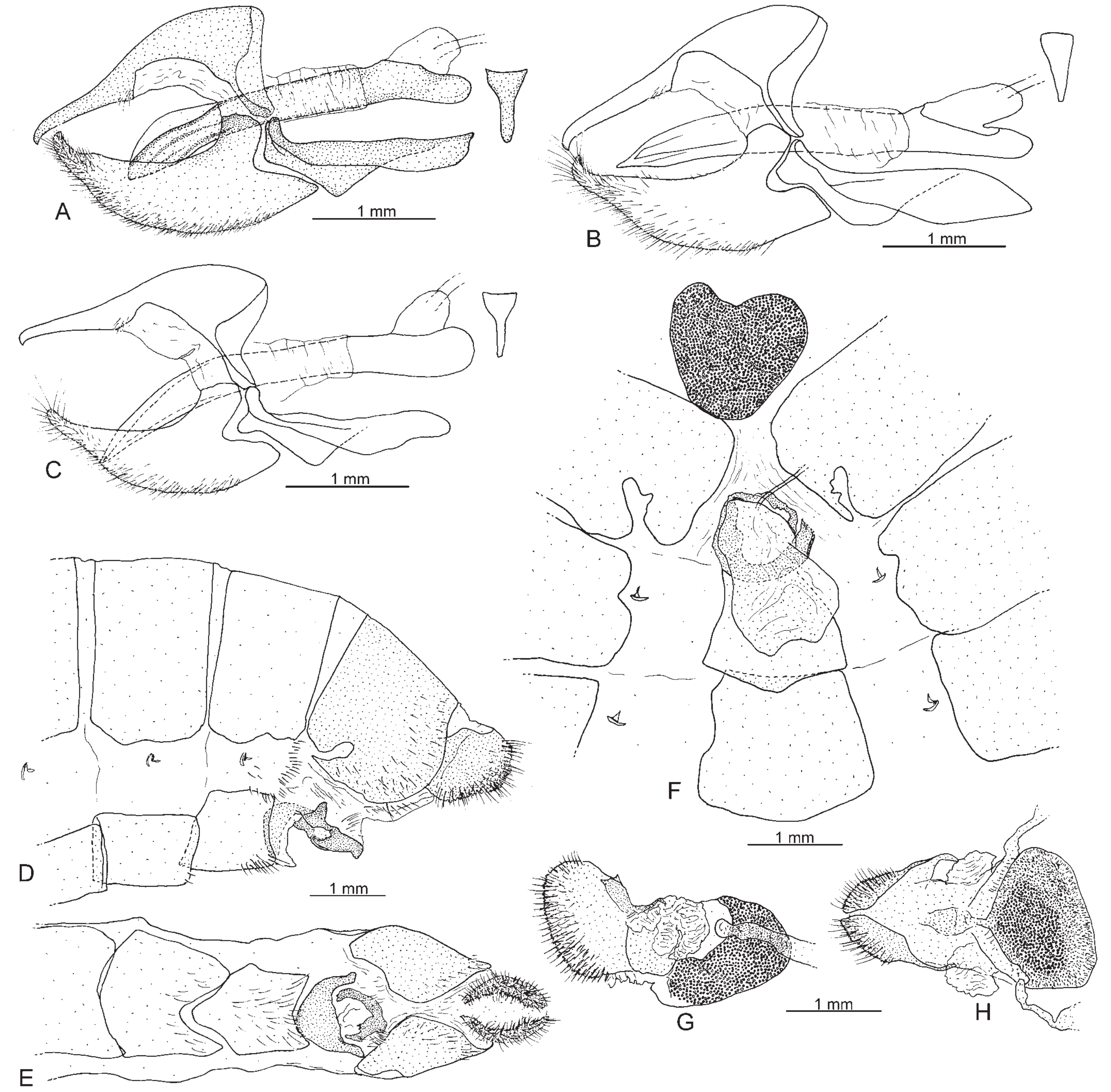


Figure 6. Genitalia of *Actinote pyrrhosticta* **n. sp. A)** *A. pyrrhosticta pyrrhosticta* **n. sp.**, **HT** ♂, Ecuador, lateral view genitalia and posterior view juxta (upper right); **B)** *A. pyrrhosticta quintecocha* **n. ssp.**, ♂, Peru (MUSM-2010-11-26-07), lateral view genitalia and posterior view juxta (upper right); **C)** *A. pyrrhosticta apurimac* **n. ssp.**, ♂, Peru (MUSM-2010-11-26-08), lateral view genitalia and posterior view juxta (upper right); **D-H**: *A. pyrrhosticta pyrrhosticta* **n. sp.**, ♀ (FLMNH-MGCL-209927; KW-16-63): **D)** lateral view posterior tip abdomen; **E)** ventral view posterior tip abdomen; **F)** abdomen interior and genitalia dorsal view; **G)** papillae anales and subpapillary glands lateral view; **H)** same as F, dorsal view.

under the description of *A. pyrrhosticta* **n. sp.** DNA barcode sequence data support conspecificity of this taxon with *A. hilaris sourakovi* **n. ssp.** and *A. hilaris desmiala* (Fig. 1). Mean pairwise sequence divergence within *A. hilaris* was 0.9%, and mean between-group divergence was 3.9% (*A. hilaris/A. eresia*) and 4.5% (*A. hilaris/A. pyrrhosticta*). The female of this taxon is rather variable in the tone of the FW orange markings, the extent to which the orange DFW basal area is obscured with black scaling, and in the color of the DFW postdiscal band, which may be a pale cream color (Fig. 5D-H). We have not examined a sufficient number of specimens to determine whether females of *A. hilaris arcoiris* **n. ssp.** can be consistently distinguished from those of the nominate subspecies (Fig. 5L), but these two taxa are widely disjunct.

Distribution and natural history: This subspecies is known from central to southeastern Ecuador in the provinces of Morona-Santiago and Zamora-Chinchipe, where it is rather

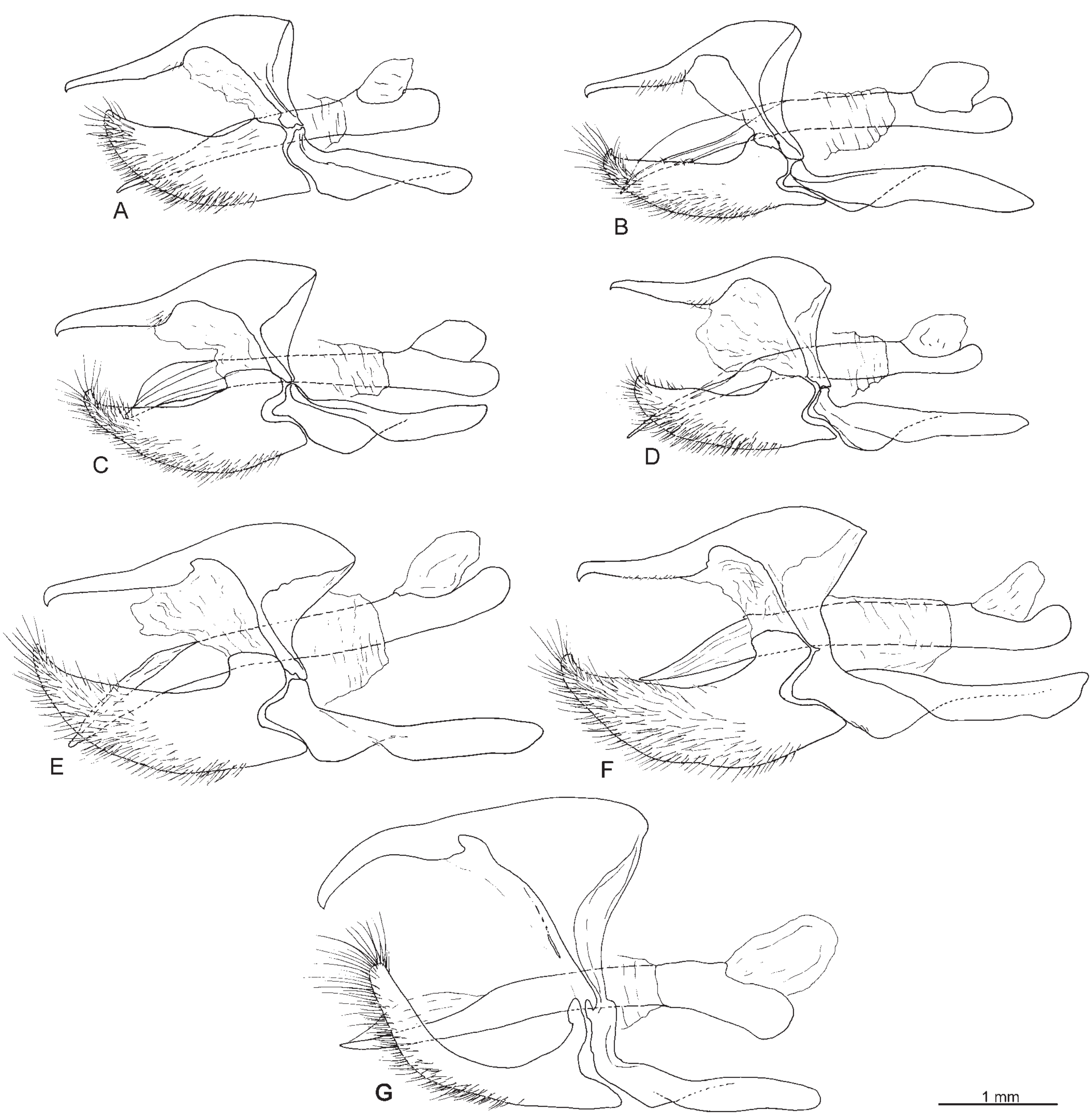


Figure 7. Male genitalia of *Actinote eresia*, *Actinote hilaris* and *Actinote trinacria*, lateral view. **A)** *A. eresia eresia*, ♂, Colombia (CEPUJ); **B)** *A. eresia leptogramma*, ♂, Ecuador (FLMNH-MGCL-113366; KW-15-157); **C)** *A. eresia eresina*, ♂, Peru (MUSM-2010-11-26-03); **D)** *A. eresia canyaris* **n. ssp.**, **HT** ♂, Peru; **E)** *A. hilaris arcoiris* **n. ssp.**, **HT** ♂, Ecuador; **F)** *A. hilaris sourakovi* **n. ssp.**, **HT** ♂, Ecuador; **G)** *A. trinacria alegria* **n. ssp.**, **HT** ♂, Ecuador.

rare and typically found in relatively undisturbed cloud forest from 1600-2300 m. In Ecuador, males were found feeding on flowers in the forest canopy 20 m above the ground from 10:00-11:00 hr and 14:00-16:00 hr, and were also observed flying 2-3 m above a forested river in bright sun from 10:00-11:00 hr. A female was encountered flying 4 m above the ground over a ridgetop road through forest at 13:00 hrs, and two others were observed puddling solitarily in the morning at damp sand, not in the company of males.

Actinote hilaris sourakovi Willmott & Lamas, **new subspecies**

Figs. 2L, 5I,J, 7F, 9C, 11K,L

Diagnosis and identification: This subspecies is easily distinguished from all other taxa within *A. hilaris, A. eresia* and *A. pyrrhosticta* **n. sp.** by the entirely black DFW basal area (Fig. 5I,J). The VHW is similar to that of *A. hilaris hilaris* in having pale yellowish white scaling extending from the base

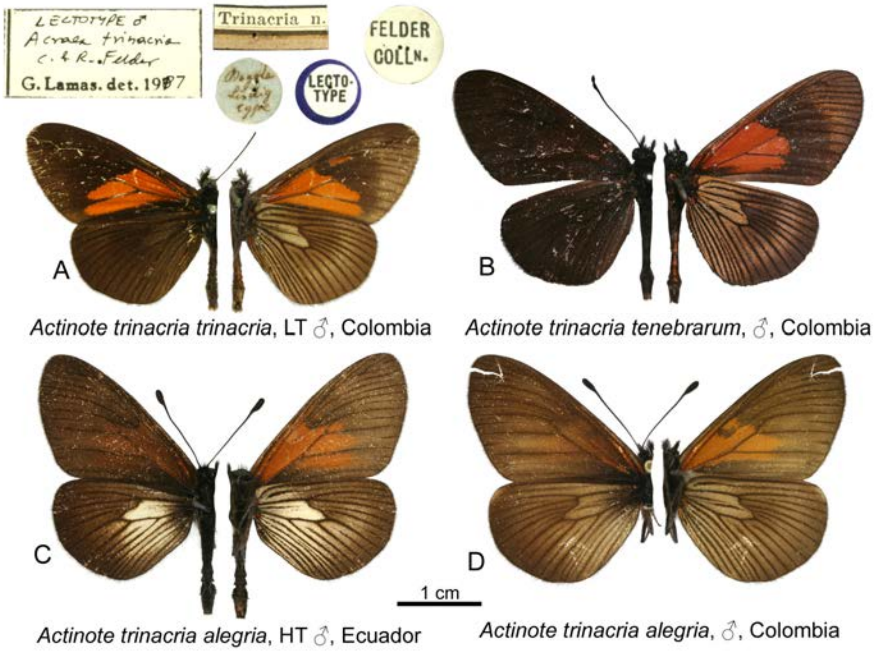


Figure 8. *Actinote trinacria* specimens, left half dorsal surface, right half ventral surface. **A)** *A. trinacria trinacria,* **LT** ♂, Colombia, 'Bogotá' (NHMUK); **B)** *A. trinacria tenebrarum*, ♂, Colombia, Antioquia, Valdivia (NHMUK); **C)** *A. trinacria alegria* **n. ssp.**, **HT** ♂, Ecuador, Sucumbíos, El Calvario-La Alegría rd. (PIBO); **D)** *A. trinacria alegria* **n. ssp.**, ♂, Colombia, Cauca, Leticia to Puracé (NHMUK).

to the edge of the pale postdiscal band in the posterior half of the wing, and in this respect it differs (in males) from *A. hilaris arcoiris* **n. ssp.**

Description: MALE (Fig. 5I): Forewing length of HT 27.9 mm (27.9-31.4 mm, mean 29.8 mm, n=4). *Wings*: as illustrated. *Head, thorax, abdomen*: as in *A. hilaris arcoiris* **n. ssp.**, except ventral thoracic spots on katepisternum and epimeron orange (not yellow). *Genitalia* (Fig. 7F): similar to *A. hilaris arcoiris* (Fig. 7E) and nominate subspecies (pers. obs.).

FEMALE: (Fig. 5J): Forewing length mean 34.3 mm (32.8-36.7 mm, n=3). *Wings*: as illustrated. *Head, thorax, abdomen*: similar to *A. hilaris arcoiris* **n. ssp.**, including sphragis (Fig. 2L) (present in three specimens). *Genitalia*: not examined.

Types: HOLOTYPE ♂: **ECUADOR**: *Zamora-Chinchipe*: Reserva Tapichalaca, Quebrada Honda trail, [4°28'21"S,79°7'18"W], 1900 m, (Willmott, K. R.), 30 Nov 2005, [FLMNH-MGCL-111075; DNA voucher LEP-00007; Genitalic dissection KW-19-064], (MGCL, to be deposited in INABIO).

PARATYPES (12 ♂, 11 ♀): **ECUADOR**: *Loja*: 'above Yangana' [=La Entrada], [4°25'6"S,79°9'18"W], 2500 m, (Aldas, I.), May 2000, 1 ♂, (PIBO), (Boyer, P.), May 2000, 3 ♂, (PIBO); *Zamora-Chinchipe*: above Valladolid, [4°31'18"S,79°7'48"W], (Sourakov, A.), 17-21 May 1993, 1 ♀ [FLMNH-MGCL-281001], (MGCL); above Valladolid, [4°31'18"S,79°7'48"W], 2000 m, (Sourakov, A.), 17-21 May 1993, 1 ♀, (MGCL); km 4.3 San Andrés-Jimbura rd., [4°47'59"S,79°18'18"W], 2020 m, (Willmott, K. R.), 13 Oct 2010, 1 ♂ [FLMNH-MGCL-146473], (MGCL); km 5.3 San Andrés-Jimbura rd., Finca San Carlos, [4°47'53"S,79°18'34"W], 2000 m, (Willmott, K. R.), 15 Oct 2010, 1 ♀ [FLMNH-MGCL-145578], (MGCL); km 8 Valladolid-Tapala rd., [4°32'22"S,79°6'21"W], 1600 m, (Willmott, K. R.), 1 Dec 2005, 1 ♂ [FLMNH-MGCL-111076], (MGCL); Reserva Tapichalaca, Quebrada Honda trail, [4°28'21"S,79°7'18"W], 1900 m, (Willmott, K. R.), 30 Nov 2005, 1 ♀ [FLMNH-MGCL-111074], (MGCL). **PERU**: *Amazonas*: 2 km NW Ocol, [6°15'S,77°35'W], 2550 m, (Grados, J.), 19 Aug 1998, 1 ♀ [MUSM-ENT-7540], (MUSM); 3 km N Nueva Esperanza, Quebrada Piruro, [6°23'S,77°26'W], 1700 m, (Wojtusiak, J.), 19 Sep 1999, 1 ♀, (CEPUJ); 5 km N Molinopampa, [6°10'S,77°39'W], 3000 m, (Grados, J.), 20 Aug 1998, 1 ♂ [MUSM-ENT-7538], 1 ♂ [MUSM-ENT-7539], (MUSM); Rodríguez de Mendoza, 'Hingil Pata' [=Inguilpata], [6°14'S,77°57'W], 2300 m, (Calderón, B.), 2 Sep 1998, 1 ♂, (CEPUJ); Rodríguez de Mendoza, 'Llanoaico' [=Quebrada Yanahuayco], [6°24'S,77°26'W], 1600-2000 m, (Pyrcz, T. W.), Sep 1998, 1 ♂, (CEPUJ); Molinopampa-El Tingo, [6°13'15"S,77°38'37"W], 2400 m, (Pyrcz, T. W.), 26 Jun 1998, 1 ♂, (CEPUJ); Pomacochas, [5°49'S,77°58'W], 2200 m, (Calderón, B.), 18 Aug 1998, 1 ♀, (CEPUJ); Quebrada La Florida, [5°45'27.86"S,78°04'34"W], 2133 m, (Quispe, E. R.), 16 Nov 2019, 1 ♀, (MUSM); *Cajamarca*: Naranja, [6°16'S,78°51'W], 2300 m, (Grados, J.), 18 Oct 1998, 1 ♀ [MUSM-ENT-7541], (MUSM); Prov[incia]. San Ignacio, nr. C[entro]. P[oblado]. Pueblo Libre, [5°06'02"S,79°14'12"W], 2070 m, (Sánchez, P.), 9 Oct 2017, 1 ♀, (MUSM); *San Martín*: 'Jorge Chávez' - (error), (Calderón, B.), Jul 2005, 1 ♂, (PIBO); Puente Nieva, [5°41'S,77°47'W], 2025 m, (Lamas, G.), 9 Nov 1998, 1 ♀ [MUSM-ENT-7542], (MUSM).

Other records: **Peru**: *Amazonas*: Abra Patricia, [5°42'S,77°48'W], 2150 m, (Geale, D.), 4 Dec 2022, 1 ♀, (photograph of live specimen) (Geale, D. (May 2023, pers. comm. to KRW with photo)). *Pasco*: 'Camino del Pichis, 'Tambo Eneñas' [= Eneñas] to Dos de Mayo' - (error), (Cornell University Expedition), 5 Jul 1930, 1 ♀ [Lot 607 Sub 126, R. W. L. Potts Collection], (CAS).

Etymology: This distinctive taxon is named for Andrei Sourakov, in recognition of many years of friendship, wit, lively debate and forthright criticism. Andrei also collected the first known specimens of this subspecies from Ecuador, during a remarkably successful expedition to the Valladolid region (KRW, JPWH).

Taxonomy and variation: Characters supporting recognition of this taxon as conspecific with *A. hilaris hilaris* are discussed under the description of *A. pyrrhosticta* **n. sp.** DNA barcode sequence data support conspecificity of this taxon with *A.*

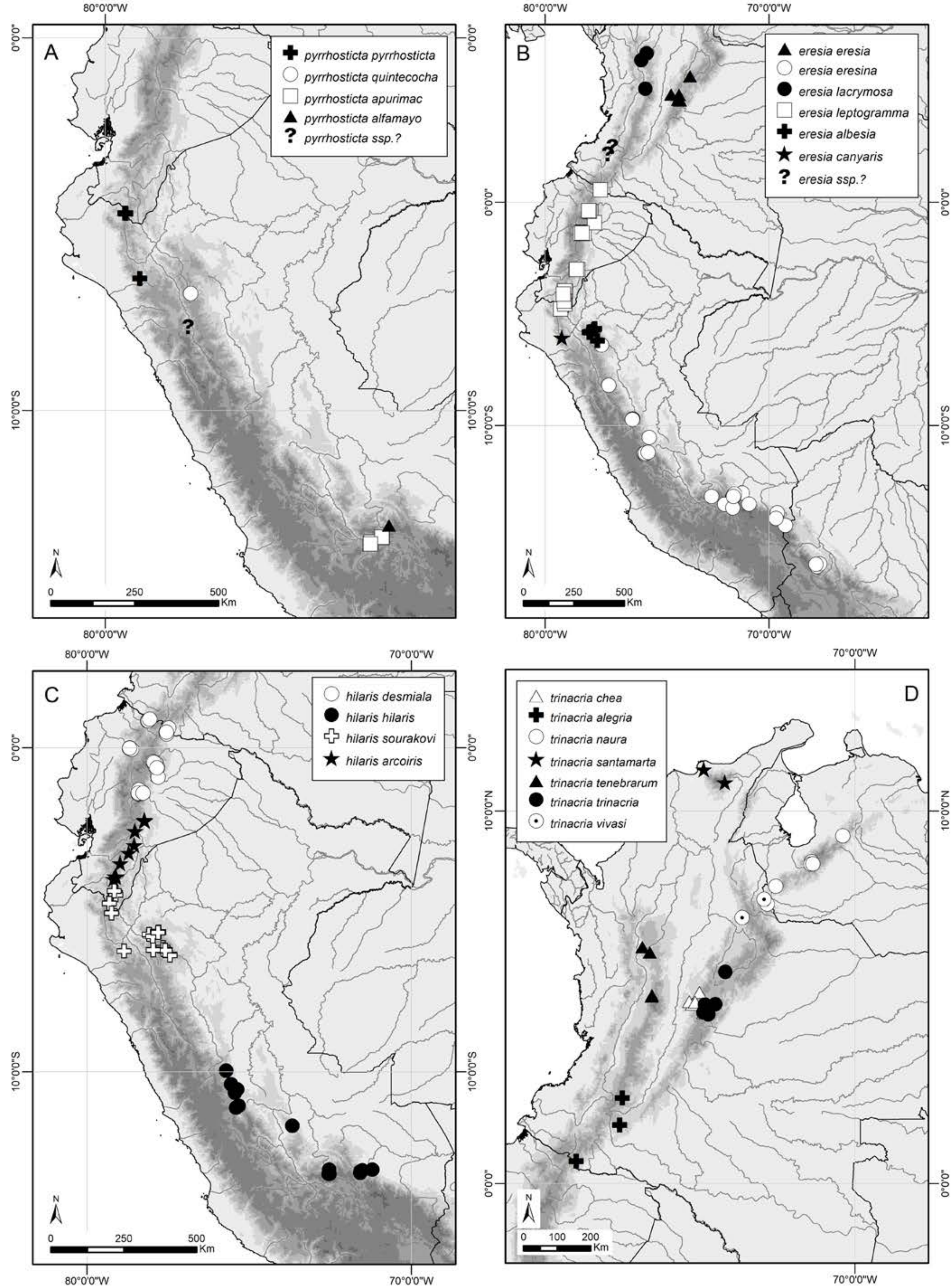


Figure 9. Maps depicting recorded localities for *Actinote* taxa. **A)** *A. pyrrhosticta* **n. sp.**; **B)** *A. eresia*; **C)** *A. hilaris*; **D)** *A. trinacria*.

hilaris arcoiris **n. ssp.** and *A. hilaris desmiala* (Fig. 1). The width of the FW orange band is slightly variable.

Distribution and natural history: This subspecies occurs from extreme southern Ecuador (Zamora-Chinchipe, in the upper valleys of rivers that flow into the Río Marañón) through northern Peru as far south as San Martín (Fig. 9C). A historical specimen from Pasco, within the distribution of the nominate subspecies, seems likely to be mislabeled. The taxon is found in relatively undisturbed cloud forest from 1600-2550 m (with one record from 3000 m), where it is uncommon. In Ecuador, both sexes were found feeding on flowers along the edges of rivers and roads in the mid-morning. One little-damaged male was found in early December dead on the ground by a stream in the morning, during a period of unusually clear and cold nights.

Figure 10. Habitats of new *Actinote* taxa. **A)** Ecuador, Loja, Jimbura-San Andrés road, type locality of *Actinote pyrrhosticta* **n. sp.,** stream gully and road where numerous individuals were observed on the morning of 12 June 2014; **B)** Peru, Cajamarca, El Pargo, habitat of *A. pyrrhosticta* **n. sp. C)** Peru, Apurímac, Santuario Nacional Ampay, Laguna Angasocha, type locality of *A. pyrrhosticta apurimac* **n. ssp. D)** Peru, Apurímac, Santuario Nacional Ampay, Laguna Uspacocha, habitat of *A. pyrrhosticta apurimac* **n. ssp. E)** Peru, Lambayeque, Cañaris, type locality of *A. eresia canyaris* **n. ssp. F)** Ecuador, Zamora-Chinchipe, San Francisco, type locality of *Actinote hilaris arcoiris* **n. ssp.**

Actinote trinacria alegria Boyer & Willmott, **new subspecies**

Figs. 7G, 8C,D, 9D

Diagnosis and identification: This subspecies is distinguished from other *A. trinacria* (C. Felder & R. Felder, 1862) taxa by the dark DFW, lacking any orange markings in the discal cell (otherwise occurring only in *A. trinacria tenebrarum* Oberthür, 1917), and by the unique whitish patches in the basal third of the DHW (Fig. 8C,D). The ground color of the wings is dark brown, rather than black as in other subspecies of *A. trinacria*.

Description: MALE (Fig. 8C): Forewing length 24.2 mm (n=1). *Wings*: as illustrated, veins M_1 and Rs fused near their base. *Head, thorax, abdomen*: as in nominate subspecies, including spots of orange-yellow scales on ventral thorax near base of legs which appear to be smaller than in nominate subspecies, and no orange-red line down middle of ventral abdomen, in contrast to *A. t. trinacria* and *A. t. naura*. *Genitalia* (Fig. 7G): uncus curving downwards, valvae elongate, narrow, of even width throughout most of length, upwardly curved in middle.

FEMALE: unknown.

Types: HOLOTYPE ♂: **ECUADOR**: *Sucumbíos*: El Calvario-La Alegría rd., [0°36'N,77°28'36"W], 2800 m, (Boyer, P.), 26 Nov 1999, (PIBO, to be deposited in CEPUJ).

Other specimens examined (see discussion under Taxonomy and variation) (2 ♂): **COLOMBIA**: *Cauca*: eastern slopes of Cordillera Central, [Santa] Leticia to Puracé, [2°17'53"N,76°13'57"W], 2650-2700 m, (Adams, M. J., Hardy, P. J.), Aug 1979, 1 ♂, (NHMUK); San Juan de Villalobos km 90, [1°29'53"N,76°22'32"W], 1800 m, (Prieto, C.), 22 Jun 2013, 1 ♂ [g 066], (RCCP) (photograph examined).

Etymology: The subspecies name is derived from that of the type locality, and is also, appropriately, the Spanish word for 'happiness', given the serendipity of the collection of the holotype (see below). The name is treated as a feminine noun in apposition.

Taxonomy and variation: This taxon is associated with other taxa currently treated as subspecies of *A. trinacria* on the basis of several shared characters, including: relatively small size, whitish gray VHW discal cell contrasting with reddish spots at the base of the wing anterior and posterior of the discal cell, and indistinct whitish-gray VHW postdiscal band tapering anteriorly (e.g., Fig. 8A,B). The genitalia of the holotype of *A. trinacria alegria* **n. ssp.** are similar to those of a dissected specimen of *A. trinacria trinacria* (Colombia, Boyacá, vic. Arcabuco, in MGCL) in having narrow, upwardly curving valvae, a character that may prove to be distinctive for this species. We examined two Colombian specimens (Fig. 8D) that are similar to this taxon in lacking conspicuous orange DFW markings and in the pale shading in the basal half of the DHW, although both differ from the holotype of *A. t. alegria* **n. ssp.** in having more muted whitish gray coloring on the HW, especially the specimen from Leticia-Puracé, and in the orange on the VFW being reduced (absent in cell Cu_1-M_3 and reduced in cell 2A-Cu_2). In addition, the figured Colombian specimen from Leticia to Puracé (Fig. 8D) differs from the holotype of *A. trinacria alegria* **n. ssp.** (Fig. 8C) in having HW veins M_1 and Rs separate at their bases. Although the fusion or not of the bases of these two veins can be taxonomically important in *Actinote* (e.g., see description of *Actinote balletae* Neild & Romero, 2008 (Neild, 2008: 32)), in this case the difference seems to represent intraspecific variation, since the other Colombian specimen has these veins touching where they leave the discal cell, intermediate between the two states discussed above. Furthermore, we observed similar variation in other species of *Actinote*, such as *A. johncoulsoni* Willmott, Lamas & Hall, 2017 and *A. stratonice* (Latreille, [1813]). The two Colombian specimens are regarded at present as representing the same taxon as the Ecuadorian holotype, but were excluded from the type series and may ultimately prove to represent a distinct subspecies.

Distribution and natural history: This taxon is the southernmost representative of *A. trinacria*, occurring in northeastern Ecuador in Sucumbíos, potentially to southern Colombia in Cauca on the eastern slopes of the Cordilleras Central and Oriental (Fig. 9D). The three specimens discussed here were collected between 1800-2800 m. The holotype was found crawling across a damp, dirt road through cloud forest on a very cool, overcast morning.

Annotated checklist of relevant species

A single dash before a name indicates a valid subspecific name and two dashes indicates a synonym. All distributions from Ecuador to Bolivia are on the eastern slopes of the Andes unless otherwise noted.

pyrrhosticta Lamas, Willmott & Hall, **n. sp.** [Fig. 2A-C; S.W. Ecuador (Loja) to N.W. Peru (Cajamarca, Piura)]
- *quintecocha* Lamas & Willmott, **n. ssp.** [Fig. 2D; N. Peru (Amazonas)]
- *apurimac* Lamas & Willmott, **n. ssp.** [Fig. 2E-G; S. Peru (Apurímac, Cuzco)]
- *alfamayo* Lamas & Willmott, **n. ssp.** [Fig. 2H,I; S. Peru (Cuzco)]
- n. ssp.? [Fig. 11I; Peru (La Libertad)]; photographs of live butterflies taken by Jonathan Newman (Fig. 11I) and Remco Hofland (https://observation.org/observation/175942503/) on the same day at Cochorco, La Libertad, Peru (7°45'28"S,77°46'20"W) may represent an additional undescribed subspecies not yet represented in any collection. These specimens are similar to the nominate subspecies but the outer edges of the orange postdiscal bands on both wings are tinged pale yellowish. Hofland (pers. comm.) reported seeing approximately 20 adults in the early afternoon of 7 July 2019 at Cochorco, which is also one of the few known sites for the extremely localized endemic Peruvian hummingbird Purple-backed Sunbeam (*Aglaeactis aliciae* Salvin). Given the large gaps within the distribution of *A. pyrrhosticta*, additional undescribed taxa seem likely.

eresia (C. Felder & R. Felder, 1862) [Fig. 3A,B; E. Colombia (Cordillera Oriental)]
- *lacrymosa* Oberthür, 1917 [Fig. 3C,D; C. Colombia (Cordillera Central)]

Figure 11. Images of new *Actinote* taxa in nature. **A,B)** Mating pair of *Actinote pyrrhosticta* **n. sp.**, female in foreground (A), and male (B), resting on rocks and low vegetation near edge of stream gully at type locality; **C-H**, *Actinote pyrrhosticta apurimac* **n. ssp.**, Peru, Cuzco, above Mollepata (photographs by David Geale). **C)** Last instar; **D)** Pupal case with freshly emerged adult adjacent; **E)** Cluster of pupae; **F,G)** Males nectaring on Asteraceae flowers; **H)** Female nectaring on Asteraceae flowers; **I)** *Actinote pyrrhosticta* n. ssp.?, Peru, La Libertad, Cochorco (photograph by Jonathan Newman); **J)** *A. hilaris arcoiris* **n. ssp.** female, puddling on damp gravel, Ecuador, Morona-Santiago, Cebadas-Macas road; **K,L)** *Actinote hilaris sourakovi* **n. ssp.** female, dorsal (K) and ventral (L), Peru, Amazonas, Abra Patricia (photographs by David Geale).

- *leptogramma* Jordan, 1913 [Fig. 3E-H; Ecuador (Sucumbíos to Zamora-Chinchipe)]; the valva of the male genitalia in *A. e. leptogramma* (Fig. 7B) is noticeably broader and blunter than that of *A. e. eresina* (Fig. 7C) and the nominate subspecies (Fig. 7A), but it is similar to that of *A. e. canyaris* (Fig. 7D). Furthermore, the single available sequence of *A. eresia eresina* (AC87), from Cochabamba, Bolivia, did not form a clade with the remaining *A. eresia* sequences from Colombia and Ecuador (Fig. 1). Finally, in the few examined specimens, the sphragis of *A. e. eresina* was squared at the tip, and blunter than the pointed sphragis of *A. e. leptogramma*. Collectively, these observations suggest that *A. e. eresina* might perhaps be considered a species distinct from remaining *A. eresia* taxa, but the relatively close allopatry of known taxa suggests that they should conservatively be treated as conspecific until more data are available. Two specimens of *A. eresia* from west Colombia (Cauca) in the CEPUJ (Fig. 3J) and RCCP are somewhat intermediate in wing pattern between *A. e. leptogramma* and typical *A. e. lacrymosa*, and may represent an undescribed subspecies, but given the variability within *A. e. leptogramma* and *A. e. lacrymosa*, we feel that more material is needed to clarify the taxonomy. Similarly, the southernmost known specimen of *A. e. leptogramma*, a female from the Jimbura-San Andrés road on the southern Ecuador-northern Peru border (PIBO), might represent a distinct subspecies, although it only differs from that shown in Fig. 3I in having more reduced orange at the base of the DFW.
- *albesia* Lamas & Willmott, **n. ssp.** [Fig. 4A,B; N. Peru (Amazonas)]
- *canyaris* Pyrcz & Lamas, **n. ssp.** [Fig. 4C,D; N.W. Peru (Lambayeque)]
- *eresina* (Hopffer, 1874) [Fig. 4E-O; N. Peru (Amazonas, an apparently intermediate specimen to *albesia* Fig. 4E) to Bolivia (Cochabamba)]; Lamas (2004) listed several additional undescribed subspecies from Peru, which we here provisionally treat as *A. eresia eresina*. There is substantial variation within *A. eresia eresina*, both geographic (clinal?) and local, which includes, in particular: the presence or absence of a black spot in the middle of the FW discal cell, the separation or fusion of the DFW orange postdiscal band with the immediately basal orange area, the width of the dark margin in the DFW tornus and on the DHW, and the overall dorsal color, which varies from pale orange to a darker reddish orange (Fig. 4F-O). At least some locally distinctive phenotypes seem to be stable, but overall the picture is complex. Furthermore, the lack of DNA sequence data hinders recognition of genetically well-defined populations that might correspond with wing pattern differences, and the fact that the single available sequence for *A. e. eresina* does not group with other *A. eresia* (see discussion above under *leptogramma*) suggests that a thorough molecular and morphological study of *A. eresia* would be valuable, to determine both species and subspecies limits.
- - *binghamae* Dyar, 1913, **n. syn.** [Fig. 4K]; Lamas (2004) retained *Actinote binghamae* Dyar, 1913 as a valid subspecies, but the type locality (San Miguel, Cuzco, Peru) lies within the range of *A. eresia eresina*. A somewhat similar specimen in the PIBO from Peru, Puno, Sina (Fig. 4L), and another from Peru, Huánuco, E Acomayo (not figured) suggests that the holotype of *binghamae* is a form of *A. eresia eresina*, and we therefore place the name in synonymy (**n. syn.**).

hilaris Jordan, 1910 [Fig. 5K,L; C. Peru (Pasco) to Bolivia (Santa Cruz)]
- *desmiala* Jordan, 1913 [Fig. 5A,B; N.W. Ecuador (Carchi to Pichincha), N.E. Ecuador (Sucumbíos to Tungurahua)]
- - *culoti* (Oberthür, 1916)
- - *brownorum* (Potts, 1943)
- *arcoiris* Willmott & Hall, **n. ssp.** [Fig. 5C-H; S. Ecuador (Morona-Santiago to Zamora-Chinchipe)]
- *sourakovi* Willmott & Lamas, **n. ssp.** [Fig. 5I,J; S. Ecuador (Zamora-Chinchipe) to C. Peru (San Martín)]

trinacria (C. Felder & R. Felder, 1862) [Fig. 8A; E. Colombia (E. slope Cordillera Oriental)]
- - *iguaquensis* Andrade & Restrepo, 1992
- *naura* (Druce, 1875) [Venezuela (Cordillera de Mérida)]
- *chea* Druce, 1903 [E. Colombia (W. slope Cordillera Oriental)]; three males in the HAWA from Colombia, Cundinamarca, Chicaque road, resemble *A. t. trinacria* but have reduced red on the DFW, and may represent a distinct subspecies. A male specimen with similar wing pattern in the HAWA was collected further north, in Boyacá, thus leap-frogging the distribution of *A. trinacria chea* on the western slopes of the Cordillera Oriental. There is thus the possibility that these specimens represent transitional forms between subspecies, and we refrain from describing new taxa until the distribution of these forms becomes better known.
- *tenebrarum* Oberthür, 1917 [Fig. 8B; C. Colombia (Cordillera Central)]
- - *unicolor* Talbot, 1932
- *vivasi* Neild & Romero, 2008 [N. Colombia (Santander) to Venezuela (Sierra de El Tamá)]
- *santamarta* (Winhard, 2017) [N. Colombia (Sierra Nevada de Santa Marta)], **rev. stat.** Winhard (2017) introduced the name *Altinote santamarta* with a simple description of the taxon, without a diagnosis, which only arguably makes the name available under Article 13.1 of the ICZN (ICZN, 1999) since the characters described were not explicitly "purported to differentiate the taxon". Lamas (2004) listed this taxon as "*Altinote trinacria* n. ssp. [2]", since it shares a number of wing pattern characters with other taxa currently treated as subspecies of *A. trinacria*, as discussed under the description of *A. t. alegria*, and we here place it as a subspecies of *Actinote trinacria*. *Actinote trinacria santamarta* is most similar in wing pattern to *A. trinacria naura* and *A. trinacria vivasi*, but differs from both in having a reddish mark at the end of the DFW discal cell, and a DFW subapical band of three reddish marks in cells M_3-R_5.
- *alegria* Boyer & Willmott, **n. ssp.** [Fig. 8C,D; S. Colombia (Cauca) to N. Ecuador (Sucumbíos)]

ACKNOWLEDGMENTS

We thank the museum curators who allowed us to examine the Acraeini collections under their care, and individuals who provided access to or shared information from their private collections or field work, including Allan & Lesley Wolhuter, Carlos Prieto, Jere Schweikert, Steven Heydon, Jeff & Cathy Smith, Lynn Kimsey, Haydon Warren-Gash, Jamie Radford, Jean-Claude Petit, Phil Ackery, Blanca Huertas, Bob Robbins, and Axel Hausmann. We thank the Trustees of the Natural History Museum, London, for permission to publish images of specimens in that collection. We thank Santiago Villamarín, Sofía Nogales, Diego Inclán, the INABIO and Ecuadorian Ministerio del Ambiente, Agua y Transición Ecológica for arranging the necessary permits for research in Ecuador, most recently under the project 'Diversity and Biology of Lepidoptera in Ecuador' (No. MAATE-DNB-CM-2023-0298). Museum and field work was funded in part by the Leverhulme Trust, the Darwin Initiative, the FLMNH Museum Associates, the National Geographic Society (Research and Exploration Grant #5751-96), and the US National Science Foundation (NSF) (DEB-0103746, DEB-0639977, DEB-0639861, DBI-0847582, DEB-1256742). The fieldwork of Tomasz Pyrcz in Peru was supported by NCN grant Harmonia-10 2018/30/M/NZ8/00293 "Evolutionary biogeography and diversification of the predominantly Andean butterfly subtribe Pronophilina (Nymphalidae, Satyrinae) based on phylogenetic data generated using modern molecular methods". We thank the owners and/or managers of Parque Nacional Podocarpus, Reserva Tapichalaca, and Fundación Arcoiris for providing access to their properties and facilities for research. For their companionship and assistance in the field, and/or providing specimen data and images, we thank Julia and Jamie Robinson Willmott, Kim Garwood, Andrew Neild, David Geale, Jonathan Newman, Remco Hofland, Washington Galiano, and Raúl Aldaz. We thank the numerous people who contributed to databasing museum specimens, and Akito Kawahara, Becky Messcher and the ButterflyNet project (NSF DEB # 1541557) for providing two of the sequences used in the analysis. Finally, we thank Marlon Paluch and Carlos Prieto for their helpful comments on the manuscript.

LITERATURE CITED

Carvalho, A. P. S., St Laurent, R. A., Toussaint, E. F. A., Storer, C., Dexter, K. M., Aduse-Poku, K., Kawahara, A. Y. 2021. Is sexual conflict a driver of speciation? A case study with a tribe of brush-footed butterflies. *Systematic Biology* 70(3): 413-420.

Chazot, N. *et al.* 2021. Conserved ancestral tropical niche but different continental histories explain the latitudinal diversity gradient in brush-footed butterflies. *Nature Communications* 12(5717): 1-10.

Comstock, J. H., Needham, J. G. 1898. The wings of insects. Chapter III. The specialization of wings by reduction. *American Naturalist* 32(376): 231-257.

Francini, R. B., Freitas, A. V. L., Penz, C. M. 2004. Two new species of *Actinote* (Lepidoptera, Nymphalidae) from southeastern Brazil. *Zootaxa* 719: 1-10.

Freitas, A. V. L., Francini, R. B., Paluch, M., Barbosa, E. P. 2018. A new species of *Actinote* Hübner (Nymphalidae: Heliconiinae: Acraeini) from southeast Brazil. *Revista Brasileira de Entomologia* 62(2): 135-147.

Hall, T. A. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleic Acids Symposium Series* 41: 95-98.

Hebert, P. D. N., Cywinska, A., Ball, S. L., deWaard, J. R. 2003. Biological identifications through DNA barcodes. *Proceedings of the Royal Society of London* B 270: 596-599.

ICZN (International Commission on Zoological Nomenclature) 1999. *International Code of Zoological Nomenclature. Fourth Edition*. London, The International Trust for Zoological Nomenclature.

Jasinski, A. 1996. Description of three new subspecies of *Perisama* Doubleday from Ecuador and Northern Peru (Lepidoptera: Nymphalidae: Eurytelinae: Catagrammini). *Genus* 7(3): 503-514.

Jasinski, A. 1998a. Description of a new species of *Catasticta* from Ecuador (Lepidoptera: Pieridae). *Genus* 9(3): 399-404.

Jasinski, A. 1998b. Description of a new species of *Hypanartia* from southern Ecuador and northern Peru (Lepidoptera: Nymphalidae). *Genus* 9(3): 405-410.

Kawahara, A. Y., *et al.* 2023. A global phylogeny of butterflies reveals their evolutionary history, ancestral hosts, and biogeographic origins. *Nature Ecology & Evolution* 7(6): 903-913.

Lamas, G. 2004. *Nymphalidae. Heliconiinae*, pp. 261-274. *In*: Lamas, G. (Ed.), *Checklist: Part 4A. Hesperioidea - Papilionoidea*. *In*: Heppner, J. B. (Ed.), *Atlas of Neotropical Lepidoptera. Volume 5A*. Gainesville, Association for Tropical Lepidoptera; Scientific Publishers.

Neild, A. F. E. 2008. *The Butterflies of Venezuela. Part 2: Nymphalidae II (Acraeinae, Libytheinae, Nymphalinae, Ithomiinae, Morphinae). A Comprehensive Guide to the Identification of Adult Nymphalidae, Papilionidae, and Pieridae*. London, Meridian Publications.

Paluch, M., Casagrande, M. M., Mielke, O. H. H. 2006. Três espéces e duas subespéces novas de *Actinote* Hübner (Nymphalidae, Heliconiinae, Acraeini). *Revista Brasileira de Zoologia* 23(3): 764-778.

Pierre, J. 1987. Systématique cladistique chez les *Acraea* (Lepidoptera, Nymphalidae). *Annales de la Société Entomologique de France* (N. S.) 23(1): 11-27.

Scoble, M. 1992. *The Lepidoptera: Form, Function and Diversity*. London, Oxford University Press. ix + 352 pp.

Silva-Brandão, K. L., Wahlberg, N., Francini, R. B., de Azeredo-Espin, A. M. L., Brown, K. S., Paluch, M., Lees, D. C., Freitas, A. V. L. 2008. Phylogenetic relationships of butterflies of the tribe Acraeini (Lepidoptera, Nymphalidae, Heliconiinae) and the evolution of host plant use. *Molecular Phylogenetics and Evolution* 46(2): 515-531.

Tamura, K., Stecher, G., Kumar, S. 2021. MEGA11: Molecular Evolutionary Genetics Analysis version 11. *Molecular Biology and Evolution* 38(7): 3022-3027.

Williams, M. C., Henning, G. A. 2023. Taxonomic revision of the tribe Acraeini Boisduival, 1833 (Papilionoidea: Nymphalidae: Heliconiinae). *Metamorphosis* 34: 35-49.

Willmott, K. R., Freitas, A. V. L., Hall, J. P. W., Silva-Brandão, K. L., Paluch, M. 2009. A new species of *Actinote* Hübner from the eastern Andes of Ecuador (Lepidoptera: Nymphalidae: Heliconiinae). *Proceedings of the Entomological Society of Washington* 111(1): 47-56.

Willmott, K. R., Lamas, G., Hall, J. P. W. 2017. Notes on the taxonomy of *Actinote intensa* Jordan (Lepidoptera: Nymphalidae: Heliconiinae) and the description of a new sibling species from eastern Ecuador. *Tropical Lepidoptera Research* 27(1): 6-15.

Winhard, W. 2017. Neue tagfalterarten und -unterarten aus Kolumbien und Ecuador (Lepidoptera: Papilionidae, Pieridae et Nymphalidae). *Atalanta* 48(1-4): 261-274.

Zhang, J., Cong, Q., Shen, J., Opler, P. A., Grishin, N. V. 2021. Genomics-guided refinement of butterfly taxonomy. *The Taxonomic Report of the International Lepidoptera Survey* 9(3): 1-54.

Appendix 1. Voucher specimen information for DNA sequence data.

Taxon	Locality (decimal latitude and longitude)	DNA voucher number	GenBank number
Acraea (Telchinia) issoria	Vietnam	NW108-22	EU275531
Actinote alcione sodalis	Peru: Junín: no specific locality	ac28	EU275554
Actinote brylla	Argentina: Misiones: Departamento de Iguazú, Parque Nacional Iguazú, Seccional Yacui (-25.675, -54.169)	LEPIG188-11	MF546916
Actinote dicaeus albofasciata	Ecuador: Napo: no specific locality	E-51-18	EU275555
Actinote dicaeus callianira	Peru: Amazonas: 'Rodríguez de Mendoza' [= Mendoza] (-6.4, -77.483)	ac58	EU275557
Actinote dicaeus callianira	Peru: Junín: no specific locality	ac25	EU275556
Actinote dicaeus ozinta	Colombia: Putumayo: no specific locality	C-17-3	EU275558
Actinote eresia eresia	Colombia: Antioquia: Alto El Indio	BMC_16368	MN306758
Actinote eresia eresia	Colombia: Antioquia: Montañitas	BMC_11135	MN306609
Actinote eresia eresina	Bolivia: Cochabamba: no specific locality	ac87	EU275559
Actinote eresia leptogramma	Ecuador: Zamora-Chinchipe: Quebrada Navidades (-3.975, -79.125)	LEP-00021	OR570623
Actinote eresia leptogramma	Ecuador: Zamora-Chinchipe: Quebrada Navidades (-3.975, -79.125)	LEP-00022	OR570624
Actinote eresia leptogramma	Ecuador: Zamora-Chinchipe: Quebrada Navidades (-3.975, -79.125)	LEP-00020	KY649580
Actinote eresia leptogramma	Ecuador: Zamora-Chinchipe: San Francisco, casa de Arcoiris (-3.988, -79.095)	LEP-00238	OR570625
Actinote eresia canyaris **n. ssp.**	Peru: Lambayeque: vía 'Kañaris' [=Cañaris] (-6.057, -79.251)	CEP-UJ-2019-1271	OR570620
Actinote erinome erinome	Peru: Junín: no specific locality	ac34	EU275516
Actinote hilaris desmiala	Ecuador: Carchi: Santa Rosa (0.827, -78.128)	LEP-04153	KY649588
Actinote hilaris desmiala	Ecuador: Napo: Estación Científica Yanayacu (-0.59, -77.883)	LEP-00240	OR570627
Actinote hilaris arcoiris **n. ssp.**	Ecuador: Morona-Santiago: km 22 Limón-Gualaceo rd. (-3.008, -78.539)	LEP-04159	OR570631
Actinote hilaris arcoiris **n. ssp.**	Ecuador: Morona-Santiago: km 22 Limón-Gualaceo rd. (-3.008, -78.539)	LEP-04160	OR570632
Actinote hilaris arcoiris **n. ssp.**	Ecuador: Zamora-Chinchipe: Quebrada Zurita (-3.972, -79.103)	LEP-04158	OR570630
Actinote hilaris arcoiris **n. ssp.**	Ecuador: Zamora-Chinchipe: Quebrada Zurita (-3.972, -79.103)	LEP-06930	OR570634
Actinote hilaris arcoiris **n. ssp.**	Ecuador: Zamora-Chinchipe: San Francisco, casa de Arcoiris (-3.988, -79.095)	LEP-00239	OR570626
Actinote hilaris arcoiris **n. ssp.**	Ecuador: Zamora-Chinchipe: San Francisco, casa de Arcoiris (-3.988, -79.095)	LEP-01555	OR570628
Actinote hilaris arcoiris **n. ssp.**	Ecuador: Zamora-Chinchipe: San Francisco, casa de Arcoiris (-3.988, -79.095)	LEP-01556	OR570629
Actinote hilaris sourakovi **n. ssp.**	Ecuador: Zamora-Chinchipe: Finca San Carlos (-4.798, -79.309)	LEP-04161	OR570633
Actinote hilaris sourakovi **n. ssp.**	Ecuador: Zamora-Chinchipe: Quebrada Honda trail (-4.472, -79.122)	LEP-00006	OR570621
Actinote hilaris sourakovi **n. ssp.**	Ecuador: Zamora-Chinchipe: Quebrada Honda trail (-4.472, -79.122)	LEP-00007	OR570622
Actinote intensa	Ecuador: Zamora-Chinchipe: Quebrada San Ramón, power station (-3.97, -79.062)	LEP-37581	KY649611
Actinote johncoulsoni	Ecuador: Zamora-Chinchipe: Finca San Carlos (-4.798, -79.309)	LEP-04156	KY649589
Actinote mamita	Argentina: Buenos Aires: Partido de Magdalena, Estancia El Destino (-35.125, -57.375)	LEPPA098-11	MF546233
Actinote melanisans	Argentina: Misiones: Departamento de Iguazú, Parque Nacional Iguazú, Seccional Yacui (-25.675, -54.169)	LEPIG155-11	MF546994
Actinote momina	Peru: Cuzco: no specific locality	RV-03-V240	EU275560
Actinote negra demonica	Bolivia: La Paz: Coroico (-16.226, -67.737)	ac46	EU275561
Actinote negra demonica	Peru: Cuzco: Santa Teresa (-13.187, -72.588)	ac45	EU275573
Actinote negra euclia	Peru: Cajamarca: no specific locality	ac64	EU275562
Actinote neleus neleus	Colombia: Antioquia: Sabaneta	ac16	EU275563
Actinote pellenea pellenea	Brazil: São Paulo: Santos (-23.967, -46.333)	ac37	EU275600
Actinote pellenea ssp	Argentina: Buenos Aires: Partido de Magdalena, Estancia El Destino (-35.125, -57.375)	LEPPA087-11	MF546829
Actinote p. pyrrhosticta **n. sp.**	Ecuador: Loja: km 13.2 Jimbura-San Andrés rd. (-4.709, -79.446)	LEP-16954	OR570635
Actinote p. pyrrhosticta **n. sp.**	Ecuador: Loja: km 13.2 Jimbura-San Andrés rd. (-4.709, -79.446)	LEP-16955	OR570636
Actinote p. pyrrhosticta **n. sp.**	Ecuador: Loja: km 13.2 Jimbura-San Andrés rd. (-4.709, -79.446)	LEP-37389	OR570637
Actinote rubrocellulata	Peru: Ancash: no specific locality	ac76	EU275564
Actinote tenebrosa tenebrosa	Ecuador: Sucumbíos: La Bonita (0.474, -77.54)	NW90-15	EU275565

A new species of *Pseudodebis* Forster, 1964 from Panama (Lepidoptera: Nymphalidae: Satyrinae)

Shinichi Nakahara[1], Albert Thurman[2] and Gordon B. Small, Jr.[†]

1. Department of Organismic and Evolutionary Biology, Museum of Comparative Zoology, Harvard University, 26 Oxford Street, Cambridge, MA 02138 USA;
2. 5138 E. Tunder Cir, Phoenix, AZ 85044 USA; †Deceased 21 January 1989. *Corresponding author: snakahara@fas.harvard.edu; snakahara@g.harvard.edu.

Date of issue online: 27 October 2023
Zoobank Registered: urn:lsid:zoobank.org:pub:7F096F3C-B421-4A6F-9F86-20AA9657CDEA
Electronic copies (ISSN 2575-9256) in PDF format at: https://journals.flvc.org/troplep; https://zenodo.org; archived by the Institutional Repository at the University of Florida (IR@UF), http://ufdc.ufl.edu/ufir; **DOI**: 10.5281/zenodo.10027654.

Abstract: A distinctive new species of *Pseudodebis* Forster, 1964 is named herein as *P. macdonaldi* Thurman & Nakahara, **n. sp.**, described and compared with congeneric taxa based solely on external morphology. This new species is known only from two male specimens from the type locality situated in Panama, collected by the senior author in the mid-1970s. A list of nymphalid butterflies collected by the senior author at the type locality of *P. macdonaldi* **n. sp.** is compiled from research notes left by him and provided here.

Resumen: Se nombra una nueva especie distintiva de *Pseudodebis* Forster, 1964 como *P. macdonaldi* Thurman & Nakahara, **n. sp.**, descrita y comparada con taxones congéneres basándose únicamente en la morfología externa. Esta nueva especie es conocida a partir de dos especímenes machos de la localidad tipo ubicada en Panamá, recolectados por el autor principal a mediados de 1970. Una lista de mariposas ninfálidas recolectadas por el autor principal en la localidad tipo de *P. macdonaldi* **n. sp.** es recopilada a partir de sus notas de investigación y estas son proporcionadas aquí.

Key Words: Bayano; Euptychiina; taxonomy; USNM.

INTRODUCTION

The so-called "*Taygetis* clade" (*sensu* Murray & Prowell, 2005) is one of the eight major clades recognized in the diverse nymphalid subtribe Euptychiina (Espeland *et al*., 2019, 2023). Like many other euptychiine genera, the generic classification of this clade has been in flux for decades until the recent rise of molecular techniques. Indeed, genetic analyses do reveal evolutionary relationships that were either unrecognized or not necessarily apparent from the study of morphology. Matos-Maraví *et al*. (2013) was the first to produce a comprehensive phylogeny for the "*Taygetis* clade" based on molecular markers, where several taxonomic changes were proposed, building on a classification scheme generated from traditional comparative morphological approaches by Forster (1964). Although subsequent phylogenetic studies (e.g., Nakahara *et al*., 2018; Espeland *et al*., 2023) consistently confirmed the monophyly of genera in the "*Taygetis* clade", challenges remain when assigning newly described species into these existing genera. The issue becomes overwhelmingly apparent when genetic data are not available for a species of interest, as well as when morphological synapomorphies for genera have not been identified. Consequently, species-level classifications in Euptychiina can still be based heavily on comparative morphological studies where species are tentatively assigned to genera by interpreting certain external morphological features (e.g., Nakahara *et al*., 2021). Nevertheless, morphological characters can be retrospectively understood in the light of molecular data, thus yielding internally consistent classifications derived from phylogenetic hypotheses generated solely on DNA data. This suggestion was recently supported by a study of *Pseudodebis* Forster, 1964, in which a synapomorphy for the genus was identified based on an ancestral state reconstruction of a male genitalic character (Nakahara *et al.,* 2021a). *Pseudodebis* is a genus supported within the so-called "*Taygetis* clade", with 13 valid species recognized to date and its center of diversity found in Central America (Nakahara *et al*., 2022).

Godman & Salvin's (1879-1899) *Biologia Centrali-Americana. Insecta. Lepidoptera-Rhopalocera* is one of the earliest contributions towards our understanding of the Central American butterfly fauna, including Panamanian butterflies. Their study was followed by several works on Panamanian butterflies in the early 1900s, such as Dyar (1914), Bell (1931, 1937), Huntington (1932) and Sheldon (1933), although the focus of some of these works was limited to Barro Colorado Island. In the past few decades, a checklist of a certain portion of the Panamanian butterfly fauna (Lamas & Small, 1992), as well as descriptions of new taxa, have been published (e.g., Willmott & Lamas, 2004 (Nymphalidae); Robbins & Duarte, 2005 (Lycaenidae); Anderson, 2014 (Hesperiidae); Nakahara *et al*., 2018 (Pieridae); Hall *et al*., 2023 (Riodinidae)), increasing our knowledge of Panamanian butterflies. It must be noted that these recent increases in knowledge regarding Panamanian butterflies rely heavily on the results of the pioneering and tireless collecting efforts made by the last author, including collecting the entire type series for several butterfly taxa (e.g., Willmott & Lamas, 2004; Nakahara *et al.*, 2021c). Although Gordon Small himself did author scientific literature (Nicolay & Small,1969, 1981; Robbins & Small, 1981; Lamas & Small, 1992; Maza & Small, 1979), his primary contribution lies in his comprehensive collection of Panamanian butterflies and research notes housed at the National Museum of Natural History, Smithsonian Institution, Washington, DC, USA (formerly United States National Museum) (USNM). Unfortunately, Gordon left this world unexpectedly early, leaving with us a rich legacy. Nevertheless, Gordon's spirit still lives on in a number of modern lepidopterists, especially those who share the same interests and motivation in documenting the rich butterfly fauna of Panama. For instance, John Richard MacDonald is an outstanding lepidopterist whose numerous trips to Panama, often accompanied by the second author, have contributed to recent descriptions of new Lepidoptera species from Panama and adjacent countries (e.g., St Laurent *et al*., 2019; Nakahara *et al*., 2018, 2021b). John is one such individual who has been inspired by Gordon and carries his legacy forward by exploring the rich butterfly fauna of Panama.

Here, we name and describe a new species of *Pseudodebis* from Panama based solely on morphological study. This taxon is known to date by two individuals from Bayano, Panama, both collected by the senior author, and we take this opportunity to name this species after John R. MacDonald, not only to recognize his contributions in increasing our knowledge of Panamanian butterflies, but also to acknowledge the high esteem he holds for the senior author. Additionally, we assembled a checklist of nymphalid butterflies collected by the senior author at the type locality based on his research notes and existing specimens housed at the USNM.

MATERIALS AND METHODS

The senior (GBS) and the second author (AT), as well as other colleagues, have been conducting field work in Panama since the 1960s to collect butterfly specimens for faunistic study, which has resulted in a total of >1,00 days of field work throughout the country. We examined the extensive collecting records and miscellaneous notes of Panamanian butterflies for >50,000 specimens compiled by GBS (Smithsonian Institution Archives. Record Unit 7474, Box 1). In addition, we reviewed >20 years of correspondence between GBS and Colonel Stanley Swenson Nicolay (1917-2004) (hereunder Stan) starting from 1 July 1960, currently kept separate from the aforementioned archives. Based on these archival notes, a checklist of nymphalid taxa from the type locality (Bayano, Panama) of *P. macdonaldi* **n. sp.** collected by GBS is compiled and provided in Table 1. We made an attempt to clarify the identities of these nymphalid specimens in the notes by examining the GBS collection at the USNM. The revised identification of these nymphalid butterflies is also provided (where necessary), in addition to collection dates recorded from labels.

The authors and other colleagues have examined *Pseudodebis* specimens in several public and private collections in Europe and the Americas, including type materials, as indicated in our preceding studies revising species-level classifications of the genus (Nakahara *et al*., 2021a,b, 2022). Information used for comparative study in the current work, as well as application of species-group names, is largely based on specimens studied while preparing these three articles. We also studied the external morphology of *P. macdonaldi* **n. sp.** largely in accordance with these preceding works on *Pseudodebis*, with the male genitalic dissection vial indicated below. The genitalia were imaged using Canon EOS 5D Mark II, outfitted with a Canon MP-E 65mm f/2.8 1-5x Macro Lens by appending a 1.4 tele-extender, stacked with Helicon Focus. All the morphological study was conducted at the USNM.

SPECIES DESCRIPTION

Pseudodebis macdonaldi Thurman & Nakahara, **new species**

(Figs. 1-2)

Systematic placement and diagnosis. The "*Taygetis* clade" is embedded inside a large clade containing the "*Pareuptychia* clade", "*Splendeuptychia* clade" and "*Archeuptychia* clade" (Espeland *et al*., 2019, 2023). The genus *Pseudodebis* is recovered as sister to *Taguaiba* Freitas, Zacca & Siewert, 2023 within the "*Taygetis* clade". Despite the lack of genetic data to assess the systematic placement of *P. macdonaldi* **n. sp.**, this taxon can be accommodated in the '*valentina* clade" (*sensu* Nakahara *et*

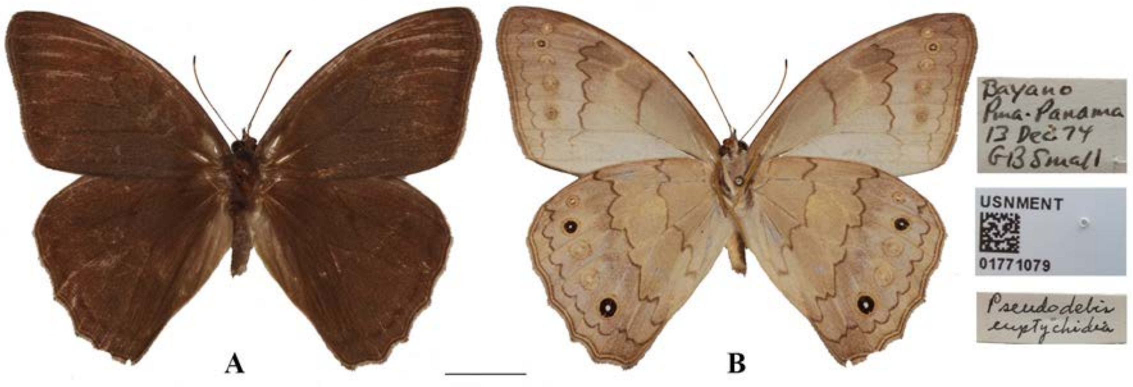


Figure 1. The holotype specimen of *Pseudodebis macdonaldi* **n. sp.** (USNM-ENT 01771079) with associated labels: A) dorsal surface; B) ventral surface. Scale bar = 10 mm.

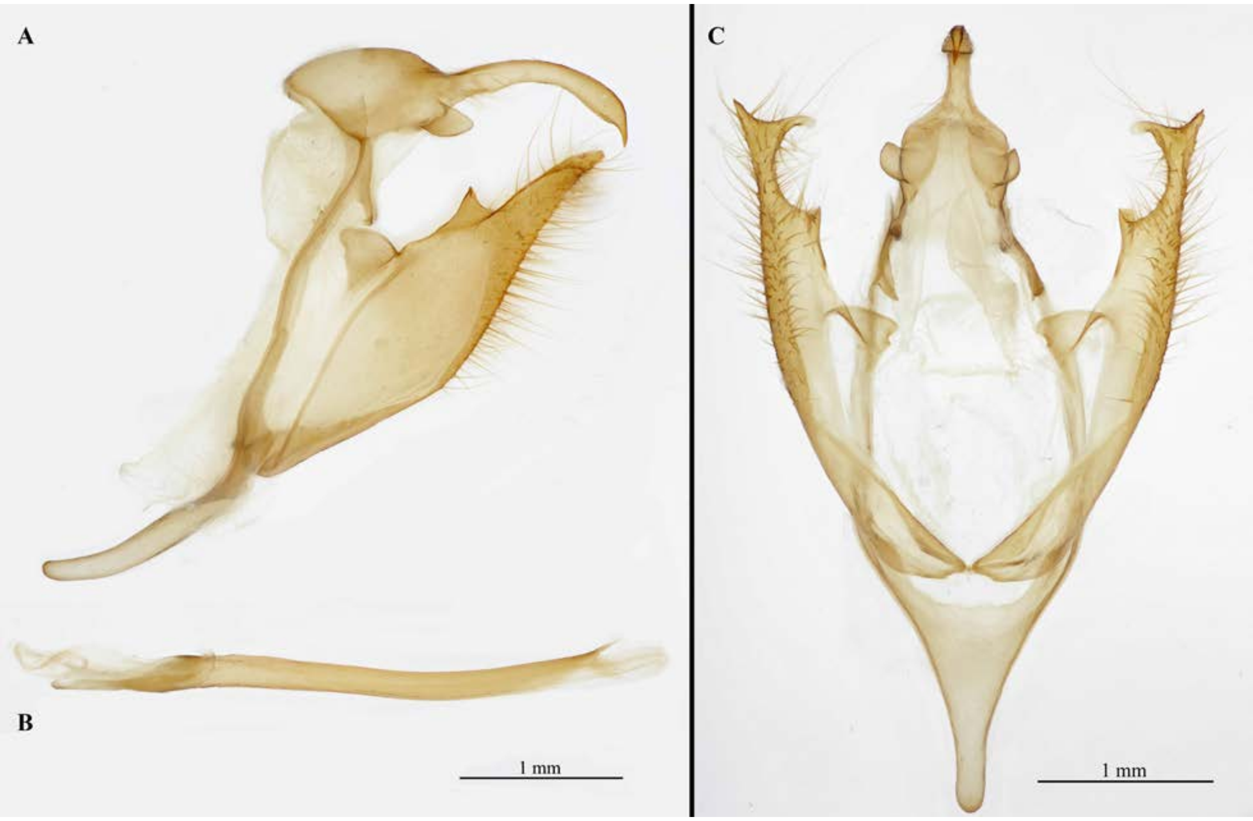


Figure 2. The male genitalia of *Pseudodebis macdonaldi* **n. sp.** (USNM-ENT 01771079): A) genitalia in lateral view; B) phallus in lateral view; C) genitalia in ventral view.

al., 2021a,b: Fig. 1) of *Pseudodebis* based on characters (2), (4), (5), (6), (7) provided below. *Pseudodebis macdonaldi* **n. sp.** is readily distinguished from other congeneric species by the combination of these following characters: 1) pale ocher ventral surface; 2) jagged ventral forewing postdiscal band as well as undulating ventral hindwing discal and postdiscal band; 3) lack of orangish scaling in the ventral hindwing discal cell; 4) ocellus in ventral hindwing cells M_1 and Cu_1 with a black central area; 5) brachia reduced but clearly visible (compared to species in the "*celia* clade" of *Pseudodebis* where this structure is absent); 6) triangular projection present along dorsal margin of valva distal of costa; 7) inner margin of apical process of the valva curved inwards, forming a hooked projection (visible in dorsal and ventral view). To date, no other congeneric species are found in micro-sympatry with *P. macdonaldi* **n. sp.**, although characters discussed above distinguish this taxon from other Panamanian *Pseudodebis*. Additionally, *P. macdonaldi* **n. sp.** somewhat resembles *Sepona punctata* (Weymer, 1911), but the former taxon can be distinguished from the latter by these following characters: a) rather falcate forewing shape; b) ventral forewing and hindwing submarginal bands wavy (curving outwards in each cell) (compared to more zig-zagged submarginal band of *S. punctata*); c) uncus narrow and curving; d) reduced brachia.

Description. MALE: Forewing length: 30.3-32.7 mm (n=2). **Head:** Eyes with light brown hair-like setae, white scales at base; first segment of labial palpi short, with white scales and concolorous elongated hair-like scales ventrally, second segment about twice as long as eye depth, dorsally and ventrally with white long hair-like setae, outside appearing darker, third segment porrect, with brownish scales and white scales visible laterally; antennae orangish, *ca*. 34 flagellomeres (n=2; scape and pedicel not examined), distal five flagellomeres darker, antennae shorter than length of forewing discal cell (from base to discocellular vein), distal 9-10 flagellomeres composing rather insignificant club. **Thorax:** Brown, dorsally with light brown scales and long hair-like scales, laterally and ventrally (i.e., below wings) with white scales and hair-like scales; prothoracic leg with white long hair-like setae; pterothoracic leg femur whitish ventrally, tibia and tarsus light ocher with pair of tibial spurs, equal in length, at distal end of tibia, longitudinal rows of spines visible on ventral side of tibia and tarsus, as well as row of spines discernible laterally on both sides of tibia (inner side of tibia with greater number of spines). **Abdomen:** Eighth tergite not located in genitalic vial. **Wing venation, shape and pattern:** Forewing rather elongate and somewhat falcate: forewing recurrent vein absent in discal cell; hindwing humeral vein developed; dark androconial scales present on roughly basal two-thirds of dorsal forewing (visible when lit from underneath), otherwise wing shape and pattern as illustrated in Fig. 1 and described in comparison with other congeneric species above (see "Systematic placement and diagnosis"). **Genitalia:** Setae visible at base of uncus, cornuti absent, otherwise as illustrated in Fig. 2, and described in comparison with other congeneric species (see "Systematic placement and diagnosis").

FEMALE: Unknown or unrecognized.

Types. HOLOTYPE, male from Bayano, Panama, with the following labels written verbatim, separated by double slashes: //Bayano Pma. [Panamá Province] Panama 13 Dec 74 G B Small// USNMENT 01771079// St Laurent dissection: USNM-ENT 01771079// (USNM). PARATYPE, male with the following labels written verbatim, separated by double slashes: //Bayano Pma. [Panamá Province] Panama 25 Jan 75 G B Small// USNM-ENT 01771080// (USNM).

Etymology. This species-group name is in recognition of John R. MacDonald, an extremely dedicated and imaginative lepidopterist whose numerous collecting trips to Panama have greatly enhanced our understanding of Panamanian butterfly fauna. John is from Massachusetts, USA, and met Gordon in Panama in the mid-1970s, where Gordon was his math teacher at Balboa Junior College. The specific epithet should be regarded as a Latinized masculine noun in the genitive case.

Type locality. *Pseudodebis macdonaldi* **n. sp.** was identified as *Pseudodebis* "*euptychidia* Butler" in the research notes of GBS (Fig. 3) and these two specimens were previously identified as such in the USNM collection. The day and year of collection were not specified in GBS's notes, and the month of collection was indicated as XII [December] and I [January] for *P.* "*euptychidia*", which corresponds to information on the labels associated with the two known specimens in the type series. The type locality of *P. macdonaldi* **n. sp.** is indicated as "Bayano" on the labels associated with the holotype and paratype, and this handwritten label by GBS is the typical label for specimens from this site (Fig. 1). On the other hand, this site is referred to as "Rio [Río] Bayano" in Gordon's field notes. This slight discrepancy regarding the locality name between Gordon's research notes and the labels can be seen in many other species from "Bayano" (e.g., four specimens of *Splendeuptychia salvini* (Butler, 1867) (Nymphalidae) all bear a label with "Bayano", written by GBS, whereas the site is referred to as "Rio Bayano" in his notes). These two terms are thus used interchangeably, both referring to an area in Panamá Province where Bayano Lake is currently situated, as seen in the map of eastern Panama dated "28/II/[19]77", found in a folder labeled as "Lepid. Misc" (folder number unspecified) among the archival documents which were possessed by GBS (Fig. 4A). This map, illustrating various construction projects of the Pan-American highway, was likely used by GBS to navigate sites, evidenced by the marking of "Río Tortí" in his handwriting. The locality name "Bayano" was likely applied by GBS based on where the Bayano bridge is currently situated. Another document entitled "Carretera Panamericana - east of Panamá City" originating from the same folder also shows the association between the bridge and the term "Bayano" (Fig. 4B; this map is likely produced by GBS based on Fig. 4A). The Bayano Bridge opened in late 1974 to early 1975 (Miller, 2014), around the time type materials of *P. macdonaldi* **n. sp.** were collected. In fact, the majority of specimens from "Bayano" collected by GBS were obtained between May 1974 and February 1975 (e.g., Table 1), presumably due to access to the area not being possible until then. Despite the extensive correspondence between GBS and Stan bound in two large files, beginning with a letter dated 1 July 1960 (from GBS to Stan), the locality "Bayano" did not appear nor was discussed in their letters prior to 1975:

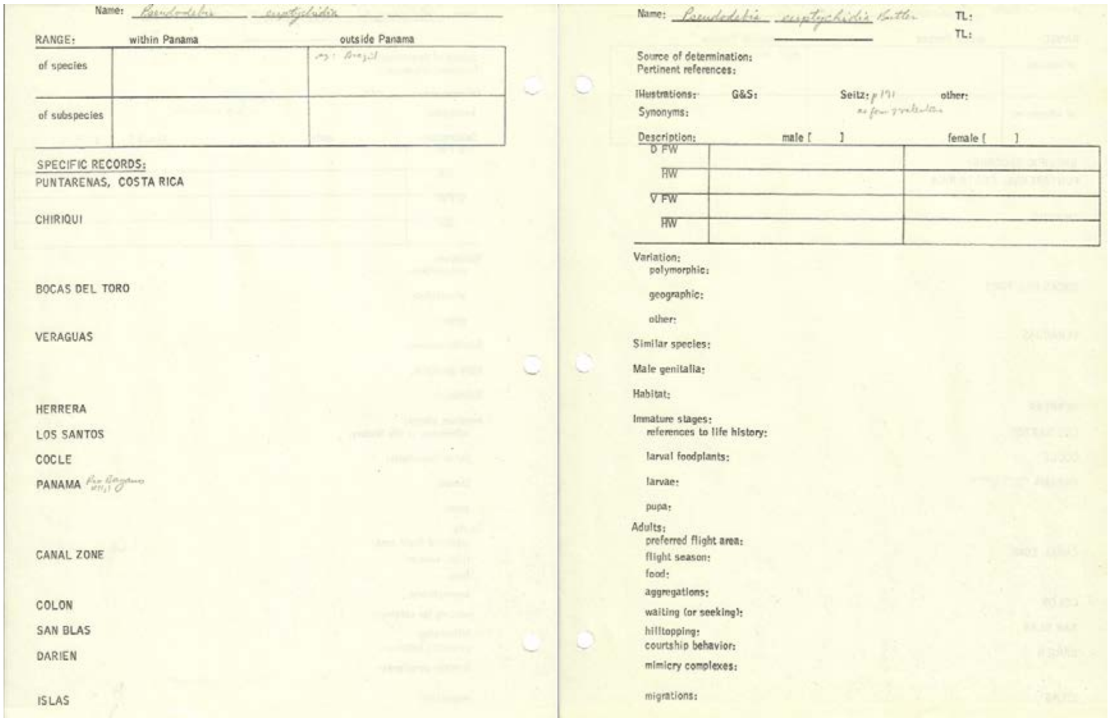
15 December 1975 - GBS writes to Stan and states that Keith [Spalding Brown, Jr.] is arriving in Panama and would like to collect in the Bayano area. GBS also mentions about "that picky National Guardsman" on the Bayano bridge [Stan and Gordon collected (together ?) in Bayano in January 1975].

1 January 1978 - GBS writes to Stan and states that his sighting of GBS at Bayano several years ago is confirmed.

15 October 1978 - GBS writes to Stan and states the he has been to the Bayano area a couple of times, and hopes to get back there multiple times in the fall.

1 November 1978 - GBS writes to Stan and states that the Bayano road has been paved and further explains that the site not been as productive as it used to be for "Theclas" (i.e., *Thecla* Fabricius, 1807 (Lycaenidae)) due to logging of the area.

4 November [1978] - GBS writes to Stan and states that he went to Bayano the previous day and had "beautiful weather but



Name: Pseudodebis euptychidia

RANGE:	within Panama	outside Panama
of species		eg: Brazil
of subspecies		

SPECIFIC RECORDS:
PUNTARENAS, COSTA RICA
CHIRIQUI
BOCAS DEL TORO
VERAGUAS
HERRERA
LOS SANTOS
COCLE
PANAMA Rio Bayano XII, I ♂
CANAL ZONE
COLON
SAN BLAS
DARIEN
ISLAS

Name: Pseudodebis euptychidia Butler TL:
TL:
Source of determination:
Pertinent references:
Illustrations: G&S: Seitz: p 191 [illegible] other:
Synonyms:

Description:	male [ ]	female [ ]
D FW		
HW		
V FW		
HW		

Variation:
polymorphic:
geographic:
other:
Similar species:
Male genitalia:
Habitat:
Immature stages:
references to life history:
larval foodplants:
larvae:
pupa:
Adults:
preferred flight area:
flight season:
food:
aggregations:
waiting (or seeking):
hilltopping:
courtship behavior:
mimicry complexes:
migrations:

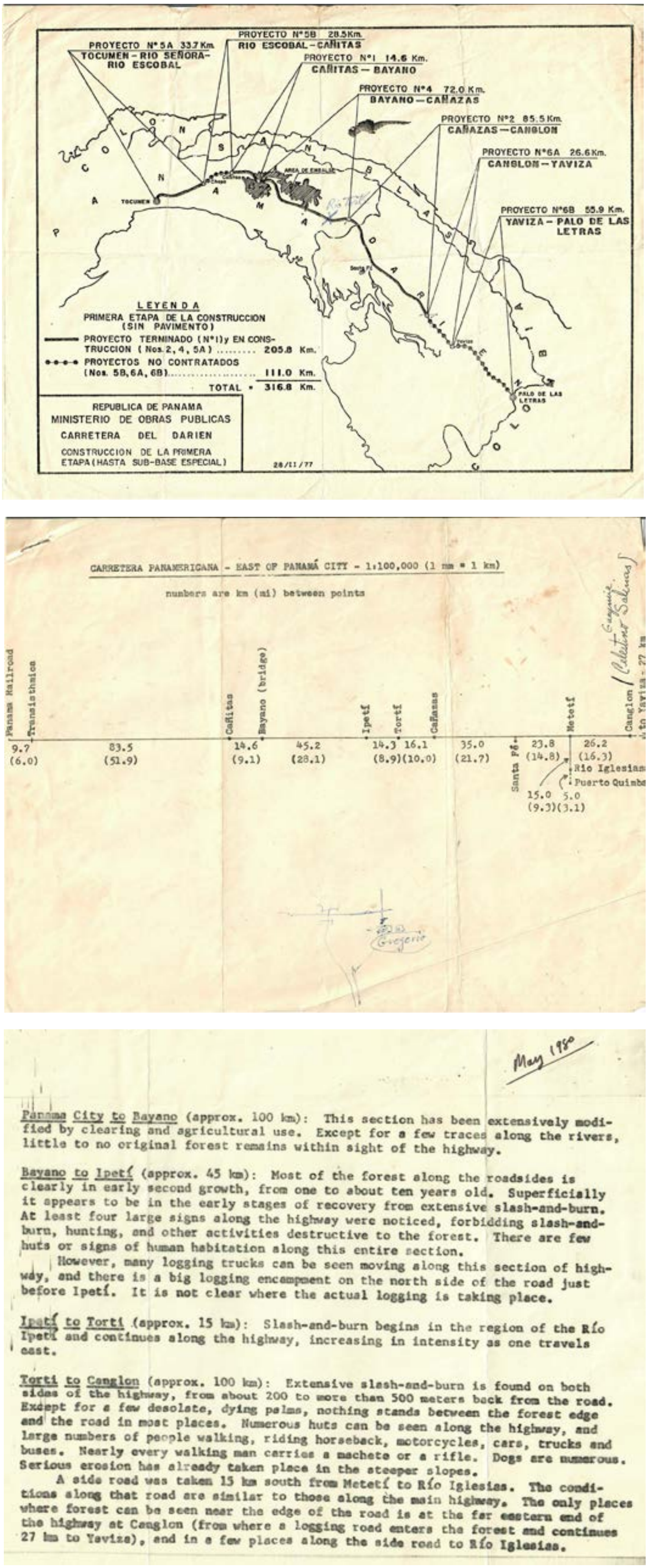
Figure 3. A page on *Pseudodebis* "*euptychidia*" (= *P. macdonaldi* **n. sp.**) from the senior author's research notes. Smithsonian Institution Archives. Record Unit 7474, Box 1. Folder 10.

poor collecting”.

9 December 1978 - GBS writes to Stan and states that he will be giving a selection of the Bayano material [specimens].

In addition, a letter dated 22 October 1978 sent from GBS to Philip J. DeVries states that GBS “jostled through potholed roads to get to a spot in the Bayano River region”. The fact that the locality name “Bayano” was not used by GBS prior to 1975, coupled with the existence of a map associating the name with the bridge (Fig. 4B), reinforces the hypothesis that GBS based his locality name on the bridge rather than Río Bayano. Thus, the type locality of *P. macdonaldi* **n. sp.** is likely to be in the vicinity of the Bayano bridge. Back then, “Bayano” could have meant the general area in the vicinity of where the highway terminated or where the dam construction was ongoing until the construction of the bridge. As mentioned in letters from GBS to Stan in 1978, Bayano was no longer a prolific collecting site for GBS. This explains why sampling at Bayano by GBS was concentrated from 1974 to early 1975 and became sporadic subsequently, as well as implying the original habitat of *P. macdonaldi* **n. sp.** perhaps no longer existed even back in 1978 when GBS revisited the area. The whereabouts of “Bayano”

Figure 5. General habitat pictures of Bayano based on trails located approximately 10 km east of Bayano bridge (9°9'58.1652"N, 78°42'27.9102"W). A) photographed in August 2014; B) photographed in May 2009. Both photographed by AT.



May 1980

Panama City to Bayano (approx. 100 km): This section has been extensively modified by clearing and agricultural use. Except for a few traces along the rivers, little to no original forest remains within sight of the highway.

Bayano to Ipetí (approx. 45 km): Most of the forest along the roadsides is clearly in early second growth, from one to about ten years old. Superficially it appears to be in the early stages of recovery from extensive slash-and-burn. At least four large signs along the highway were noticed, forbidding slash-and-burn, hunting, and other activities destructive to the forest. There are few huts or signs of human habitation along this entire section.

However, many logging trucks can be seen moving along this section of highway, and there is a big logging encampment on the north side of the road just before Ipetí. It is not clear where the actual logging is taking place.

Ipetí to Torti (approx. 15 km): Slash-and-burn begins in the region of the Río Ipetí and continues along the highway, increasing in intensity as one travels east.

Torti to Canglon (approx. 100 km): Extensive slash-and-burn is found on both sides of the highway, from about 200 to more than 500 meters back from the road. Except for a few desolate, dying palms, nothing stands between the forest edge and the road in most places. Numerous huts can be seen along the highway, and large numbers of people walking, riding horseback, motorcycles, cars, trucks and buses. Nearly every walking man carries a machete or a rifle. Dogs are numerous. Serious erosion has already taken place in the steeper slopes.

A side road was taken 15 km south from Metetí to Río Iglesias. The conditions along that road are similar to those along the main highway. The only places where forest can be seen near the edge of the road is at the far eastern end of the highway at Canglon (from where a logging road enters the forest and continues 27 km to Yaviza), and in a few places along the side road to Río Iglesias.

Figure 4. Various archival notes: A (top). A construction map of Panamerican highway in eastern Panama dated “28/II/[19]77”; B (middle). “Carretera Panamericana - east of Panamá City”, presumably produced by GBS; C (bottom). Observational notes from the relevant portion of the highway by GBS. Smithsonian Institution Archives. Record Unit 7474, Box 1. Folder with “Lepid. Misc” written on the front.

(*sensu* GBS) remain unspecified with precision, although information on the Bayano area in the 1970s is available in Ridgely (1976: 361-362): "*Beyond El Llano the main road enters increasingly forested country, and will soon be open beyond the Bayano River... The present forested aspect of most of this area will likely soon be altered, unfortunately, both because of the effect of the new road, and because of the big dam under construction on the Bayano at a site several miles above El Llano*" (from the "Chepo and Points East" section). A typed note dated "May 1980", presumably written by GBS based on his observation of the area, confirms the ongoing logging east of Bayano, as well as deforestation between Bayano and Panama City (Fig. 4C). As indicated from these quotes, Bayano has undergone deforestation since the 1970s. The contiguous tropical forests which stretched from Chepo to Darién until the 1960s were converted into pasture and subsistence agricultural plots by mestizo farmers from the interior of the country (Sloan, 2007). The damming of Río Bayano created Bayano Lake in 1976, an artificial impoundment with a surface area of approximately 350 km^2. The Pan-American highway extended eastwards in the mid-1970s and reached Darién in 1979. Despite approximately 15 days of recent field work at Bayano by AT and colleagues (Fig. 5), *P. macdonaldi* **n. sp.** has not been rediscovered since the collection of the type series in the mid-1970s. A study is underway to compile specimen data and a list of locality names associated with specimens in the GBS collection, and reference them to their present-day locations and names (Nakahara *et al*., in prep.). As part of this ongoing effort towards compiling data from the GBS collection, a list of nymphalid butterflies collected by GBS at the type locality of *P. macdonaldi* **n. sp.** with their date of sampling is provided in Table 1.

Biology. Unknown.

Table 1. A checklist of nymphalid butterflies collected by the senior author (GBS) in Bayano, Panama. Dates are incorporated from label data from specimens at USNM; N/A for the date denotes corresponding specimen(s) not located at USNM.

Subfamily	ID by GBS	Revised ID	Date	Notes
Libytheinae	*Libythea carinenta*	*Libytheana carinenta* (Cramer, 1777)	[IX-22-1974]	Partí + Rio Bayano
Charaxinae	*Archaeoprepona demophon*	N/A	N/A	
	Prepona demophoon	N/A	N/A	
	Prepona antimache	N/A	N/A	
	Anaea fabius	N/A	N/A	
	Anaea pithyusa	N/A	N/A	
Satyrinae	*Caerois gerdrudtus*	N/A	[XI-29-1974]	
	Morpho peleides	*Morpho helenor* (Cramer, 1776)	[X 1974]	
	Opsiphanes cassina	N/A	N/A	
	Pierella luna	N/A	[IX-29-1974]	
	Cithaerias menander	N/A	[IX-29-1974], [X-12-1974]	
	Euptychia mollina	*Euptychia mollis* Staudinger, 1876	[IX-22-1974]	
	Euptychia picea group	N/A	N/A	
	Pareuptychia sp. nr. *metaleuca*	*Pareuptychia metaleuca* (Boisduval, 1870)	[X-5-1974]	
	Vareuptychia sp.	*Paryphthimoides terrestris* (Butler, 1876)	[IX-28-1974]	
	Vareuptychia sp. (*pompilia* group)	N/A	N/A	
	Euptychia gulnare	*Taygetina gulnare* (Butler, 1870)	[IX-28-1974], [X-18-1974], [XI-10-1974]	
	Cissia sp. (*confusa* group)	*Modica confusa* (Staudinger, 1887)	[IX-28-1974]	
	Magneuptychia sp. (E-8)	*Modestia gomezi* (Singer, DeVries & Ehrlich, 1983)	[XII-1-1974]	
	Cissia libye	*Magneuptychia libye* (Linnaeus, 1767)	[IX-29-1974]	
	Splendeuptychia salvini	N/A	[XII-20-1974], [XII-22-1974], [I-24-1975], [XII-7-1977]	
	Posttaygetis penelea	N/A	[XI-29-1974], [II-1-1975]	
	Pseudodebis euptychidia	*Pseudodebis macdonaldi* Thurman & Nakahara, **n. sp.**	[XII-13-1974], [I-25-1975]	
	Taygetis kerea	N/A	N/A	
	Taygetis godmani	N/A	[IX-29-1974]	
	Taygetis salvini	N/A	[XI-2-1974]	
	Taygetis mermeria	N/A	[XII-22-1974]	
Danainae	*Thyridia psidii*	N/A	[IX-26-1974], [X-20-1974], [XI-28-1974], [XII-15-1974], [I-5-1974], [II-1-1975]	Partí + Rio Bayano
	Mechanites polymnia	N/A	[IX-28-1974], [IX-29-1974], [II-1-1975], [II-7-1975], [II-8-1975]	
	Mechanites lysimnia complex	*Mechanites lysimnia* (Fabricius, 1793)	[IX-22-1974], [I-25-1974], [II-8-1975]	Río Partí + Rio Bayano
	Mechanites menapis complex	*Mechanites menapis* Hewitson, 1856	[X-20-1974]	
	Napeogenes peridia complex	*Napeogenes peridia* (Hewitson, 1845)	[IX-22-1974], [IX-28-1974]	
	Hypothyris euclea	N/A	[I-31-1975], [II-1-1975]	
	Hypothyris lycaste	N/A	[IX-22-1974]	Bayano + Maje
	Ithomia iphianassa	N/A	[IX-28-1974], [IX-29-1974], [X-12-1974]	Río Partí + Rio Bayano

Table 1, continued. A checklist of nymphalid butterflies collected by the senior author (GBS) in Bayano, Panama. Dates are incorporated from label data from specimens at USNM; N/A for the date denotes corresponding specimen(s) not located at USNM.

Subfamily	ID by GBS	Revised ID	Date	Notes
	Ithomia drymo	*Ithomia jucunda* Godman & Salvin, 1878	[V-3-1974], [V-4-1974], [IX-29-1974], [XI-2-1974]	
	Aeria eurimedia	N/A	[II-8-1975]	
	Oleria paula complex	*Oleria paula* Weymer, 1883	[IX-28-1974]	
	Oleria sp. (Bayano)	*Oleria thiemei* (Oberthür, 1879)	[IX-28-1974], [IX-22-1974], [XI-29-1974], [II-8-1975]	
	Callithomia hezia complex	*Callithomia heiza* (Hewitson, [1854])	[V-3-1974], [II-5-1975], [II-8-1975]	
	Callithomia alexirrhoe	*Callithomia hydra* (C. Felder & R. Felder, 1865)	[V-3-1974], [IX-21-1974], [X-20-1974], [XII-14-1974], [XII-16-1974], [I-25-1975], [I-26-1975]	
	Dircennina dero	N/A	[IX-29-1974], [XI-10-1974], [XII-15-1974],	Río Partí + Bayano
	Pteronymia alope	*Pteronymia obscuratus* (Fabricius, 1793)	[IX-22-1974], [IX-28-1974], [IX-29-1974]	
	Pteronymia cotytto	N/A	[IX-22-1974], [IX-28-1974], [X-12-1974], [XI-2-1974]	
	Pteronymia donata complex	*Pteronymia donella* (C. Felder & R. Felder, 1865)	[V-3-1974]	
	Pteronymia vestilla	N/A	N/A	
	Pteronymia latilla	N/A	[XII-13-1974]	
	Lycorea atergatis	*Lycorea halia* (Hübner, 1816)	[XI-2-1974]	
	Heterosais giulia complex	*Heterosais giulia* (Hewitson, 1855)	[XI-2-1974]	
	Hypoleria sp. (Bayano)	*Hypoleria lavinia* (Hewitson, 1855)	[IX-22-1974], [IX-28-1974], [IX-29-1974], [XII-15-1974],	Maje + Rio Bayano
Cyrestinae	*Marpesia petreas*	N/A	N/A	
	Marpesia berania	N/A	[XI-2-1974]	
	Marpesia chiron	N/A	[IX-29-1974]	
Apaturinae	*Doxocopa laure*	N/A	N/A	Río Partí + Bayano
	Doxocopa pavon	N/A	N/A	Río Partí + Bayano
Nymphalinae	*Hypolimnas misippus*	N/A	N/A	
	Janatella leucodesma	N/A	[X-6-1978]	Río Partí + Bayano
	Castilia griseobasalis	N/A	[X-11-1974], [X-12-1974], [X-18-1974],	Río Partí + Bayano
	Eresia eunice	N/A	[IX-28-1974], [IX-29-1974]	
	Eresia clara	*Eresia clio* (Linnaeus, 1758)	[XI-2-1974]	Río Partí + Bayano
	Phyciodes frisia	*Anthanassa frisia* (Poey, 1832)	[I-1975]	
	Anthanassa drusilla	N/A	[X-6-1974]	
	Chlosyne lacinia	N/A	[X-19-1974]	Río Partí + Bayano
	Chlosyne narva	N/A	[X-20-1974]	Río Partí + Bayano
	Hypanartia letha	N/A	[XI-2-1974]	
	Anartia fatima	N/A	N/A	Río Partí + Bayano
	Colobura dirce	N/A	N/A	
	Tigridia acesta	N/A	[X-12-1974]	
Limenitidinae	*Adelpha cocala*	N/A	[XI-10-1974]	
	Adelpha iphicla	*Adelpha iphiclus* (Linnaeus, 1758)	[XI-1974]	
	Adelpha basiloides	*Adelpha paraena* (Bates, 1865)	[I-1975]	
	Adelpha naxia	N/A	[X-18-1974]	
	Adelpha ixia	*Adelpha phylaca* (Bates, 1866)	[X-20-1974], [I-1975]	
	Adelpha cythera	*Adelpha serpa* (Boisduval, 1836)	[X-12-1974], [XI-23-1974]	Río Partí + Bayano
Heliconiinae	*Eueides aliphera*	N/A	[XI-2-1974]	Partí + Rio Bayano
	Eueides isabella	N/A	[X-20-1974]	Partí + Rio Bayano
	Heliconius hecale complex	*Heliconius hecale* (Fabricius, 1776)	[X-20-1974]	
	Heliconius ismenius complex	*Heliconius ismenius* Latreille, 1817	[X-20-1974], [I-26-1975]	Partí + Rio Bayano
	Heliconius melpomene complex	*Heliconius melpomene* (Linnaeus, 1758)	[X-22-1974]	Partí + Rio Bayano
	Heliconius cydno complex	*Heliconius cydno* (Doubleday 1847)	N/A	
	Heliconius erato complex	*Heliconius erato* (Linnaeus, 1758)	[XI-2-1974], [XI-10-1974]	Partí + Rio Bayano
Biblidinae	*Hamadryas feronia*	N/A	N/A	
	Hamadryas iphthima	N/A	[X-12-1974]	
	Ectima rectifascia	N/A	N/A	
	Eunica monima	N/A	N/A	
	Temenis laothoe	N/A	[X-20-1974]	Río Partí + Bayano
	Pyrrhogyra neaerea	N/A	N/A	
	Pyrrhogyra crameri	N/A	[XII-14-1974]	Río Partí + Bayano
	Catagramma lyca	N/A	N/A	
	Diaethria marchalii	*Diaethria clymena* (Cramer, 1775)	[X-21-1974]	
	Dynamine pierioides	*Dynamine athemon* (Linnaeus, 1758)	[X-6-1974], [X-11-1974], [XI-23-1974], [XI-24-1974]	

ACKNOWLEDGMENTS

We thank Robert K. Robbins, Brian Harris, and Ryan St Laurent (USNM) for allowing us to access materials at USNM; Robert K. Robbins and Brian Harris for kindly loaning us valuable archival notes kept at USNM; Philip J. DeVries and Julia Meyer for providing us access to GBS letters; Karolyn Darrow (USNM) for photographing the genitalia; John R. MacDonald for discussion and inspiration; Tad Bennicoff (USNM) for allowing us to access the Smithsonian Institution Archives; Pável Matos-Maraví and another reviewer for reviewing the manuscript post-submission; Sebastián Padrón for improving the Spanish abstract; SN acknowledges an Edward O. Wilson Biodiversity Postdoctoral Fellowship at Harvard University.

LITERATURE CITED

Anderson, A. 2014. A new species of *Panoquina* from Panama (Lepidoptera: Hesperiidae, Hesperiinae, Calpodini). *Tropical Lepidoptera Research* 24(1): 1-3.

Bell, E. L. 1931. A list of Hesperiidae from Barro Colorado Island, Canal Zone, and adjacent Panama, with a description of a new species. *Journal of the New York Entomological Society* 39 (1): 81-108.

Bell, E. L. 1937. A new species of Hesperiidae, and notes on others, from Panama (Lepidoptera-Rhopalocera). *American Museum Novitates* 938: 1-7.

Dyar, H. G. 1914. Report on the Lepidoptera of the Smithsonian Biological Survey of the Panama Canal Zone. *Proceedings of the US National Museum* 47(2050): 139-350.

Espeland, M., Breinholt, J. W., Barbosa, E. P., Casagrande, M. M., Huertas, B., Lamas, G., Marín, M. A., Mielke, O. H. H., Miller, J. Y., Nakahara, S., Tan, D., Warren, A. D., Zacca, T., Kawahara, A. Y., Freitas, A.V.L., Willmott, K. R. 2019. Four hundred shades of brown: Higher level phylogeny of the problematic Euptychiina (Lepidoptera, Nymphalidae, Satyrinae) based on hybrid enrichment data. *Molecular Phylogenetics and Evolution* 131: 116-124.

Espeland, M., Nakahara, S., Zacca, T., Barbosa, E. P., Huertas, B., Marín, M. A., Lamas, G., Benmesbah, M., Brévignon, C., Casagrande, M. M., Fåhraeus, C., Grishin, N., Kawahara, A. Y., Mielke, O. H. H., Miller, J. Y., Nakamura, I., Navas, V., Patrusky, B., Pyrcz, T. W., Richards, L., Tan, D., Tyler, S., Viloria, Á., Warren, A. D., Xiao, L., Freitas, A. V. L., Willmott, K. R. 2023. Combining target enrichment and Sanger sequencing data to clarify the systematics of the diverse Neotropical butterfly subtribe Euptychiina (Nymphalidae, Satyrinae). *Systematic Entomology* 48(4): 498-570.

Forster, W. 1964. Beiträge zur Kenntnis der Insektenfauna Boliviens XIX. Lepidoptera III. Satyridae. *Veröffentlichungen der zoologischen Staatssammlung München* 8: 51-188.

Godman, F. D., Salvin, O. 1879-1899. *Biologia Centrali-Americana. Insecta. Lepidoptera-Rhopalocera*. London, Dulach & Co.

Hall, J. P. W., Willmott, K. R., Ahrenholz, D. H. 2023. A review of the *Argyrogrammana* fauna of the Transandean region (Lepidoptera: Riodinidae: Symmachiini). *Tropical Lepidoptera Research* 33(Supplement 1): 49-60.

Huntington, E. I. 1932. A list of the Rhopalocera of Barro Colorado Island, Canal Zone, Panama, with descriptions of two new species of Theclinae. *Bulletin of the American Museum of Natural History* 63(3): 191-230.

Lamas, G., Small, G. B. 1992. *Catalogue of the Nymphalinae of Panama (Lepidoptera: Nymphalidae)*, pp. 554-566. *In*: Quintero, D., Aiello, A. (Eds.), *Insects of Panama and Mesoamerica. Selected studies*. Oxford, Oxford University Press

Matos-Maraví, P. F., Peña, C., Willmott, K. R., Freitas, A. V. L., Wahlberg, N. 2013. Systematics and evolutionary history of butterflies in the "*Taygetis* clade" (Nymphalidae: Satyrinae: Euptychiina): Towards a better understanding of Neotropical biogeography. *Molecular Phylogenetics and Evolution* 66: 54-68.

Maza-Elvira, J. de la., Small, G. B. 1979. Descripción del macho de *Epiphile grandis* Butler (Nymphalidae). *Revista de la Sociedad mexicana de Lepidopterología* 4(2): 57-60.

Miller, W. 2014. *Historical logging in eastern Panama: Genesis of a social-ecological landscape*. Canada, McGill University, Smithsonian Tropical Research Institute. *In*: *Panama Field Studies Semester ENVR Report* 451.

Murray, D., Prowell, D. P. 2005. Molecular phylogenetics and evolutionary history of the neotropical Satyrine subtribe Euptychiina (Nymphalidae: Satyrinae). *Molecular Phylogenetics and Evolution* 34: 67-80.

Nakahara, S., Janzen, D. H., Hallwachs, W., Huertas, B., Das, G. N., Willmott, K. R. 2022. Revision of the "*celia* clade" of *Pseudodebis* Forster, 1964, with two new species and notes on *Papilio phorcys* Fabricius, 1793 (Lepidoptera: Nymphalidae: Satyrinae). *Neotropical Entomology* 51: 536-556.

Nakahara, S., MacDonald, J. R., Delgado, F., Padrón, P. S. 2018. Discovery of a rare and striking new pierid butterfly from Panama (Lepidoptera: Pieridae). *Zootaxa* 4527 (2): 281-291.

Nakahara, S., Matos-Maraví, P., Barbosa, E. P., Willmott, K. R., Lamas, G., Freitas, A. V. L. 2019. Two new species of *Taygetina* with a possible case of 'Juxta Loss' in butterflies (Lepidoptera: Nymphalidae: Satyrinae). *Insect Systematics and Diversity* 3: 1-13.

Nakahara, S., Matos-Maraví, P., Schwartz, J., Willmott, K. R. 2021a. Assessing generic synapomorphy of *Pseudodebis* Forster, 1964 (Lepidoptera: Nymphalidae: Satyrinae) and a recent speciation between two new species with a shift in elevation in the western Andes. *Invertebrate Systematics* 35: 158-180.

Nakahara, S., Matos-Maraví, P., Willmott, K. R., Nakamura, I., MacDonald, J. R. 2021b. Description of a new species of *Pseudodebis* Forster, 1964 from Central America. (Lepidoptera: Nymphalidae: Satyrinae). *Tropical Lepidoptera Research* 31(1): 35-41.

Nakahara, S., Willmott, K. R., MacDonald, J. R., Thurman, A. 2021c. Description of an enigmatic new species of *Chloreuptychia* Forster, 1964 from Panama (Lepidoptera: Nymphalidae: Satyrinae). *Tropical Lepidoptera Research* 31(3): 145-150.

Nicolay, S. S., Small, G. B. Jr. 1969. A new subspecies of *Pyrrhopyge creon* (Hesperiidae) from Panama. *Journal of the Lepidopterists' Society* 23(2): 127-130.

Nicolay, S. S., Small, G. B. Jr. 1981. Illustrations and descriptions of some species of *Pyrrhopyginae* from Costa Rica, Panama and Colombia. *Journal of Research on the Lepidoptera* 19(4): 230-239.

Ridgely, R. S. 1976. *A Guide to the Birds of Panama*. Princeton, Princeton University Press. 394 pp.

Robbins, R. K., Duarte, M. 2005. Two phylogenetically significant new *Calycopis* species (Lycaenidae: Theclinae: Eumaeini). *Journal of Research on the Lepidoptera* 38: 27-34.

Robbins, R. K., Small, G. B. Jr. 1981. Wind dispersal of Panamanian hairstreak butterflies (Lepidoptera: Lycaenidae) and its evolutionary significance. *Biotropica* 13(4): 308-315.

Sheldon, W. G. 1933. Barro Colorado: a tropical nature reserve. *Entomologist* 66: 217-221.

Sloan, S. 2007. Reforestation amidst deforestation in the Bayano-Darién frontier, Eastern Panama: variations on the forest- transition thesis. MA Thesis. Montreal, McGill University.

St Laurent, R. A., Carvalho, A. P. S., Kawahara, A. Y. 2019. Two new species of *Psychocampa* and a possible case of visual mimicry in the Sack-Bearer Moths (Lepidoptera: Mimallonoidea). *Insect Systematics and Diversity* 3(2): 3; 1-9.

Willmott, K. R., Lamas, G. 2004. A new species of *Tithorea* (Lepidoptera: Nymphalidae: Ithomiinae) from the Chocó region of northwestern South America and Panama. *Journal of New York Entomological Society* 112(1): 1-17.

Butterfly farming for promoting sustainability and ecotourism: a case study of feasibility in Western Ecuador

María F. Checa[1,2,*], Paulina Rosero[3], Mathieu de Goulaine[4] and Marianne Schmink[5]

1. Museo QCAZ de Invertebrados, Pontificia Universidad Católica del Ecuador, 170121 84, Quito, Ecuador (mfcheca@puce.edu.ecu; telephone number: 593 022991700 ext 1294); ORCiD ID: 0000-0001-8825-3675; 2. McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History, University of Florida, Gainesville, FL, USA; 3. Departamento de Biología, Universidad Central del Ecuador (pissku@gmail.com); 4. Quinta de Goulaine, Ecuador (mathieudegoulaine@gmail.com); 5. Center for Latin American Studies, University of Florida (schmink@latam.ufl.edu). ORCiD ID: 0000-0002-7150-2863. * Corresponding author.

Date of issue online: 5 April 2024
Electronic copies (ISSN 2575-9256) in PDF format at: http://journals.fcla.edu/troplep; https://zenodo.org; archived by the Institutional Repository at the University of Florida (IR@UF), http://ufdc.ufl.edu/ufir; **DOI**: 10.5281/zenodo.10881974

Abstract: Butterfly-farming projects have been economically successful, increasing livelihood opportunities for local people and promoting women's empowerment, governance, and conservation behavior. Moreover, local butterfly exhibitions can diversify the attractions of natural reserves and promote ecotourism. Butterfly farming involves rearing butterflies in captivity and marketing them to local or international exhibitions. We researched the feasibility of a butterfly farming project in Western Ecuador during summer 2013 as part of a longer-term applied research program involving capacity-building for local people. A preliminary strategic plan was developed, including a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis and an analysis of market demand for a butterfly exhibition. In addition, biological research was carried out, and local people were trained to address two main weaknesses to implement an exhibition. Results showed that a butterfly farming project is feasible in the area due to the availability of biological information about butterfly species, a market niche for a butterfly exhibition at the reserve, and increased technical capacity and willingness of local stakeholders to participate. This study contributes to understanding how applied biological research can act synergistically to promote sustainability and ecotourism in collaboration with local people.

Keywords: biodiversity conservation; butterfly farming; capacity-building; dry forests; ecotourism.

INTRODUCTION

Natural resources significantly contribute to national economies, although their contribution is rarely included in economic statistics, resulting in the so-called economic invisibility of nature (Bishop, 2015; TEEB, 2012); they represent strategic elements to achieve development in emerging countries (Blicharska *et al.,* 2019; UNDP, 2020). In addition, according to the UN, a development pathway encompassing biodiversity conservation has far-reaching consequences in people's capabilities, "going beyond incomes and livelihoods to include impacts on health, education and other dimensions of well-being" (UNDP, 2011). Achieving sustainability is nevertheless not an easy task because, among other factors, areas containing the greatest concentration of natural resources also face development challenges. The tropical regions in South America and Africa, for instance, include the highest concentration of biodiversity and wilderness areas (Myers *et al.,* 2000) but also have alarming levels of poverty (Wilshusen *et al.,* 2003; Chigonda, 2017). A challenge thus exists of balancing and even combining biological conservation with sustainable economic benefits for local populations near reserves, where natural resources concentrate (Boppre & VaneWright, 2012).

Sustainability refers to economic activities that "meet the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). Several initiatives, including ecotourism projects to promote sustainability, have emerged to protect natural resources while enabling local people living in highly diverse and emerging countries to prosper (Roosa, 2020). One type of these successful initiatives is the development of projects involving the domestication and commercialization of natural resources, which are one of the few potentially 'win-win' effective solutions to preserve natural forests and reduce poverty (see Mpand *et al.,* 2014). An example of domestication is butterfly farming, linked to ecotourism. Unlike many other Integrated Conservation and Development Projects (ICDPs), butterfly farming has been economically successful and promoted sustainability (see Morgan-Brown *et al.,* 2010). Successful butterfly farming projects have been implemented in several developing countries, such as Tanzania (e.g., Amani Butterfly Project, Morgan-Brown *et al.,* 2010), Cambodia (van der Heyden, 2011), Kenya (e.g., KEEP project, Omenge, 2002; Kipepeo, 2006), Malaysia (e.g., Penang Butterfly Farm, Le Roux, 2012), Papua New Guinea (Parsons, 1992), Costa Rica (Brinckerhoff, 1999; Ickis, 2006) and Guyana (e.g., Kawe Amazonia butterfly Farm, Sambhu & van der Heyden, 2010).

Butterfly farming involves rearing butterflies in captivity and marketing them mainly to local or international exhibitions (predominantly in the USA and Europe). Costa Rica, El Salvador, Colombia and Ecuador breeders mostly sell live butterflies for exhibits, and Peru farmers mostly sell dried butterflies to supply the collection and decoration market. Peruvian breeders have been also successful with rare species such as *Prepona* (previously belonging to the genus *Agrias*), and have even produced hybrids of different species of *Prepona* and former *Agrias*. The exhibition industry has reached a global turnover of up to US$ 100 million (Mpand *et al.*, 2014); close to 40 million tourists visit butterfly exhibitions per year, and numbers are increasing (Boppre & Vane-Wright, 2012). In 2023, the two major butterfly pupae producers in Ecuador have exported over US$ 500,000 of pupae. A close link exists between this activity and forest conservation, since farmers rely on natural forests to obtain butterfly species and seedlings/seeds of host plants (i.e., plant species that provide food to larval stages of butterflies) to develop their captive populations (Morgan-Brown *et al.*, 2010).

Butterfly farming can promote local economies through ecotourism, because reared butterflies can be part of a local butterfly exhibition. These exhibitions can complement and enhance tourism to reserves (Gordon & Ayiemba, 2003), particularly in areas receiving large numbers of tourists (Rafi *et al.*, 2003). Revenue comes from entrance fees, mainly from other customer services facilities such as restaurants and souvenir shops (Ansari *et al.*, 2019), but also from sales of live pupae and dried butterflies. It is necessary to sell pupae very quickly, as most butterflies hatch in 8 to 15 days, whereas dried specimens might be sold months or years later. Local communities can participate directly as farmers, diversifying their livelihoods (Boppre & Vane-Wright, 2012), but also through other economic activities, such as the elaboration of handicrafts with butterfly wings (*e.g.*, frames, jewelry, etc.) (Rios, 2002). Local exhibitions can also contribute to address the demand constraints of international exhibits by creating an additional market within the country the butterflies are farmed.

Ecuador has a great potential to develop butterfly-farming initiatives, as it is one of the most butterfly-diverse countries worldwide, along with Peru and Colombia, with an estimated diversity of 4,000 species (Checa, 2013), almost twice the species richness found in Costa Rica, a widely recognized ‘butterfly farming country’ (see Checa, 2008). However, such projects are limited in Ecuador, which have been primarily focused on production for local exhibitions mainly found in lodges in the Amazon and northwest (Checa, 2008), with current activities mostly focused on pupae exports.

The initial economic investment required to develop butterflies farming initiatives is relatively small, demanding low costs from producers and requiring less land and effort than other crops (Rafi *et al.*, 2003; Gordon & Ayiemba, 2003). However, an essential constraint to developing butterfly farming projects in Ecuador and elsewhere is the lack of biological knowledge about butterfly species and technical capacity for butterfly farming (butterfly collection, rearing species in captivity, among others) (see Checa, 2008). Indeed, the latter is a significant problem, as local communities or farmers usually lack the resources, technical knowledge, or alliances with researchers to cover this gap (Carbó *et al.*, 2008; Baca, 2006). Although breeders might have the knowledge and skills for butterfly farming, active partnerships of actors in the butterfly house industry with scientists are seen as a key aspect to success, as scientists are able to generate baseline information for rearing butterflies and for developing educational material (Boppre & Vane-Wright, 2012). In addition, academic institutions could be involved in sustainability initiatives such as butterfly farming through participation in planning, management, and research, but also through capacity-building of local people (Shiel *et al.*, 2016; Schmitz *et al.*, 2010).

Therefore, two important objectives of this research were: 1) to apply ongoing butterfly research to generate baseline information for a butterfly farming and ecotourism initiative, and 2) to build the capacity of local people for this initiative in terms of butterfly research. Butterfly farming, like any other business, requires developing a strategic plan for its implementation and success. Hence, the third objective of this study was to create the preliminary steps of strategic planning for implementing a butterfly farming initiative at Lalo Loor Dry Forest Reserve (LLDFR), which might serve as a baseline for future planning efforts. It was a preliminary scheme since, to succeed, strategic planning must be a participatory process in which all stakeholders discuss and provide comments to construct it and further implement the project. The preliminary strategic planning carried out included an analysis of the feasibility of butterfly farming at LLDFR in terms of economics (*e.g.*, market demand), environment (*e.g.*, diversity and natural history of butterflies), and social perspectives (*e.g.*, the buy-in of local people). The strategic plan developed identified two challenges to implement the project, which were addressed through linkages to an ongoing biological research program to: 1) build the capacity of local people for butterfly farming research, including collection and rearing techniques, and 2) generate prior biological knowledge required for setting up a butterfly exhibition (*i.e.*, the natural history of butterfly species).

METHODS

Study site

Ecuador is a small South American country (256,370 km^2) located between Peru and Colombia. Ecuador is a megadiverse country containing two significant hotspots of diversity and endemism and one of the major wilderness areas, the Amazon (Myers *et al.*, 2000). Development following principles of sustainability is urgently required, particularly in Western Ecuador, where 70% of people are poor, and less than 5% of forests remain (Checa, 2008). Climate change and agricultural expansion are the major threats for conservation because of the positive feedback between forest fragmentation and drought (Laurance & Williamson, 2001). This feedback also poses risks for agricultural productivity, the primary economic income source of local communities.

Ecuador is an important ecotourism destination in Latin America due to its natural and cultural richness, receiving, for example, approximately 2.5 million tourists in 2018 alone; indeed, tourism, in general, represents the third contributing sector in terms of economic income (not considering the oil sector) for the national economy (Diaz-Christiansen, 2019). The Galapagos Islands have been a worldwide recognized

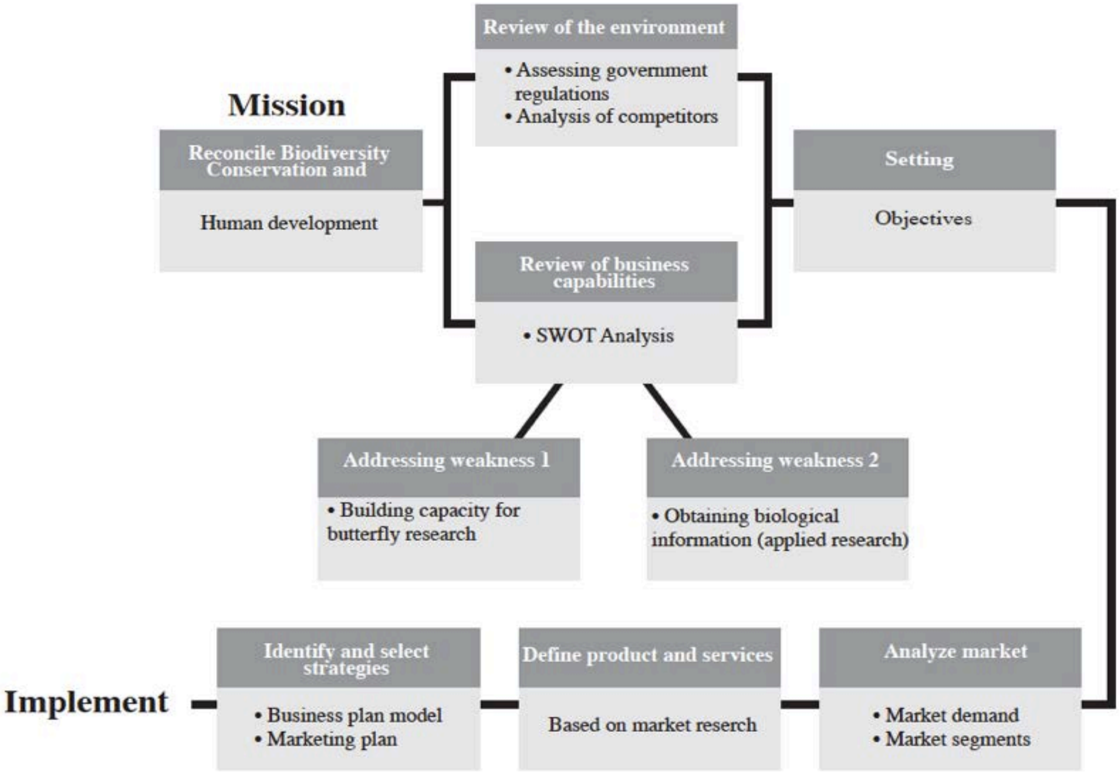
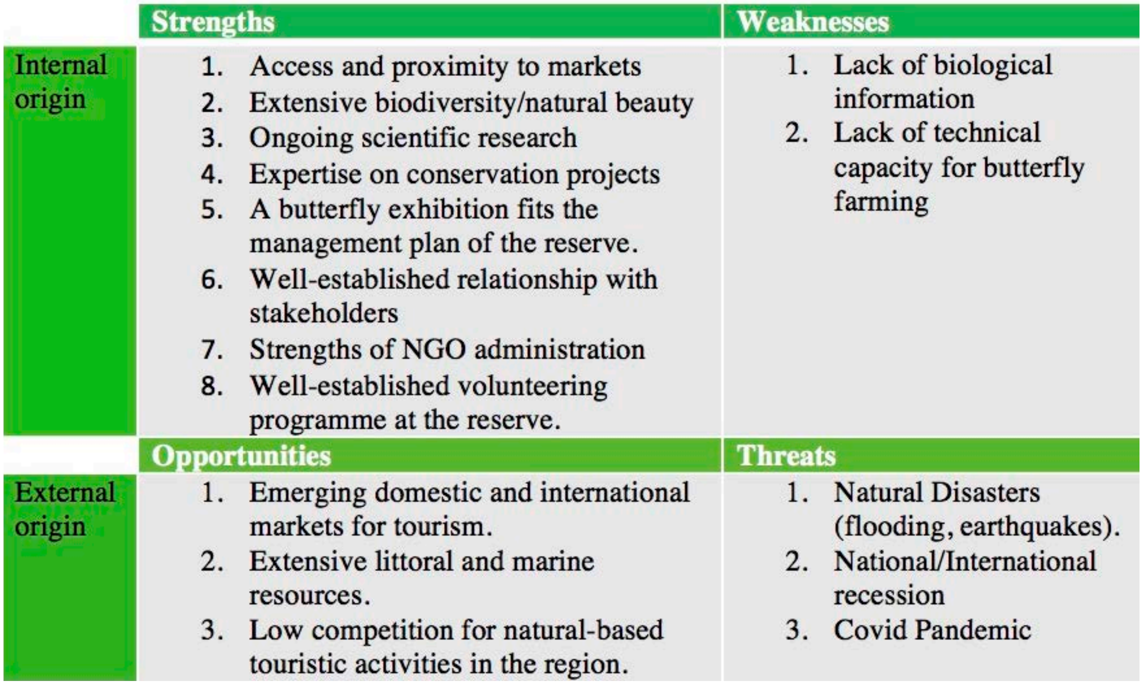


Figure 1. The strategic planning process to establish a butterfly exhibition at Lalo Loor Dry Forest Reserve (LLDFR) from mission to implementation. Through research, two main weaknesses were partially addressed: lack of technical capacity and biological knowledge about butterflies. Based on Patterson (2007).



	Strengths	Weaknesses
Internal origin	1. Access and proximity to markets 2. Extensive biodiversity/natural beauty 3. Ongoing scientific research 4. Expertise on conservation projects 5. A butterfly exhibition fits the management plan of the reserve. 6. Well-established relationship with stakeholders 7. Strengths of NGO administration 8. Well-established volunteering programme at the reserve.	1. Lack of biological information 2. Lack of technical capacity for butterfly farming
	Opportunities	**Threats**
External origin	1. Emerging domestic and international markets for tourism. 2. Extensive littoral and marine resources. 3. Low competition for natural-based touristic activities in the region.	1. Natural Disasters (flooding, earthquakes). 2. National/International recession 3. Covid Pandemic

Figure 2. SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis for a butterfly exhibition at LLDFR in Manabí Province, Ecuador.

ecotourism destination and are the most visited site in Ecuador; numbers of tourists have continuously increased from 41,000 in 1990 to 180,000 in 2008, which has also posed challenges for biodiversity conservation (Self *et al.*, 2010). This research was carried out in the Lalo Loor Dry Forest Reserve (LLDFR), located in the coastal region of Ecuador in Manabí province. The LLDFR is a private reserve and cover 180 hectares of tropical dry forest, a highly threatened ecosystem that is nearly extinct in Ecuador. Ceiba Foundation, which previously administered the reserve, is leading a conservation easement initiative to guarantee long-term protection of the reserve.

A butterfly monitoring scheme started in June 2009 and continued through July 2014, with some results published (Checa *et al.,* 2014). This monitoring scheme provided information about effects of climatic variability and habitat change on butterfly communities, and butterflies were chosen because they represent one of the insect groups most widely used as biological indicators (Syaripuddin *et al.*, 2015). This monitoring scheme was based on inter-institutional collaboration at the national and international level: McGuire Center for Lepidoptera and Biodiversity (Florida Museum of Natural History, University of Florida, USA), Program of Sustainable Development Practice and Tropical Conservation and Development Program (University of Florida, USA), QCAZ Museum of Invertebrates (Pontifical Catholic University of Ecuador, Ecuador), Ministry of Environment (Ecuador, who provided research permits) and Ceiba Organization (USA, who administered the reserve and supported our research). The reserve is located just across the main highway connecting beaches and towns along the coastal region in Ecuador; indeed, it is part of a major touristic route called the *Spondylus Route,* analogous to the *Ruta del Sol* or Sun Route in Colombia. A butterfly exhibition at the reserve could thus attract incoming tourists who visit adjacent well-recognized beaches. The reserve has different attractions, including trails, birding, and wildlife viewing (e.g., howler monkeys, jaguarundi, parakeets, birds); it also offers lodging for scientific researchers, volunteers, and others (Ceiba Organization). These complement other attractions in the province, such as beaches, whale watching, and gastronomy.

Applied business research: Strategic planning

As a first step to assess the conditions for a successful butterfly farming ecotourism initiative in the LLDFR, applied research focused on business conditions was carried out using a strategic planning framework, focused on the proposed mission: *reconciling biodiversity conservation and human development in communities adjacent to the LLDFR, through a butterfly farming initiative*. To accomplish this, several steps of a strategic planning scheme were developed, following Patterson (2007), including a review of the environment for the business, review of business capabilities (using SWOT [(Strengths, Weaknesses, Opportunities, Threats] analysis), market analysis, and product/service definition (Fig. 1). In addition, biological research and capacity-building strategies (discussed below) were used to address potential weaknesses defined by the SWOT analysis, building on the long-term research program in the reserve.

The review of business environment included an analysis of competitors and the identification of competitive advantages in the tourism marketplace, and an assessment of government regulations for developing a butterfly exhibition at the reserve. These analyses and assessments were based on a literature review; a list of competitors was also created using information gathered in the field through exploration of similar businesses in the surroundings of the reserve. The review of business capabilities consisted in defining strengths and weaknesses, but also opportunities and threats through a SWOT Analysis (Fig. 2); this analysis can better inform the planning process to achieve the mission. To complete this analysis, information was gathered from fieldwork, from the literature review, and a semi-structured interview with the director of the Ceiba Organization. The following steps, analyzing the market and product definition, will be explained below.

Analyzing the tourism market and product definition were additional components of the business assessment. The market analysis focuses on determining market demand and market segments (Patterson, 2007). Market demand means people's interest in visiting a butterfly exhibition; meanwhile, the market segment refers to characteristics of potential customers (age, gender, geographic origins, interests). The market analysis for a butterfly exhibition and other ecotourism-related activities (*e.g.*, lodging and meals in the reserve, trekking trips, and others) was done using data gathered from surveys carried out with tourists, during the peak tourism season in Manabí province (July 2013). In total, 401 surveys were carried out with tourists at four different beaches located close to the reserve: Pedernales, Canoa, Bahía de Caráquez, and San Vicente. We requested oral informed consent from each person surveyed, as requested in the permit for human research issued by the Institutional Review Board at the University of Florida. A literature review was also performed to complement information gathered through surveys. Surveys were conducted on the beaches surrounding the reserve because, rather than creating 'new' tourism at its initial stages, the butterfly exhibition can take advantage of the 'well established' tourism in surrounding beaches and further complement it. To directly measure market demand, respondents were asked twice in the surveys to validate whether they were interested in visiting a butterfly farm at the reserve. Possible answers were YES, NOT SURE, and NO. Participants were also asked about their interest in other activities such as visiting a souvenir shop, walking in the forest, and lodging/eating at the reserve. Comments given when these questions were posed were recorded to get additional insight for product definition. Surveys also provided relevant information for future marketing activities (*i.e.*, where to promote products). Tourist survey data were valuable to define the business products, and services tourists were potentially interested in getting at the reserve, related to a butterfly exhibition and natural forests; product description also involved the price tourists were willing to pay to get a product or service (see Patterson, 2007).

The Contingent Valuation Method (CVM) was used to gather information about fees potential tourists were willing to pay; the method allows participants to state their willingness to pay through responses to open-ended or dichotomous choice questions in surveys (see Hejazi *et al.*, 2014). We used choice questions to determine the preferred fee; each participant was asked if they would be interested in visiting a butterfly exhibition if the cost were a fee from US$2 to US$10. The first choice given was a randomized number; if participants disagreed with the randomized value, they were asked to provide the preferred choice ranging from US$2 to US$10. Linear Regression Models in the form of Generalized Linear Models (GLM) were used to analyze which entrance fee groups of potential customers, depending on age and citizenship, were willing to pay to visit a butterfly exhibition at LLDFR. These models tested whether a significant relationship existed between a dependent variable (willingness to visit the reserve) and predictor variables (*e.g.,* age). All analyses were performed using R software.

Respondents were also asked whether they had heard about the LLDFR prior to the surveys and information source. These data were used to recommend marketing activities such as mass distribution and sales promotion.

Applied biological research: filling gaps identified in the business assessment

Results of the SWOT analysis (described below) showed two main challenges to implementing a butterfly farming project at LLDFR: lack of technical capacity and lack of biological knowledge. Therefore, biological research was carried out about butterfly species, and training programs were developed for local people to monitor, collect, and rear butterflies.

In terms of biological research, we took advantage of the monitoring program at LLDFR that started in June 2009. The biological monitoring consisted of sampling butterflies using traps with baits during seven days, every two months. This monitoring provided information about the abundance and distribution of butterfly species (where and when they occur) attracted to baits, many of which could be included in a butterfly farming project, considering their abundance and distribution.

Local people were trained about butterfly research within the monitoring scheme; training was provided during five field trips from March to November 2014. We requested oral informed consent from each person trained, as requested in the permit for human research issued by the Institutional Review Board at the University of Florida. Trainees learned about the experimental design in the reserve consisting of two transects with eight sample points each and two traps set up at each point, one in the understory and the one in the canopy (15-20 m). During the field trips, trainees accompanied a biologist to check 32 traps daily, during which they collected or marked trapped butterflies and changed the baits. The marking consisted of writing a number on the butterfly wing; the butterfly was then released after determining the species name and taking note of the collection place and date. During the inspections, trainees learned how to collect, identify, and gather collection information about butterflies (*i.e.,* site collection, date). Trainees learned how to identify butterflies in the field using a photographic guide.

Trainees also received training about butterfly-rearing techniques in May and July 2014. They learned how to collect eggs and caterpillars in the field and how to clean and feed butterflies in the rearing station. Trainees also gained knowledge on nursery production and helped establish the hostplant nursery in the station. This training was conducted during the following research phase. There are two mechanisms to find butterfly hostplants: the first consists in observing a female looking for a host plant. The second is to find plants with characteristic feeding damage left by caterpillars, such as leaving the major vein if a leaf intact as a resting perch. A second research component focused on gathering biological information about several butterfly species, including details about hostplants (*i.e.*, food for the immature stage or caterpillar), life cycle times, the survival rate of caterpillars, and other factors. The selected butterfly species were potentially useful for a butterfly exhibition.

This study was carried out from June through August 2012. Butterfly eggs or caterpillars were collected in the forest and reared in the reserve station. Immature stages were found by observing ovipositing females or searching potential hostplants. After collection, immature stages were transported to the station and kept in plastic containers until adult emergence. Containers were washed daily with soap and water to prevent viral and bacterial infections, and caterpillars were fed daily with foliage from their specific host plants. During this stage, we collected information about the development time and morphology of life stages and took photographs of different life stages. Moreover, to ensure the availability of appropriate food, a nursery of hostplants was also established in the reserve station. The nursery was developed with seedlings collected in the forests, transplanted using plastic bags and maintained in a small plot close to the rearing station. When a butterfly farming project starts, one of the main challenges for sustained butterfly production is to grow enough food plants to breed species in large quantities. As a sustainable project, collecting plants (cut branches) from the wild should be avoided, and new methods to obtain seedlings should be implemented.

RESULTS

Review of the environment (assessing government regulations and competitors)

In terms of external regulations, setting up a butterfly-exhibition ecotourism business in Ecuador requires obtaining three permits to operate, one from the Ministry of Environment (*Patente anual de funcionamiento*) to breed local fauna, another permit from the Ministry of Tourism (*Licencia anual de funcionamiento* or annual permit for operation) and a permit from the Municipality, to offer ecotourism activities. The last is indispensable if the butterfly farm is legally defined as an ecotourism venture. The Ministry of Tourism considers ecotourism as touristic activities that occur in natural areas without affecting the integrity of natural ecosystems and local culture; moreover, these activities are also expected to provide economic opportunities to promote conservation of natural resources and development for local communities (Presidencia de la República, 2008).

There are no competing butterfly exhibitions in the coastal area of Ecuador; a butterfly exhibition at LLDFR would therefore be one-of-a-kind in the region. Butterfly exhibitions are still scarce all over Ecuador, with some concentrated in the northwest and Amazonia at lodges, mainly targeting foreign visitors (Checa 2008). The most well-known exhibition, ‘*Mariposas de Mindo*’ (Mariposas de Mindo, 2012) is located in northwestern Ecuador in Mindo (96 km from Quito), and which has been operational for several years and receives thousands of visitors every year. This exhibition is 240 km away from LLDFR.

Except for whale-watching activities in June-July, there is limited availability of natural attractions in the LLDFR area due to a very low number of natural habitat fragments and/or limited availability of infrastructure/services. Nevertheless, there are increasing local efforts to attract more visitors to adjacent natural reserves, improve awareness for environmental protection, and promote community outreach, agroecology, and other topics (see Rio Muchacho [no date]; Third Millenium Alliance, 2021). Two main reserves are located in the surrounding area of LLDFR: the Jama Coaque Ecological Reserve, 3 km from the LLDFR and 7 km from the Pacific Ocean (Third Millenium Alliance, 2021), and Cerro Pata de Pájaro, which contains a mixture of primary and secondary forests, and agricultural lands (Birdlife International, 2014). Both reserves offer limited services for tourism and low accessibility. A clear comparative advantage for the LLDFR is its easy access for tourists, as it is located next to the main highway, and visitors are not required to do long walks to visit the natural habitats. Indeed, this proximity has allowed an increasing number of tourist visits to LLDFR over the past years.

Review of business capabilities: SWOT Analysis

Strengths and opportunities were analyzed to assess the business's capacity to establish a butterfly house at LLDFR. Figure 2 summarizes the main Strengths, Weaknesses, Opportunities, and Threats (SWOT) of implementing a butterfly exhibition at LLDFR. The SWOT analyses showed numerous strengths and opportunities to set up butterfly farming at LLDFR, and only two weaknesses and threats, which were partially addressed by the applied biological research described below, establishing a baseline of biological information needed and starting up the training of local people to collect and rear butterflies. During the preparation of this manuscript, a 7.8 magnitude earthquake struck Ecuador in 2016, with significant effects in Manabí, where LLDFR is located, which impeded the implementation of this project. Conditions greatly improved in the subsequent years, pointing to the feasibility of a butterfly farming project. However, during the later stages of preparation of this manuscript, another threat had to be included, the Covid pandemic, which posed major limitations to the tourism business and associated projects worldwide.

Applied Biological Research. Activities were developed to address two weaknesses identified by the SWOT analysis: lack of technical capacity and biological information. Previous experiences in other countries revealed that the initial stages of setting up a successful butterfly farming project required research about the natural history of butterfly species, implementation of rearing facilities, including a nursery, and capacity-building for butterfly research (Morgan-Brown, 2003; Sambhu & van der Heyden, 2010). These examples thus emphasize the importance of capacity-building and biological research as initial steps for butterfly farming. One of the unique aspects of this project was the opportunity to link ongoing biological research to the strategy to assess and address weaknesses identified in the butterflies farming proposal.

Biological Information. Approximately 150 caterpillars and eggs of 12 species were reared at the LLDFR Reserve from June through August 2012. From this sample, 8-9 species could be used for a butterfly exhibition due to their coloration, size, and relative ease of rearing. These species are *Heliconius erato*, *Dryas iulia*, *Itaballia marana*, *Scada zemira*, *Opsiphanes* '*cassina*', *Memphis artacaena*, *Heraclides anchisiades*, and *Consul fabius*. For these species, photographs of life stages, hostplant species, development time, and collection area were recorded. A general recommendation is to implement a butterfly house with species that are relatively more accessible for managing and rearing, and about which more experience and published information are available; this is the case for the aforementioned species, but also other species not reared in this study from the families Papilionidae, Pieridae, and Nymphalidae (see Mulanovich, 2007), such as: *Morpho helenor*, *Caligo atreus*, *Siproeta stelenes*, *Perrhybris pamela*, *Myscelia cyaniris*, *Hamadryas glauconome*, *H. amphinome*, *Elzunia pavonii*, *Parides eurimedes*, *Euptoieta hegesia*, *Biblis hyperia*, *Danaus plexippus* and *Eumaeus godartii*. All these species are known to survive very well in captivity. Information about the taxonomy and natural history of the other butterfly groups, Lycaenidae, Riodinidae, and Hesperiidae, are relatively scarce for the Neotropics. Apart from *Eumaeus godartii*, a lycaenid present at LLDFR and not too difficult to breed, very few species from these three families have been bred. Hostplant production is an important challenge, but even if it is solved, it could be difficult to obtain a second generation of these species due to the difficulties of successfully pairing males and females. For example, in our experience, in captivity males of the genus *Astraptes* (Hesperiidae) lack chemicals that are needed for pheromone production and mating, and females therefore only lay unfertilized eggs. These species thus require more research for farming and management and should not be included in a butterfly farming initiative during the initial stages.

Some characteristics make some butterfly species more attractive for a butterfly exhibition, such as larger size, bright coloration, slow-flying behavior (Checa, 2008), ease of capture, and abundance (Mulanovich, 2007). Based on these attributes, many of the butterfly species recorded at LLDFR during the monitoring scheme (2009-2014) have the potential to be farmed and to be included in a butterfly exhibition (see species list in Checa *et al.*, 2018). Butterfly diversity, abundance, and the relative ease of rearing some butterfly species and hostplants at LLDFR showed it is feasible to set up a butterfly house at the reserve in terms of the biological resources present.

Building capacity and empowering local people. Four people (three women and one man) from the surrounding communities of LLDFR received training on how to study and rear butterflies. Trainees practiced how to collect and identify butterflies in the field for five months and record and organize biological data.

Local people also learned to find and collect eggs and caterpillars, and to rear them in captivity. Women were more enthusiastic and participated in the project more than men. An important constraint for men's involvement was the fickle nature of work. For example, trainees were only required to work every two months for one week, and each received a payment of US$ 100 per week during the monitoring scheme. Men were looking for more stable jobs providing regular monthly income. This finding might indicate that women would be more willing and able to participate in a butterfly farming project at LLDFR, depending on the nature of available jobs and opportunities in the project. Two women continued to work, received training in the butterflies monitoring project, and were very enthusiastic about being involved in the project in the long term. This continuous collaboration of local people in the butterfly project, involving the collection and handling of butterfly species, showed that setting up a butterfly exhibition at the reserve is socially feasible. Further evidence for social feasibility came from solid support provided by the Ceiba Organization and the willingness to participate of young biologists who assisted in the project, who could serve as trainers for additional local people. It is, however, important for a successful long term breeding program to receive technical assistance of an experienced professional who can help rear butterflies.

Analysis of the market

Most of the 401 tourists surveyed at beaches adjacent to LLDFR were Ecuadorians (361, 90%), females (55%), and aged 15-34 years (54%). To directly measure market demand for a butterfly exhibition at LLDFR, people were asked twice about their interest to visit the exhibition: 29 (7%) respondents changed their answers when asked the second time; most of them (86%) switched from ‘no’ or ‘not sure’ to ‘yes.’ In the following sections, we analyze responses given the first time the question was posed, to get more conservative results. The majority of respondents (354 or 88%) were interested in visiting a butterfly exhibition at LLDFR; 6% were unsure, and 6% were not interested.

When asked about their willingness to visit a butterfly exhibition, some respondents shared additional comments. Several (n=15) believed having a butterfly exhibition in the area was a fascinating and fun idea; other respondents were also interested in observing more animals and visiting the forest (n=15) and expected to have additional attractions for children and a place to buy drinks and food (n=7). Five respondents believed a butterfly exhibition was an additional attraction to visit the region. Some respondents (n=3) believed an exhibition might promote conservation and more contact with nature.

Potential visitors also showed different interest levels in other activities at LLDFR, such as visiting a souvenir shop, walking in the forest, staying overnight, and dining. Most potential customers (220, 57%) were ‘very interested’ or ‘interested’ in visiting a souvenir shop, although some (39%) respondents initially doubted, to later provide a ‘yes’ as an answer (‘doubtful yes’). Some respondents were ‘very interested’/ ‘interested’ to walk in the forest (33%), stay overnight, and eat dinner (25%) at the reserve. Still, a significant group of potential customers doubted their willingness, mainly to stay overnight and have meals (67%).

These results showed evidence of market demand for a butterfly exhibition and a souvenir shop at LLDFR. There is less clear evidence of market demand for the other activities: lodging/eating and walking in the forests. More detailed surveys are required to detect why respondents are dubious about having these services at the reserve and/or how the reserve could increase their interests if these services are implemented.

Definition of products and services based on market research

Defining what customers will buy is not an easy task, and a ‘handful of surveys isn’t likely to uncover the answer’ (Mullins and Komisar 2009). Thus, people may not visit a butterfly exhibition even though survey data suggested a market demand existed. A plan is therefore required that focuses on limited investment at the initial stages. Through continuous monitoring, new approaches or expansions can be implemented to improve the butterfly exhibition business. It is important to test that plan, especially the most critical points of vulnerability. If evidence suggests the need to change the plan, it should be done while monitoring the process again (Mullins & Komisar, 2009).

Hence, a small butterfly exhibition could be initially set up at LLDFR to test the market demand suggested by tourist survey data. The exhibition might be small built with basic infrastructure to exhibit 8-10 species and 150-200 butterflies flying at any one time. Rearing could focus on butterflies with relatively fast development times (less than 2 months) and feeding habits requiring fast-growing hostplants. However, the exhibit should be large enough so that visitors perceive it is worth the entrance fee. If it is not possible at the initial stages, guided tours should be implemented later.

The initial investment to implement a butterfly rearing facility is around US$ 20,000, to cover the following facilities: a 500 m^2 greenhouse, 42 cubes with anti-mosquito nettings and 6 metallic tables to support these cubes, an automatic irrigation system (nebulization and drip systems) with a clean and permanent water supply from the ground, a workshop to store materials, and a clean area with good lighting to prepare shipments (for pupae exports). Exporting pupae for international exhibitions is highly recommended to increase income, especially to ensure the long-term sustainability of the project.

The exhibition could be complemented at the initial stages with a coffee shop and a souvenir shop. The shop might sell t-shirts and shopping bags with local flora and fauna prints. It could also distribute handicrafts made by adjacent communities (*e.g.*, lamps made with bamboo and colorful textiles made in Tabuga, a nearby town) and other souvenirs. Survey data suggested that potential customers were interested in authentic souvenirs representing local flora and fauna and low-priced products. They recommended different items such as bracelets, necklaces, t-shirts, postcards, key chains, magnets for fridge doors, and photo services available against backdrops representing butterflies, wildlife, or natural habitats.

A coffee and souvenir shop could increase revenues since these customer facilities can be more profitable than entrance fees (Rafi *et al.*, 2003). Increased revenues from additional facilities are especially important for reserves receiving low/ medium numbers of visitors (Spergel, 2007; Eagles, 2002). A restaurant could also be implemented at later stages, and the butterfly exhibition expanded. There must also be space for innovative funding with other private ventures on special-purpose merchandise (Eagles, 2002), or linking tours with other regional attractions to increase revenues.

The initial butterfly exhibition would demand at least 2-3 people from adjacent communities for the breeding program and exhibition management. Nonetheless, the possibility of a future expansion of the souvenir shop offers additional economic opportunities for more local people to get engaged in the project. Other butterfly farming ecotourism projects have successfully implemented this component (e.g., Tanzania and Kenya), which provided economic income for local women by elaborating handicrafts such as jewelry and frames using butterfly wings (Rios, 2002; Morgan-Brown, 2003; Kipepeo, 2006).

The involvement of local communities in the butterfly farming business would make the project socially fairer and more viable in the long term as a real ecotourism venture, by providing financial benefits and empowerment for local people (Honey, 2008). The business should also be aware of the other ecotourism requirements: minimize impact, build environmental awareness, provide direct benefits for conservation, respect local culture, and support human rights and democratic movements (Honey, 2008).

Survey results suggested that Ecuadorians were willing to pay a higher average entrance fee (US$ 4.9) in comparison with foreigners (US$ 4.6) to visit a butterfly exhibition at LLDFR. However, it is possible that the reduced sample size of foreigners (n=41), compared to nationals (n=361), biased the results. Furthermore, the oldest and youngest age groups were willing to pay higher fees (people aged >55 and 15-24) compared to the other age classes. However, the results of GLM showed that age and nationality were not significant predictors of willingness to pay entrance fee (age: Chi-Square 59,3 p=61; nationality Chi-Square 0.8 p=0.7).

The reserve currently charges an entrance fee of US$ 5 to visit the forest (for national and international visitors, Reserva Lalo Loor (2023)), a price very similar to that which tourists are willing to pay. However, a butterfly exhibition at LLDFR should consider offering a reduced fee for Ecuadorians, children, and the elderly, but pricing policy must reflect production costs (Eagles, 2002). It is a common strategy for reserves, including protected areas, to offer a reduced fee for national visitors. However, foreign visitors are still charged far less than they are willing to pay in many parks (Spergel, 2007). The difference between a foreign visitor and a national visitor's fee can be up to US$ 94 in areas such as the Galapagos National Park (Foreign visitors pay US$ 100, Ecuadorians US$ 6). Although foreign visitors may be willing to pay more, they also expect 'value for their expenditures' in service excellence and experience-enhancing features (Wight, 2001). The reduced fee is intended to make the visits more affordable for local people, promoting local awareness and appreciation for conservation and biodiversity.

Advertising and promotional strategies

Only 62 (15%) of respondents had heard about the LLDFR prior to the tourist surveys, and from this sample, only eight people had visited the reserve. Respondents knew about the LLDFR through different sources, mainly through the road sign that signals the entrance to the reserve (29%), radio/television (26%), and comments from other people (16%). This information can be helpful to define how to diffuse ecotourism promotional materials.

Survey data revealed that the LLDFR needs to develop marketing and advertising strategies to increase the number of tourists and hence revenues. Marketing is one of the most critical components of the travel industry in general (Honey, 2008) but is often overlooked. The lack of adequate leisure marketing and tourism management capabilities has been a key challenge common to many protected areas worldwide (Eagles, 2002). Moreover, research analyzing which major themes ecotourism operators wished they had known about before entering the business highlighted marketing and business planning (McKercher & Robbins, 1998; Page & Dowling, 2002). During an interview, Ceiba Organization mentioned that limited investment had taken place for marketing efforts. Nevertheless, marketing strategies must be implemented carefully to make the butterfly exhibition economically successful.

Not only is a marketing plan needed, but a complete business plan also is required to make the business successful. Business plans for ecotourism projects can prevent several problems by detecting vulnerable business areas in advance and effectively guiding business strategies (Patterson, 2007). The business plan involves a business description, products and services, sales and marketing, operating requirements, and financial management (Patterson, 2007).

DISCUSSION

An important contribution of this study was the opportunity to link ongoing biological research to the strategy to partially assess and address weaknesses identified in the butterfly farming ecotourism proposal (lack of biological information and technical capacity of local people). This study thus demonstrated how applied research and direct community involvement could address weaknesses and provide a solid basis for conservation and sustainable projects by creating a new attraction for ecotourism. In this way, scientists accomplished their responsibility to support butterfly farming through the generation of relevant knowledge (Boppre & Vane-Wright, 2012) and capacity-building of local people to promote sustainability (Shiel *et al.*, 2016; Schmitz *et al.*, 2010).

This research at the LLDFR remains at the initial phase mainly because of the 2016 earthquake and subsequent onset of the Covid-19 pandemic. However, a butterfly farming initiative was recently implemented in Tabuga, a town close to LLDFR, but is now facing challenges due increasing insecurity in the coastal region of Ecuador, and due to the limited funding, considering that no income is expected during the first year.

Sustainable livelihoods

Sustainable livelihoods are enhanced when butterfly farms are set up near natural reserves, decreasing the pressure for unsustainable use of forests by creating jobs and additional sources of income (van der Heyden, 2011; Sambhu & van der Heyden, 2010). Indeed, the World Tourism Organization created the Sustainable Tourism-Eliminating Poverty (ST-EP) program, recognizing tourism as an important strategy to improve socio-economic conditions of rural communities (Diaz-Christiansen, 2019), including the creation of new sources of jobs, especially for women and young people (Casas *et al.*, 2012).

Butterfly farming can promote local livelihoods and diversify household economies (Parsons, 1992), even in marginal mountain lands (Rafi *et al.*, 2003). In Kenya, the annual per capita income doubled after a butterfly farming project was implemented, and butterfly sales can contribute up to 80% of recorded revenues (Gordon & Ayiemba, 2003). In

Tanzania, the Amani Butterfly Project increased local income by at least 15-20%, and butterfly farming became an additional livelihood component, complementing other farm and off-farm activities (Mpand *et al.,* 2014).

In Latin America, butterfly farming represents a significant source of income for breeders compared to other countries worldwide. In Africa and Asia, butterfly farming is often a side part of the income and activity of the farmers, and pupae are usually sold at low prices (less than $ 1 each). In America most breeders have made butterflies their main source of income; they also benefit from a much higher sales price.

At LLDFR, a local butterfly exhibition can provide additional livelihoods as local people can get involved as farmers, services providers, or participants in additional economic activities such as the elaboration of handicrafts using butterfly wings in later stages of the project. Moreover, this initiative can also facilitate the distribution of handicrafts made by other communities to incoming tourists.

Community Development

Involvement of local communities in the butterfly business might produce far-reaching consequences, enhancing social capital through improved governance, organization, and leadership skills of local communities, and women's empowerment (Morgan-Brown, 2003; Kipepeo, 2006; van der Heyden, 2011).

Women's empowerment is promoted due to new sources of income and jobs. In Tanzania and Kenya, most butterfly farmers are women (Morgan-Brown, 2003; Le Roux, 2012). Moreover, women farmers can earn up to US$ 950 per month, much more compared to other traditional businesses such as charcoal production or farming chickens (Le Roux, 2012). It is also interesting to note that butterfly farming groups formed mainly by women (or having at least 50% women) progressed faster because women tended to provide more consistent efforts and attention to daily butterfly farming activities (Morgan-Brown, 2003). Butterfly farming can also be more suitable for women, as farmers can rear butterflies or elaborate handicrafts in their own home, combining them with domestic chores (van der Heyden, 2011), and activities are compatible with other women's activities such as chicken raising (Mpand *et al.,* 2014)

Enhanced human capital can also encourage 'grassroots' initiatives towards conservation, as has occurred with butterfly farmers from African countries. These initiatives included higher participation in environmental committee activities, planting trees, preserving natural forests in household land, community-led expansion of existing protected areas, and discouraging illegal cutting in protected areas (Morgan-Brown, 2007). Butterfly farming can thus enable local people to create bottom-up solutions, being the actors and leaders to promote sustainability.

Finally, butterfly farming projects can be a model by which key stakeholders such as local and national governments, NGOs, and local communities can collaborate and promote sustainability (Morgan-Brown, 2003). This occurs because each stakeholder has specific responsibilities and strengths, and the performance of each member is thus essential for the project's success (Sambhu & van der, Heyden 2010). Strong partnerships with local people provide political legitimacy that often is lacking, and conservation and management efforts become more efficient (Painter & Kretser, 2012).

Biodiversity and ecosystem conservation

It has been shown that butterfly farming does not have negative effects on wild populations of species reared in long-term projects (Moyle and Small 2016). Moreover, butterfly farming can directly promote conservation by creating additional sources of income for rural communities and indirectly through education (Parsons, 1992). In the case of environmental education, the butterfly exhibitions or related activities (*e.g.*, workshops for school teachers and students) can be a helpful tool, indeed changing people's attitudes towards conservation (Gordon & Ayiemba, 2003). Butterflies are ideal organisms for environmental education due to their charismatic appearance for the general public, aesthetic value, and ease to 'get in touch' through exhibitions. Consequently, the exhibition offers visitors a hands-on experience and makes the 'abstract' concept of biodiversity more real.

Moreover, the butterfly house could expand and diversify in the future to include additional species such as orchids, fishes, and frogs. Potential customers were also interested in carrying out different activities in the reserve, such as trekking and staying overnight. These activities, along with an expanded exhibition, can deepen the natural experience for visitors and increase awareness and interest in forest conservation (Le Roux, 2012; Boender, 1995) and environmental sustainability, particularly for local communities involved in the initiative (Le Roux, 2012). In addition, reared butterflies can also be exported to international exhibitions, creating an additional source of income for the reserve and people involved. It is reasonable to forecast an income of US$ 25,000 a year from export sales, an amount resulting from selling 400 pupae per week during 10 months in a year at an average price of US$ 1.5. This income will definitely contribute towards payments of infrastructure and 2-3 permanent workers. It is important to note a potential constraint to year-round butterfly production in seasonal forests as LLDFR, since several butterfly species are not present as adults during drought months. Butterfly breeding must take into account this important natural variation in wild populations, to produce a sustainable income.

Applied research closely associated with a sustainability initiative

The butterfly monitoring scheme set up at the LLDFR to detect impacts of climate and habitat change offered the opportunity to train local people and obtain biological information about which species to include in a butterfly farming project. The butterfly exhibition will closely link ongoing scientific research with a socioeconomic initiative with broader impacts. This is so because local-based biodiversity monitoring projects that integrate ecological research, capacity-building, and income generation are practical tools to achieve conservation and poverty reduction (Sekercioglu, 2012).

Furthermore, a monitoring scheme associated with a butterfly farming project at LLDFR can offer additional advantages. According to Parsons (1992), "the research and monitoring part of a butterfly farming system can ensure the implementation and promotion of educational aspects that a purely economic enterprise might not have time to do" (Parsons, 1992). For example, wildlife clubs for local children in Guyana have traditionally performed bird surveys but became interested in researching butterflies after butterfly farms were set up in their communities (Sambhu & van der Heyden, 2010).

Capacity-building for local communities

Capacity-building and technical support of local people is key for long term success in butterfly farming. It is especially important to increase the diversity of butterfly species reared in order to better compete with other breeders in Latin America. Some butterfly species are difficult to breed due to their life history traits or challenges to grow their hostplants. For example, *Cithaerias pireta* is a highly desired species for all markets but is difficult to rear in large and sustainable quantities over time; this species requires the characteristics of its natural habitat to reproduce, it is thus necessary to recreate its habitat of shaded forest in captivity to obtain fertilized eggs, information only people with technical experience can provide to local farmers.

'Unless the people of biodiversity-rich countries in the developing world can take the lead in the conservation of their regions, long-term, sustainable solutions are unlikely to be found, and the limited funds for conservation are likely to be misspent' (Rodríguez *et al.,* 2006). Capacity-building can establish strong partnerships among stakeholders, including conservationists, local people, government, and international organizations. It can also promote cooperation between national universities in the capital city and rural people, thereby helping to decentralize knowledge and research. These institutional linkages should improve the multiplier effect of capacity-building (Clubbe, 2013).

ACKNOWLEDGMENTS

We deeply thank local people who were trained in this study. We thank the Ministerio del Ambiente - Ecuador, and the Institutional Review Board at the University of Florida, respectively, for providing permits for fieldwork (005-12-IC-FAU-DNB/MA) and to carry out human research (No. 54322A). We thank Ceiba Foundation for their constant support in carrying out this study and the butterfly monitoring scheme at BSLLR, and Nathalia Artieda and Sofía Nogales, students who assisted during fieldwork. We also thank Keith Willmott for helping to identify butterfly species and his general support in carrying out this research. Funding to support this study was provided by the Program of Sustainable Development Practice (University of Florida), and we also acknowledge the support of the Florida Museum of Natural History/McGuire Center for Lepidoptera and Biodiversity (University of Florida) and Museo QCAZ de Invertebrados (PUCE). We are very grateful to the reserve staff, who made our stay very comfortable and enjoyable. Research ethics approval was provided by the Institutional Review Board at the University of Florida, No. 54322A.

LITERATURE CITED

Ansari, F., Jeong, Y., Putri, I, Kim, S. 2019. Sociopsychological aspects of butterfly souvenir purchasing behavior at Bantimurung Bulusaraung National Park in Indonesia. *Sustainability* 11: 1789.

Baca, L. 2006. *Diagnóstico del programa regional de biocomercio en la Amazonía*. Perú, Prompex.

Birdlife International. 2014. *Bosque Protector Cerro Pata de Pájaro*. http://datazone.birdlife.org/site/factsheet/bosque-protector-cerro-pata-de-p%C3%A1jaro-iba-ecuador. Accessed July 2023.

Bishop, J. 2015. *Valuing protected areas: the case for international payments for ecosystem services*, pp. 58-61. *In*: Figgis, P., Mackey, B., Fitzsimons, J., Irving, J., Clark, P. (Eds.), *Valuing Nature: Protected Areas and Ecosystem Services*. Sydney, Australian Committee for IUCN.

Blicharska, M., Smithers, R., Mikusiński, G., Rönnbäck, P., Harrison, P., Nilsson, M., Sutherland, W. 2019. Biodiversity's contributions to sustainable development. *Nature Sustainability* 2: 1083-1093.

Boender, R. 1995. The first commercial butterfly farm and public exhibition in the United States. *The Florida Entomologist* 78(1): 36-38.

Boppre, M., Vane-Wright, R. I. 2012. The butterfly house industry: Conservation risks and education opportunities. *Conservation and Society* 10 (3): 285-303.

Brinckerhoff, J. 1999. *La cría de mariposas: una industria agrícola maravillosa de papel*, pp. 521-527. *In*: *Memorias del XI Congreso Nacional Agronómico*. Costa Rica.

Carbó, R., Guerrero, C., Salas, R. 2008. *Iniciativas para el desarrollo sostenible del Área de Conservación Arenal - Huetar Norte, Costa Rica*. Costa Rica, INBIO.

Casas, C., Soler, A., Pastor, J. 2012. El turismo comunitario como instrumento de erradicación de la pobreza: potencialidades para su desarrollo en Cuzco (Perú). *Cuadernos de Turismo* 30: 91- 108.

Ceiba Organisation. [no date] *Lalo Loor Dry Forest Reserve*. https://ceiba.org/reservalaloloor/. Accessed June 2021.

Checa, M. F. 2008. *Mariposas de Canandé: sus amenazas, potencial y futuro*. Ecuador, Trama Ediciones and PUCE.

Checa, M. F. 2013. *Hadas Aladas del Yasuní*. Quito, Editorial Trama and PUCE.

Checa, M. F., Donoso, D., Rodríguez, J., Levy, E., Warren, A., Willmott, K. R. 2018. Combining sampling techniques aids monitoring of tropical butterflies. *Insect Conservation and Diversity* 12(4): 362-372.

Checa, M. F., Rodríguez, J., Willmott, K. R., Liger, B. 2014. Microclimate variability significantly affects the composition, abundance and phenology of butterfly communities in a highly threatened Neotropical dry forest. *Florida Entomologist* 97(1): 1-13.

Chigonda, T. 2017. An ecogeography of poverty? Dependence on biodiversity among communities adjacent to protected areas. *National Journal of Multidisciplinary Research and Development* 2(3): 522-529.

Clubbe, C. 2013. Building capacity for the achievement of the global strategy for plant conservation in the Caribbean Region. *Annals of the Missouri Botanical Garden* 99(2): 147-152.

Diaz-Christiansen, S. 2019. Economic contribution of ecotourism, motivations and satisfaction: the case of Puerto El Morro (Ecuador). *European Journal of Social Sciences* 2(2): 92-103.

Eagles, P. 2002. Trends in park tourism: economics, finance and management. *Journal of Sustainable Tourism* 10(2): 132-153.

Gordon, I., Ayiemba, W. 2003. Harnessing butterfly biodiversity for improving livelihoods and forest conservation: the Kipepeo Project. *The Journal of Environment and Development* 20(1): 1-17.

Hejasi, R., Shamsudin, M., Rahim, K. *et al.*, 2014. Measuring the economic values of natural resources along a freeway: a contingent valuation method. *Journal of Environmental Planning and Management* 57(4): 629-641.

Honey, M. 2008. *Ecotourism and Sustainable development*. Washington DC, Island Press.

Ickis, J., Ickis, C., Flores, J. 2006. The magic of butterflies; ecological rural development in Costa Rica. *Harvard Review of Latin America* VI: 10-12.

Kipepeo. 2006. *Kipepeo Butterfly Project*. http://kipepeo.org. Accessed May 2021.

Laurance W., Williamson, G. 2001. Positive feedbacks among forest fragmentation, drought and climate change in the Amazon. *Conservation Biology* 15(6): 1529-1535.

Le Roux, C. S. 2012. *Butterfly agriculture as a means of counteracting human-induced habitat destruction: solution or complication? In*: Proceedings of the 5th Best of both Worlds International Conference: Environmental Education and Education for Sustainable Development. South Africa, University of South Africa.

Mariposas de Mindo. 2012. *Hostería Mariposas de Mindo*. https://www.mariposasdemindo.com/. Accessed June 2021.

McKercher, B., Robbins, B. 1998. Business development issues affecting nature-based tourism operators in Australia. *Journal of Sustainable Tourism* 6(2): 173-188.

Morgan-Brown, T., S. Jacobson, W. Kenneth, Child, B. 2010. Quantitative assessment of a Tanzanian Integrated Conservation and Development project involving butterfly farming. *Conservation Biology* 24(2): 563-572.

Morgan-Brown, T. 2007. *Butterfly farming and conservation behavior in the East Usambara Mountains of Tanzania*. Masters Thesis. Gainesville, University of Florida.

Morgan-Brown, T. 2003. *Butterfly Farming in the East Usambara Mountains*. http://easternarc.or.tz/downloads/East-Usambara/Butterfly_E.Usambara.pdf. Accessed January 2023.

Moyle, B., Small, R. 2016. Butterfly farming in Gumi, Papua New Guinea. https://ssrn.com/abstract=2760105 or http://dx.doi.org/10.2139/ssrn.2760105. Accessed June 2021.

Mpand, M., Munjuga, M., Reyes, T., Said, A., Rutatina, F., Kimaro, A., van Noordwijk, M. 2014. Allanblackia, butterflies and cardamon: sustaining livelihoods alongside biodiversity conservation on the forest-agroforestry interface in the East Usambara Mountains, Tanzania. *Forests, Trees and Livelihoods* 23(1-2): 127-142.

Mulanovich, A. J. 2007. *Mariposas: Guía para el manejo sustentable de las mariposas del Perú*. Perú, Prompex.

Mullins, J., Komisar, R. 2009. *Getting to Plan B: Breaking through to a better business model*. Boston, Harvard Business Press.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., *et al.*, 2000. Biodiversity hotspots for conservation priorities. *Nature* 403: 853-858.

Omenge, P. 2002. The role of butterfly farming in forest conservation and community development in Kenya. Masters Thesis. Nairobi, University of Nairobi.

Page, S., Dowling, R. 2002. *Ecotourism*. Edinburgh, Pearson Education.

Painter, M., Kretser, H. 2012. Partnerships build adaptive capacity for conservation. *Human Dimensions of Wildlife* 17: 357-366.

Parsons, M. 1992. The butterfly farming and trading industry in the Indo-Australian Region and its role in tropical forest conservation. *Tropical Lepidoptera* 3(1): 1-31.

Patterson, C. 2007. *The Business of Ecotourism*. Canada, Trafford Publishing.

Presidencia de la República. 2008. *Reglamento General de Actividades turísticas*. http://www.turismo.gob.ec/wp-content/uploads/downloads/2014/02/Reglamento-Actividades-Tur%C3%ADsticas.pdf. Accessed June 2023.

Rafi, M. A., Irshad, M., Matin, M. 2003. Butterfly farming: an off-farm income option for mountain farming communities - Experience from Pakistan, pp. 123-125. *In*: *Mountain agriculture in the Hindu Kush-Himalayan region: Proceedings of an International Symposium.* Organized by Ya, T., Pradeep, T. Kathmandu, Nepal.

Reserva Lalo Loor [no date]. *Reserva Lalo Loor*. https://reservalaloloor.com Accessed June 2023.

Rio Muchacho [no date]. *Rio Muchacho Organic Farm and ecolodge*. https://www.riomuchacho.com/. Accessed June 2023.

Ríos, A. 2002. Flying north: potential roles of North American butterfly houses in promoting sustainable economic activities and conservation. Masters Thesis, Gainesville, University of Florida.

Rodríguez, J. P., Rodríguez-Clark, K. M., Oliveira-Miranda, M., *et al.*, 2006. Professional capacity-building: the missing agenda in conservation priority setting. *Conservation Biology* 20(5): 1340-1341.

Roosa, S. 2020. *Sustainable development Handbook*. Gistrup, River Publishers.

Sambhu, H., van der Heyden, T. 2010. Sustainable butterfly farming in tropical developing countries as an opportunity for man and nature the “Kawe Amazonia Butterfly Farm” project in Guayana as an example. *SHILAP Revista de Lepidopterología* 38(152): 451-456.

Sekercioglu, C. H. 2012. Promoting community-based bird monitoring in the tropics: conservation, research, environmental education, capacity-building, and local incomes. *Biological Conservation* 151(1): 69-73.

Shiel, C., Leal, W., do Pac, A., Brandli, L. 2016. Evaluating the engagement of universities in building capacity for sustainable development in local communities. *Evaluation and Program Planning* 54: 123-134.

Schmitz, C. L., Stinson, C. H., James, C. 2010. Community and environmental sustainability: Collaboration and interdisciplinary education. *Critical Social Work* 11(3): 83-100.

Self, R., Self, D., Bell-Haynes, J. 2010. Marketing tourism in the Galapagos Islands: ecotourism or greenwashing? *International Business & Economics Research Journal* 9(6): 111-126.

Spergel, B. 2007. *Raising Revenues for Protected Areas*. Washington, DC, World Wildlife Fund.

Syaripuddin, K., Sing, K., Wilson, J. 2015. Comparison of butterflies, bats and beetles as bioindicators based on a four key criteria and DNA barcodes. *Tropical Conservation Science* 8(1): 138-149.

TEEB. 2012. *The Economics of Ecosystem and Biodiversity: Mainstreaming the economics of nature: A synthesis of the approach, conclusions and recommendations of TEEB.* www.teebweb.net. Accessed July 2023.

Third Millenium Alliance. 2021. *Third Millenium Alliance. Reforestation, Conservation and Community outreach in Coastal Ecuador.* http://tmalliance.org. Accessed July 2021.

UNDP. 2011. *The Human Development Report 2011: Sustainability and equity*. http://hdr.undp.org/sites/default/files/reports/271/hdr_2011_en_complete.pdf. Accessed July 2023.

UNDP. 2020. *The Human Development Report 2020: The next frontier, human development and the Anthropocene.* http://hdr.undp.org/sites/default/files/hdr2020.pdf. Accessed July 2023.

van der Heyden, T. 2011. Local and effective: two projects of butterfly farming in Cambodia and Tanzania. *SHILAP Revista de Lepidopterología* 39(155): 267-370.

Wight, P. 2001. *Ecotourists: not a homogeneous market segment*. *In*: Weaver, D. (Ed.), *The Encyclopedia of ecotourism*. Oxon, CABI Publishing.

Wilshusen, P. R., Brechin, S. R., Fortwangler, C. L., West, P. C. 2003. Contested nature: conservation and development at the turn of the twenty-first century. In: Brechin, S., Wilshusen, P. R., Fortwangler, C. L., West, P. C. (Eds.), *Contested nature: promoting international biodiversity with social justice in the twenty-first century)*. New York, State University of New York Press.

World Commission on Environment and Development. 1987. *Report of the World Commission on Environment and Development: Our Common Future*. United Nations General Assembly document A/42/427.

Rediscovery of *Adelpha herbita herbita* Weymer 1907 more than a century after its description (Nymphalidae: Limenitidinae)

André V. L. Freitas[1], Laura Braga[2], Augusto H. B. Rosa[1] and Keith R. Willmott[3]

1. Departamento de Biologia Animal and Museu de Diversidade Biológica, Instituto de Biologia, Universidade Estadual de Campinas, 13083-862 Campinas, São Paulo, Brazil; 2. Departamento de Biodiversidade, Evolução e Meio Ambiente, Universidade Federal de Ouro Preto, 35400000, Ouro Preto, Brazil; 3. McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History, University of Florida, Gainesville, Florida, USA.

Date of issue online: 5 April 2024
Electronic copies (ISSN 2575-9256) in PDF format at: https://journals.flvc.org/troplep; https://zenodo.org; archived by the Institutional Repository at the University of Florida (IR@UF), http://ufdc.ufl.edu/ufir; **DOI**: 10.5281/zenodo.10882153

Abstract: *Adelpha herbita* is a very rare species of *Adelpha* Hübner, [1819] described by Weymer in 1907 from Santa Catarina, southern Brazil. Until recently, no specimens were known of the species and its taxonomic status was uncertain, until the discovery and description of a new taxon regarded as conspecific with *A. herbita* from Espírito Santo, southern Brazil. Nevertheless, the nominate subspecies has remained known only from the original description and illustration, until now. Here, we report the collection of an *Adelpha* specimen that we regard as representing *A. herbita herbita* Weymer, 1907, not only confirming the validity of this taxon, but also extending the range of this subspecies by at least 250 km to the east of the type locality.

Key words: Atlantic Forest; *A. serpa* group; rediscovery.

Resumo: *Adelpha herbita* é uma espécie muito rara do gênero *Adelpha* Hübner, [1819] descrita por Weymer em 1907, de um exemplar de Santa Catarina, sul do Brasil. Até recentemente, nenhum exemplar dessa espécie era conhecido e seu status taxonômico era incerto, até a descoberta e descrição de um novo taxon do Espírito Santo, Sudeste do Brazil, considerado como coespecífico de *A. herbita*. Entretanto, até o momento a subespécie nominal permanecia como conhecida apenas pela ilustração em sua descrição original. Neste trabalho nós registramos a coleta de um exemplar de *Adelpha* que consideramos como representando *A. herbita herbita* Weymer, 1907, não apenas confirmando a validade deste táxon, mas também aumentando sua distribuição em mais de 250 km a leste de sua localidade tipo.

Palavras chave: grupo *A. serpa*; Mata Atlântica; redescoberta.

INTRODUCTION

At the beginning of the 20th century, Gustav Weymer described several new butterfly taxa in his work Exotische Lepidopteren (Weymer, 1907), including the enigmatic *Adelpha herbita* Weymer, 1907. This species was described based on a female specimen from Weymer's collection, but the specimen has never been located and no additional specimens have been collected or found in any museum collection (Willmott, 2003; Willmott *et al*., 2016). Nevertheless, both wing surfaces of the supposed holotype were carefully illustrated in color (Weymer, 1907), suggesting a highly distinctive taxon with an unusual grayish ventral surface that also lacked the reddish bands typical of *Adelpha* Hübner, [1819]. This unique wing pattern and the absence of additional specimens even raised questions about whether the original illustration represented a valid species, or whether it might be a highly inaccurate painting or an aberration of another more common species (Willmott, 2003).

More than a century later, seven specimens of an undescribed *Adelpha* taxon from the state of Espírito Santo (southeastern Brazil) were found in three entomological collections. The ventral wing pattern of this taxon closely matched the drawing of *A. herbita* from Weymer's description, but given differences in the dorsal wing pattern and geographic distribution it was described as a new subspecies, *Adelpha herbita perdita* Willmott & Freitas, 2016 (Willmott *et al.*, 2016). Although this discovery confirmed the species status of *A. herbita*, the nominate subspecies, *Adelpha herbita herbita* Weymer, 1907, has remained a mystery.

Recently, an effort to inventory the butterfly fauna of the forest reserve "Legado das Águas - Reservas Votorantim", a large area of continuous Atlantic Forest in Brazil's south São Paulo state, has resulted in several new discoveries for the fauna of the lowland Atlantic Forest. The inventory is not comprehensive, with only 317 species reported so far (from a total that could exceed 500 species in this region, see Francini *et al*., 2011), but it includes some species rarely observed (Braga, 2022), some remarkable distribution extensions (e.g., Braga *et al*., 2018), and also a single individual of *Adelpha herbita herbita* (Fig. 1A). Here we report this finding, including a description of the female of *A. herbita herbita* based on the specimen collected.

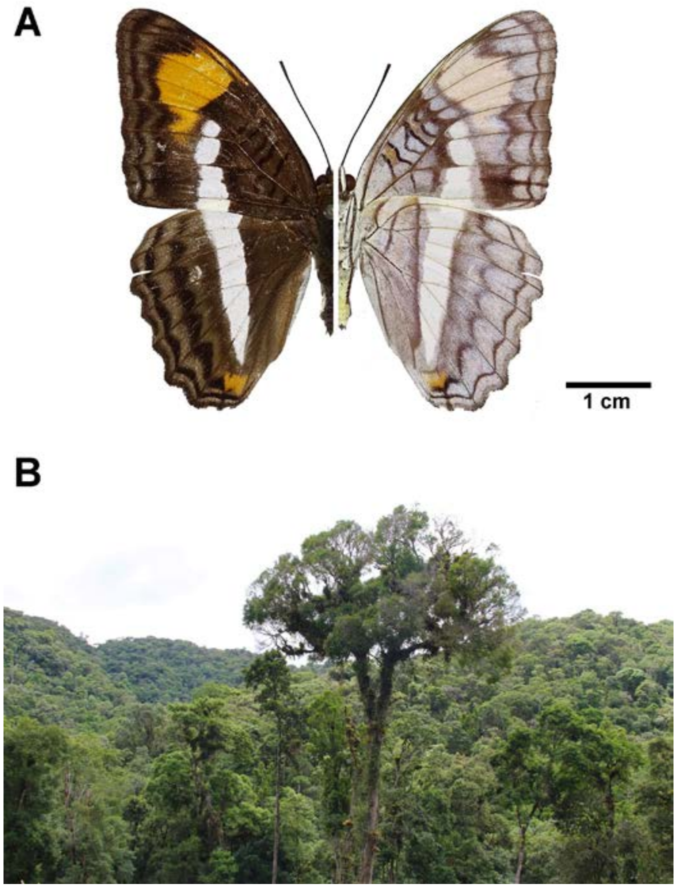


Figure 1. A. *Adelpha herbita herbita* female (dorsal left, ventral right); **B**. Forest habitat of *Adelpha herbita herbita* at the study site in Legado das Águas, São Paulo, Brazil.

MATERIALS AND METHODS

Adelpha specimens were examined in major public and private collections in Europe, North and South America, as listed in Willmott (2003), to record distributional data, study morphological variation, assess taxonomic diversity and locate type specimens. Morphology was studied using standard techniques, with adult abdomens being soaked in hot 10% KOH for 10-15 minutes, dissected and subsequently stored in glycerin. Body morphology and dissections were studied using a binocular microscope at 50× magnification. The terminology for morphology and wing pattern follows Willmott (2003). We use the abbreviations DFW, VFW, DHW and VHW for dorsal and ventral forewing and hind wing.

Field work was carried out in the forest reserve “Legado das Águas - Reservas Votorantim”, a private reserve of 31,000 ha located in the largest continuous area of Atlantic Forest, in the municipalities of Miracatu, Juquiá and Tapiraí in the state of São Paulo. The area is mostly covered by well-preserved forest interspersed with some areas of secondary vegetation (Fig. 1B). The altitude ranges from 15 to 960 m, average temperature varies from 15 to 28 °C, and annual rainfall can reach 1800 mm, without a marked dry season. The specimen was collected with entomological net by the second author (Laura Braga), landing on vegetation. Baited traps were also used during the surveys but *A. herbita herbita* was not caught using this method.

RESULTS

Description of the female and diagnosis: The female specimen illustrated in Fig. 1A shares the following distinctive wing pattern elements with the original illustration of *A. herbita* in Weymer (1907): **a)** the “V”-shaped third VFW discal cell bar, typical of the *A. serpa* group of Willmott (2003), is clearly isolated from the second discal cell bar (also true to some extent of *A. paroeca* (H. Bates, 1864)); **b)** the VFW upper postdiscal band is unbroken, even, and narrow, touching the inner postdiscal series (upper postdiscal band absent in *A. zea* (Hewitson, 1850); in remaining species the band is typically present as a series of dashes that are often absent in cell M$_3$-M$_2$, although in some taxa these dashes are enlarged and form a continuous, relatively wide band); **c)** lack of reddish shading in the VHW discal cell (unique in *A. serpa* group, although there is only vestigial reddish scaling in *A. diocles* Godman & Salvin, 1878 and *A. paroeca*); **d)** VHW first discal cell bar not continuing to vein 3A (also true of *A. bredowii* Geyer, 1837 and relatives, *A. diocles* and *A. zea*); **e)** VHW with very broad (similar width to postdiscal band), undivided inner submarginal series (similarly broad submarginal series occur in only a few *A. serpa* group taxa, such as *A. seriphia egregia* Röber, 1927, *A. margarita* Willmott & Hall, 2013); **f)** uniformly colored cell 3A-2A (unique in the *A. serpa* group); **g)** DFW orange subapical marking extending through cell Cu$_1$-M$_3$ into cell Cu$_2$-Cu$_1$. Overall, this unique combination of characters strongly supports the specimen figured in Fig. 1A as representing *A. herbita*.

As mentioned in the original description of *A. herbita perdita* (Willmott *et al.*, 2016), the nominate subspecies differs from that subspecies by the shape of the orange DFW subapical marking, which extends through cell Cu$_1$-M$_3$ into cell Cu$_2$-Cu$_1$, rather than terminating at vein M$_3$ or extending only as diffuse scaling into cell Cu$_1$-M$_3$. Nevertheless, the orange DFW subapical marking in the São Paulo specimen is less extensive than that illustrated in the original description of *A. herbita herbita* (Weymer, 1907). Whether this represents variation, either local or geographic, remains to be determined. The

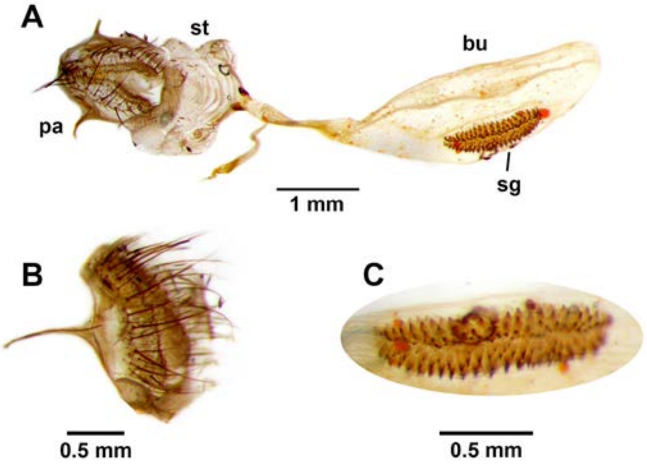


Figure 2. Female genitalia of *A. herbita herbita*. **A**. lateral view; **B**. magnified view of the papilla analis; **C**. magnified view of the signum. Acronyms: bu, corpus bursae; pa, papilla analis; sg, signum; st, sterigma.

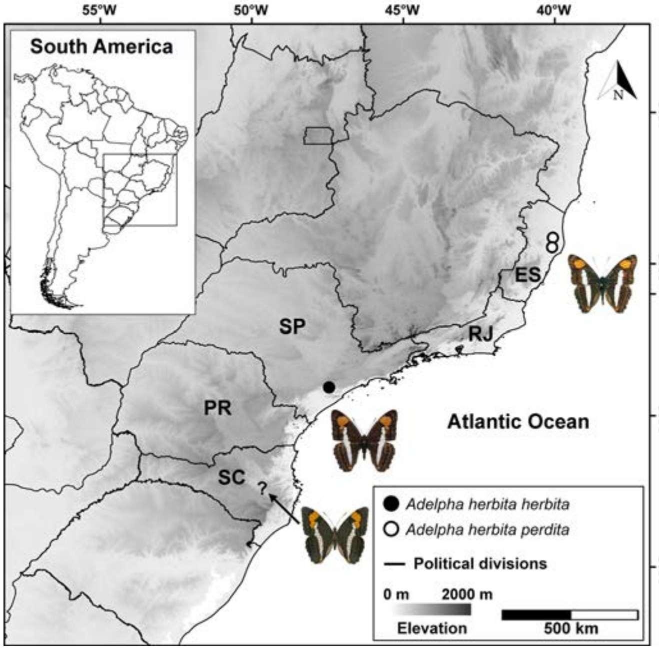


Figure 3. Map showing the known distribution of the two subspecies of *Adelpha herbita*: The type locality for the nominate subspecies is an unknown site in the state of Santa Catarina (black arrow). Acronyms for Brazilian states: SC = Santa Catarina, PR = Paraná, SP = São Paulo, RJ = Rio de Janeiro, ES = Espírito Santo.

specimen of *A. herbita herbita* matches the original illustration in several additional characters that further differentiate the nominate subspecies from *A. herbita perdita*. These include, in *A. herbita herbita*: **a)** the inner submarginal series on the VFW is broader, closely bordering the distal edge of the dorsal orange subapical markings anterior of vein M_1 (mentioned as a possible character by Willmott *et al.* (2016)); **b)** the inner submarginal series on the VFW is not strongly reduced in the middle of the wing, in cell Cu_1-M_3; **c)** the ventral surface lacks the dark purplish cast of *A. herbita perdita*, notably just basal and distal of the white VHW postdiscal band; **d)** the area distal of the white VHW postdiscal band is filled with whitish gray scaling, rather than being purplish brown.

Female genitalia (Fig. 2): The lamella postvaginalis is narrow, wrinkled and weakly sclerotized, and the corpus bursae has an elongate, oval signum, similar to *A. herbita perdita* and *A. paroeca*.

Taxonomy: The very distinctive wing pattern of the single female specimen closely matches the original description and illustration of *A. herbita*, and includes several characters shared with *A. h. perdita* (as discussed above), supporting treatment of these two taxa as conspecific. Several shared characters with the original illustration of *A. herbita*, from Santa Catarina, that differ from *A. herbita perdita*, support recognition of two subspecies within *A. herbita*.

Distribution: This subspecies is known only from the "Legado das Águas" reserve, in South São Paulo state, and from the unknown locality in the state of Santa Catarina, southern Brazil, from where the taxon was originally described by Weymer (1907) (Fig. 3).

Habitat and adult ecology: The only known individual of this taxon was observed and collected on the "Estrada do Alecrim" trail (24°4’41.65”S, 47° 27’7.48” W) on 28 April 2019, flying at a sunny forest edge. In the sector where the specimen was collected altitudes vary from 400 to 450 m, and the vegetation can be considered lowland ombrophilic Atlantic Forest.

The dorsal wing pattern of *A. herbita herbita* matches those of a number of *Adelpha* present (or potentially present) in the region, in particular the Atlantic Forest endemics *Adelpha falcipennis* Fruhstorfer, 1915, *Adelpha calliphane* Fruhstorfer, 1915, *Adelpha mythra* (Godart, [1824]), *Adelpha abia* (Hewitson, 1850), *Adelpha gavina* Fruhstorfer, 1915, *Adelpha serpa* (Boisduval, 1836) and *Adelpha zea* (Hewitson, 1850), all of which have the orange DFW subapical marking narrowing and extending to vein Cu_2 (Willmott, 2003). These species are likely involved in mimicry.

DISCUSSION

The rediscovery of *Adelpha herbita herbita* in the State of São Paulo more than a century after its description is noteworthy for two reasons: 1) this is the rarest known taxon of *Adelpha* in the Brazilian Atlantic Forest, known from only two individuals so far (the lost holotype and the specimen here described), and 2) it extends the distribution of this taxon by almost 250 km, considering the nearest localities with similar vegetation in the state of Santa Catarina. Based on this new record, the potential occurrence of *A. herbita herbita* is considerably expanded to include all lowland and submontane coastal forests that still persist in the states of Santa Catarina, Paraná and São Paulo.

The collection of a specimen of *A. herbita herbita* is also important, since it supports the validity of *A. herbita perdita* based on the differences in dorsal wing pattern, and additional differences now noted here in the ventral wing pattern. Also, the current record gives us some clues as to where the holotype could have been collected in Santa Catarina. Good candidate areas could include the lowland wet forests of the largely forested region from Jaraguá do Sul to Blumenau, two regions with similar vegetation and equivalent distance from the ocean, also known as important sources of biological material sent to Europe by independent collectors in the 19th and 20th centuries. From a conservation perspective, *A. herbita herbita* deserves concern since it is known from only two localities in the Atlantic Forest. However, although the original type locality in Santa Catarina remains imprecisely known, the range of this taxon includes the largest continuum of remaining Atlantic Forest, including several large public and private conservation units (MMA, 2000), meaning that there are many opportunities for conservation of this species in the region.

ACKNOWLEDGMENTS

We thank the work team of "Legado das Águas", who facilitated the study in the "Legado das Águas - Reservas Votorantim" and the ICMBio for the research permits (SISBIO no 55075-1, 10802-5 and 8482-1). Bianca S. Matinata helped with the process of donation of the specimen for the "Museu de Diversidade Biológica, Unicamp", and kindly received our team in “Legado das Águas” reserve. Ricardo Siewert and André Tacioli helped with dissection and pictures of the female genitalia. Eduardo Barbosa and an anonymous referee revised the last version of the manuscript. LB thanks Janaína Silva de Oliveira and Willer Santos Bontempo for the support in the field. KRW acknowledges support from NSF (DEB-1342705) and the McGuire Center for Lepidoptera and Biodiversity and thanks Jesse Cable, Sumayya Mujeeb and Gebreyes Kassu for assistance in curating *Adelpha*. AVLF thanks the Brazilian Research Council - CNPq (fellowship 304291/2020-0), and the FAPESP (grants 2011/50225-3, 2013/50297-0 and 2021/03868-8). AHBR thanks Coordenação de Aperfeiçoamento de Pessoal de Nível Superior–Brazil (CAPES) - Finance Code 001. This publication is part of the RedeLep “Rede Nacional de Pesquisa e Conservação de Lepidópteros” SISBIOTA-Brasil/CNPq (563332/2010-7). This study is registered under de SISGEN (AE1ED8D).

LITERATURE CITED

Braga, L., Ramos, R. R., Aguiar, T. M. C., Freitas, A. V. L. 2018. Distribution extension of *Godartiana byses* (Nymphalidae: Satyrinae) and first record for the state of São Paulo, Brazil. *Journal of the Lepidopterists’ Society* 72: 176-179.

Braga, L. 2022. *Borboletas do Legado das Águas*. Reservas Votorantin.178 pp.

Francini, R. B., Duarte, M., Mielke, O. H. H., Caldas, A., Freitas, A. V. L. 2011. Butterflies (Lepidoptera, Papilionoidea and Hesperioidea) of the “Baixada Santista” region, coastal São Paulo, southeastern Brazil. *Revista Brasileira de Entomologia* 55: 55-68.

MMA. 2000. *Avaliação e ações prioritárias para a conservação da biodiversidade da Mata Atlântica e Campos Sulinos*. Brasília, MMA/SBF. 40 pp.

Weymer, G. 1907. Exotische Lepidopteren. *Deutsche Entomologische Zeitschrift “Iris”* 20(1): 1-51.

Willmott, K. R. 2003. *The genus* Adelpha*: its Systematics, Biology and Biogeography (Lepidoptera: Nymphalidae: Limenitidini)*. Gainesville, Scientific Publishers. viii + 322 pp.

Willmott, K. R., Hall, J. P. W. 2013. A new species and two new subspecies of *Adelpha* Hübner, [1819] from the tropical Andes (Nymphalidae: Limenitidinae). *Journal of the Lepidopterists Society* 67: 241-252.

Willmott, K. R., Mielke, O. H. H., Freitas, A. V. L. 2016. A new subspecies and validation of the enigmatic species *Adelpha herbita* Weymer endemic to the Brazilian Atlantic forest (Nymphalidae: Limenitidinae). *Tropical Lepidoptera Research* 26(1): 32-37.

New records of *Adelpha atlantica* Willmott, 2003 (Nymphalidae: Limenitidinae) help to clarify its current conservation status

Augusto H. B. Rosa and André V. L. Freitas*

Departamento de Biologia Animal and Museu de Diversidade Biológica, Instituto de Biologia, Universidade Estadual de Campinas. Rua Monteiro Lobato, 255, CEP 13083-862, Campinas, São Paulo, Brazil. *Corresponding author: baku@unicamp.br.

Electronic copies (ISSN 2575-9256) in PDF format at: https://journals.flvc.org/troplep; https://zenodo.org; archived by the Institutional Repository at the University of Florida (IR@UF), http://ufdc.ufl.edu/ufir; **DOI**: 10.5281/zenodo.10882191

Abstract: The Neotropical genus *Adelpha* Hübner, [1819] is remarkable for its high species richness, including many species whose adults are extremely similar in dorsal wing pattern but not closely related, and by the rarity of some species in collections. Described based on only two individuals, *Adelpha atlantica* Willmott, 2003 is a rare Brazilian butterfly listed as "Endangered" in the Brazilian Red List. The present study reports six new individuals of *A. atlantica*, representing two new geographical records in the Atlantic Forest. With these two additional geographical records, both the known extent of occurrence (EOO) and the area of occupancy (AOO) have expanded considerably, suggesting that this species should be considered as "Least Concern (LC)" in future conservation status assessments.

Key words: area of occupancy; Atlantic Forest; Brazil; extent of occurrence.

Resumo: O gênero Neotropical *Adelpha* Hübner, [1819] é notório por sua alta riqueza de espécies, por apresentar muitas espécies cujos adultos são muito similares no padrão alar dorsal ainda que não estreitamente aparentados, e pela raridade de algumas espécies em coleções. Descrita com base em apenas dois indivíduos, *Adelpha atlantica* Willmott, 2003 é uma espécie brasileira rara listada como "Em perigo" na Lista Vermelha do Brasil. O presente estudo registra seis novos indivíduos de *A. atlantica,* representando dois registros geográficos inéditos. Com esses dois novos registros ambas, a extensão de ocorrência (EOO) e a área de ocupação (AOO) mostram um aumento considerável, significando que esta espécie deve ser considerada como "Pouco preocupante" em futuras avaliações do seu status de conservação.

Palavras chave: área de ocupação; Brasil; extensão de ocorrência; Mata Atlântica.

INTRODUCTION

The Neotropical genus *Adelpha* Hübner, [1819] is remarkable for its high species richness (93 described species) and for including many species whose adults are extremely similar in dorsal wing pattern but not closely related (Willmott, 2003b; Ebel *et al*., 2015; Freitas *et al*., 2019 and references therein). In addition, several species are rare in collections, with 14 species known from fewer than 25 specimens at the time of Willmott's (2003a) study. This was also the case for *Adelpha atlantica* Willmott, 2003, a species described based on only two individuals from two different localities in the state of Rio de Janeiro (Willmott, 2003a). In 2013, an additional specimen was collected in the municipality of Maricá (also in Rio de Janeiro state) (Almeida *et al*., 2018). Therefore, based on its apparently restricted distribution in areas of intense anthropogenic pressure, this species was assessed as "Endangered (EN)" (MMA, 2022). Recently, as part of a large project focusing on threatened Brazilian butterflies, six additional specimens of *A. atlantica* were found in two different collections. The aim of this study is to report new geographical records of *A. atlantica* and to review its conservation status in light of these new data.

MATERIALS AND METHODS

Individuals of *A. atlantica* were found in four public/private collections: **DZUP**, Departamento de Zoologia, Universidade Federal do Paraná, Curitiba, Paraná, Brazil; **OM**, Olaf Mielke Collection, Curitiba, Paraná, Brazil; **USNM**, Smithsonian Institution National Museum of Natural History, Washington, D.C., USA; **ZUEC**, Museu de Diversidade Biológica, Universidade Estadual de Campinas, Unicamp, Campinas, São Paulo, Brazil (Table 1). In addition, all photographs of *Adelpha* from Bahia to Rio Grande do Sul available until May 2023 in the website iNaturalist (www. inaturalist.org) were checked and identifications verified.

Geographical range (extent of occurrence EOO and area of occupancy AOO) was estimated based on all known sites of *A. atlantica*. The EOO is the area contained within the shortest continuous boundary (minimum convex polygon) that includes all known distribution points of a species, and the AOO is the area within its EOO that is actually occupied by a given taxon (IUCN, 2012; IUCN Standards and Petitions Committee, 2022). The EOO as recommended by IUCN includes all areas across the taxon's geographical distribution to measure the degree

Table 1. Data for all known individuals of *Adelpha atlantica* deposited in four public/private collections (see text for acronyms). PA = Protected area (where pertinent). *Acronyms for Brazilian states: PR = Paraná, RJ = Rio de Janeiro, SC = Santa Catarina; Protected areas: PSP = Parque Estadual do Palmito, PEPA = Petrópolis Environmental Protection Area, SDFEPA = Serra Dona Francisca Environmental Protection Area.

Acronym	N and sex	Date	State*	Municipality	Site	PA
USNM (Holotype)	1 male		RJ	Petrópolis		PEPA
DZUP (Paratype)	1 male	22.V.1980	RJ	Duque de Caxias	Imbariê	-
DZUP	1 male	12-13.II.2014	PR	Paranaguá	Parque Estadual do Palmito	PSP
DZUP	1 male	27.III.1970	SC	Joinville		SDFEPA
DZUP	1 male	9.XII.1975	SC	Joinville		SDFEPA
DZUP	1 male	15.I.1977	SC	Joinville		SDFEPA
OM	1 male	24.X.1992	SC	Joinville	Vila Nova, Serrinha	SDFEPA
OM	1 male	21.XII.1993	SC	Joinville	Vila Nova, Serrinha	SDFEPA
ZUEC	1 male	1.I.2013	RJ	Maricá	Serra do Camburi	-

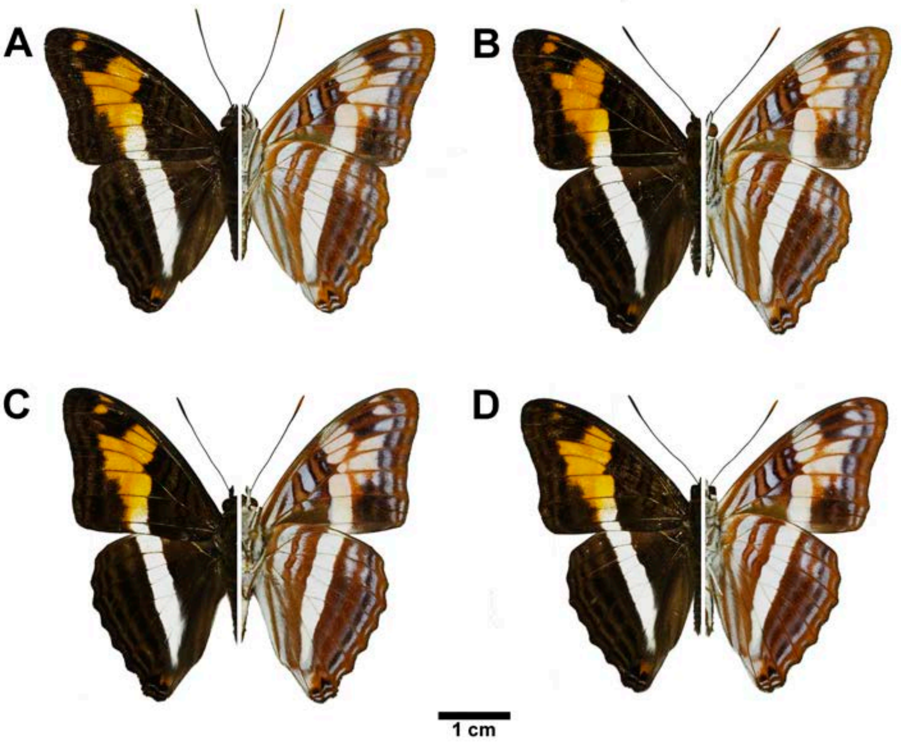


Figure 1. Four males of *A. atlantica* from the DZUP collection (all representing new localities for the species). A: Parque Estadual do Palmito, Paranaguá, Paraná state; B-D: Joinville, Santa Catarina state (dorsal left, ventral right).

to which risks from threatening factors are spread spatially, even if this is on land and/or ocean. Both EOO and AOO were estimated using the online open-source program GeoCAT (Geospatial Conservation Assessment Tool, available at http://geocat.kew.org) (Bachman *et al.*, 2011). As recommended by IUCN for AOO analyses, a 2 km grid of all cells (area of 4 km^2) which contain distribution points for the species was used (IUCN 2012; IUCN Standards and Petitions Committee, 2022). No species distribution model was used to estimate EOO or AOO.

RESULTS

Six additional males were found in two collections (the female is unknown), resulting in two new sites of occurrence for *A. atlantica* in southern Brazil (Table 1, Fig. 1, 2). No individuals of *A. atlantica* were found in iNaturalist (approximately 1,500

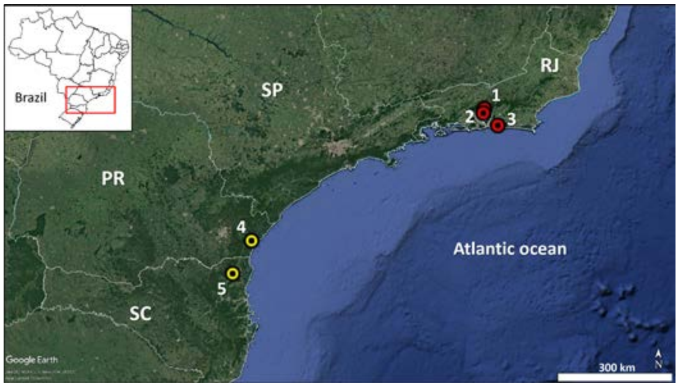


Figure 2. Map showing the five known localities for *A. atlantica*. 1. Petrópolis, RJ; 2. Duque de Caxias, RJ; 3. Maricá, RJ; 4. Paranaguá, PR; 5. Joinville, SC. Red circles: previous records; yellow circles: new records. Acronyms: PR: Paraná, RJ: Rio de Janeiro, SC: Santa Catarina, SP: São Paulo.

observations were revised by the first author). In addition, a photograph of the specimen referred to as *A. atlantica* from south São Paulo mentioned in Braga (2022) was inspected, and the specimen proved to be a tattered specimen of *Adelpha capucinus velia* (C. Felder & R. Felder, 1867). The extent of occurrence (EOO) using only the previous three known records was estimated as 215 km^2. By adding the two new sites, the EOO was calculated as 33,164 km^2, an increase of 15,302%. Similarly, the previous AOO was estimated as 12 km^2, and increased to 20 km^2 after adding the two new localities.

DISCUSSION

The results presented here reinforce the conclusion that the perceived rarity of some species of *Adelpha* is an artifact resulting from two main causes: 1) particular behavioral traits, such as flying in the canopy and far from open trails (see Rosa *et al.*, 2023, and references therein), and 2) because of the strong similarity in wing pattern, individuals of some uncommon species have remained unnoticed in museum collections, mixed with other more common widespread species (Almeida *et al.*, 2018; Freitas *et al.*, 2019; a detailed discussion about the rarity of some *Adelpha* species and subspecies can be found in Willmott, 2003a).

Based on previous records of *A. atlantica,* its restricted distribution in habitats with continuing decline in quality caused by anthropic activity resulted in it being categorized it as “Endangered (EN)” in the list of threatened species in Brazil (MMA, 2022). With the addition of the two new locations, the EOO estimate is considerably larger and it is probable that this species may still occur in the largest conserved area of Atlantic Forest, between the states of Rio de Janeiro and Santa Catarina. As a result, we suggest that this species should be considered as “Least Concern (LC)” in future conservation status assessments, because its EOO is now above the threshold of a threatened category (more than 20,000 km^2). However, based on the AOO, the species would still meet IUCN thresholds to be considered “Endangered” after the inclusion of the additional records (Rosa *et al.*, 2023). Nevertheless, we believe that this conclusion is currently not justified, since the current knowledge for this species likely underestimates its true AOO, as for many other threatened Brazilian butterflies (see Rosa *et al.*, 2023 for more information). In the particular case of *A. atlantica,* there are also large areas of suitable habitat within which this species could be present inside the EOO polygon. Finally, in addition to bringing new information about a little-known butterfly species, the present study demonstrates the importance of biological collections as source of data for ecological and conservation studies (Hilton *et al.,* 2021).

ACKNOWLEDGMENTS

We thank: Mirna Casagrande, Eduardo Carneiro, Matheus H. F. Barbosa, Olaf Mielke for access and photos of the material deposited in the DZUP collection; Olaf Mielke for the access to material deposited in his collection; Bob Robbins for access to material deposited in the USNM collection; Keith Willmott for confirming the identification of *A. atlantica* from the DZUP collection; Laura Braga for sending us information and photographs of the specimen of *Adelpha capucinus velia* from Legado das Águas. Ryan Hill and Keith Willmott for their valuable comments and suggestions to improve the manuscript; AVLF thanks the Brazilian Research Council - CNPq (fellowships 421248/2017-3 and 304291/2020-0), and the FAPESP (grant 2021/03868-8). AHBR thanks Coordenação de Aperfeiçoamento de Pessoal de Nível Superior–Brazil (CAPES) - Finance Code 001. This publication is part of the RedeLep “Rede Nacional de Pesquisa e Conservação de Lepidópteros” SISBIOTA-Brasil/CNPq (563332/2010-7). This study is registered under de SISGEN (A57D479).

LITERATURE CITED

Almeida, G. S., Raby, R., Magaldi, L. M., Freitas, A. V. L. 2018. A new record for the rare Atlantic Forest endemic butterfly *Adelpha atlantica* (Nymphalidae: Limenitidinae). *Journal of the Lepidopterists’ Society* 72(3): 249-251.

Bachman, S., Moat, J., Hill, A. W., De La Torre, J., Scott, B. 2011. Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. *ZooKeys* 150: 117-126.

Braga, L. 2022. *Borboletas do legado das Águas*. São Paulo, SP, Reservas Votorantim. 78 pp.

Ebel, E. R., DaCosta, J. M., Sorenson, M. D., Hill, R. I., Briscoe, A. D., Willmott, K. R., Mullen, S. P. 2015. Rapid diversification associated with ecological specialization in Neotropical *Adelpha* butterflies. *Molecular Ecology* 24(10): 2392-2405.

Freitas, A. V. L., Woodbury, M. S., Barbosa, E. P., Willmott, K. R. 2019. A new subspecies of *Adelpha messana* (C. Felder & R. Felder) from the Brazilian Atlantic forest (Nymphalidae: Limenitidinae). *Tropical Lepidoptera Research* 29(2): 62-66.

Hilton, E. J., Watkins-Colwell, G. J., Huber, S. K. 2021. The expanding role of natural history collections. *Ichthyology & Herpetology* 109(2): 379-391.

IUCN. 2012. *IUCN Red List Categories and Criteria: Version 3.1.* Technical Report, IUCN Species Survival Commission. Gland, Switzerland and Cambridge, UK, IUCN.

IUCN Standards and Petitions Committee. 2022. *Guidelines for Using the IUCN Red List Categories and Criteria. Version 15.1.* Prepared by the Standards and Petitions Committee. https://www.iucnredlist.org/resources/redlistguidelines. Accessed 2 April 2023.

MMA. 2022. *Portaria MMA Nº 148, de 7 de junho de 2022 - Atualiza o teor do Anexo da Portaria nº 443, de 17 de dezembro de 2014, Lista oficial de espécies da flora brasileira ameaçadas de extinção*. Diário Oficial da União, Brasilia, DF. Seção 1, 108: 74.

Rosa, A. H. B., Ribeiro, D. B., Freitas, A. V. L. 2023. How data curation and new geographical records can change the conservation status of threatened Brazilian butterflies. *Journal of Insect Conservation* 27: 403-414.

Willmott, K. R. 2003a. *The Genus* Adelpha*: its Systematics, Biology and Biogeography (Lepidoptera: Nymphalidae: Limenitidini).* Gainesville, Scientific Publishers. viii + 322 pp.

Willmott, K. R. 2003b. Cladistic analysis of the neotropical butterfly genus *Adelpha* (Nymphalidae: Limenitidini), with comments on the subtribal classification of the tribe Limenitidini. *Systematic Entomology* 28: 1-43.

Additions to the moth (Lepidoptera) fauna of India from the eastern Himalaya and northeastern region

Sanjay Sondhi[1,2], Rachit Pratap Singh[2,4], Ujwala Pawar[3] and Krushnamegh Kunte[2,3]

1. Titli Trust, 49 Rajpur Road Enclave, Dhoran Khas, Dehradun, Uttarakhand 248001, India. 2. Indian Foundation for Butterflies Trust, C-703, Alpine Pyramid Apts, near Canara Bank Layout, Kodigehalli, Bengaluru, Karnataka 560097, India. 3. National Centre for Biological Sciences, Tata Institute of Fundamental Research, Bellary Road, Bengaluru, Karnataka 560097, India. 4. McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History, University of Florida, Gainesville, FL 32611, USA. sanjay.sondhi1@gmail.com (corresponding author); ORCID ID: https://orcid.org/0000-0002-3970-6858; rachitsingh98@gmail.com; https://orcid.org/0000-0001-6158-7659; ujwalamp@ncbs.res.in; https://orcid.org/0000-0003-1281-2228; krushnamegh@ncbs.res.in (corresponding author); https://orcid.org/0000-0002-3860-6118

Date of issue online: 5 April 2024
Electronic copies (ISSN 2575-9256) in PDF format at: http://journals.fcla.edu/troplep; https://zenodo.org; archived by the Institutional Repository at the University of Florida (IR@UF), http://ufdc.ufl.edu/ufir; **DOI**: 10.5281/zenodo.10882236

Abstract: Ten moth species, *Monema coralina* Dudgeon, 1895, *Paralbara watsoni* (Holloway, 1976), *Phalera eminens* Schintlmeister, 1997, *Phalera argenteolepis* Schintlmeister, 1997, *Striatella nigralba* (Hampson, 1894)**,** *Stigmatophora roseivena* (Hampson, 1894), *Tamba lala* (Swinhoe, 1900), *Mosopia kononenkoi* Holloway, 2008, *Chloroplaga pallida* Warren, 1916 and *Somatina densifasciaria* Inoue, 1992 are reported here as new species records for India from the eastern Himalaya and northeastern region based on museum specimens and genitalia dissections. Recent records of an additional three species, *Chalcosiopsis variata* Swinhoe, 1894, *Macrobrochis flavicincta* Hampson, 1905 and *Striatella pluma* (Černý, 2009) that have only a few published records from India, are also presented. These discoveries showcase the unexplored biodiversity of the eastern Himalaya and northeastern India, highlighting urgent need to undertake extensive biodiversity surveys and to protect habitats facing numerous anthropogenic threats.

Key words: Faunal discovery; Himalayan biodiversity; moth diversity; moth taxonomy; range distributions

INTRODUCTION

The state of Arunachal Pradesh in north-eastern India is situated at the junction of the Oriental and Palearctic biogeographic regions. The state is part of the Himalayan (NE Pakistan eastward to Arunachal Pradesh) and Indo-Burma Biodiversity Hotspots (east of the Brahmaputra River), spanning two of the four globally recognized hotspots in India. Arunachal Pradesh has 79.33% of its land area forested (Forest Survey of India, 2021). Its forests support unusually high species diversity and many prominent endemic species, making this a globally important biodiversity area.

Mouling National Park is located in the Indian state of Arunachal Pradesh, spread primarily over the Upper Siang District, parts of the West Siang and East Siang Districts. We sampled moth diversity as part of ongoing faunal surveys primarily in Mouling NP and its surrounding areas in 2022 and 2023. Moths of Arunachal Pradesh are poorly studied. Historically, the best-studied sites in the Himalayan and NE regions were around hill stations, during the British rule of India. Consequently, most historical moth records in the Eastern Himalaya and northeast India are near cities such as Darjeeling (West Bengal) and Shillong (Meghalaya). Other areas that were well surveyed were the Naga Hills in Nagaland and Manipur, and the Khasi Hills in Meghalaya. Arunachal Pradesh, without any major hill city, was historically poorly studied. In recent years, we have reported over 500 moth species from Tale WLS in Arunachal Pradesh (Sondhi *et al.*, 2021). Three new moth species, *Elcysma ziroensis* Chada, Gogoi & Young, 2017, *Metallolophia taleensis* Sondhi, Nath, Sondhi & Kunte, 2020, *Piarsoma arunachalensis* Sondhi, Efetov, Tarmann & Kunte, 2023 (Chada *et al.*, 2017; Sondhi *et al.*, 2020; Sondhi *et al.*, 2023), were also recently described from Arunachal Pradesh, showcasing the state's unexplored biodiversity.

Here, we report ten moth species that have previously not been recorded from India. For each of these species, we provide information about material (specimens) examined, dissected genitalia (nine species), species identification, and distribution. An additional three species, which have only a few published records from India, are also discussed. We also report a new moth record from India from Zunheboto District, Nagaland.

MATERIAL AND METHODS

We have been conducting moth surveys in northeast India for over a decade. During surveys in Arunachal Pradesh and Nagaland, numerous moth species were recorded that have not been previously reported from India. The list of survey sites referred to in this paper is provided in Table 1. We surveyed moths using a 160 W mercury vapor bulb powered with a Honda™ EP1000 portable generator, or a LepiLED Maxi (Brehm, 2017) supported by three 20,000-mAH Li-Polymer power banks, and a 120 x 150 cm white cloth-screen. We photographed moths on the cloth-screen using a Nikon™ D750 camera with an AF-S

Table 1: List of survey sites with GPS coordinates, altitudes and survey details.

S No	Site location	District, State	GPS coordinates	Altitude	Months surveyed	Survey nights
1	Gobuk	Upper Siang District, Arunachal Pradesh	N 28° 34.649', E 095° 07.643'	1215 m	Jan, Aug	4
2	Jengging	Upper Siang District, Arunachal Pradesh	N 28° 32.708', E 095° 03.614'	838 m	Mar, Apr, May, Sep	5
3	Yemsing	East Siang District, Arunachal Pradesh	N 28° 06.84200', E 95° 0.46300'	481 m	Mar	1
4	Piiyu Tierra Resort, Pasighat	East Siang District, Arunachal Pradesh	N 28° 09.113', E 095° 16.386'	209 m	Jan, May	2
5	Ramsing	Upper Siang District, Arunachal Pradesh	N 28° 39.387', E 094° 58.576'	630 m	Jan, Apr, May, Aug, Sep	7
6	Kallek	East Siang District, Arunachal Pradesh	N 28° 07.063, E 095° 10.157'	819 m	Mar	1
7	Kivikhu	Zunheboto District, Nagaland	N 25° 50.530' E 94° 29.931'	1642 m	Apr, May, Sep, Dec	5

VR Micro-Nikkor^{TM} 105mm f/2.8G IF-ED lens and a Canon EOS R6 with a Canon RF 100 mm Macro f/2.8 IS lens. We collected moth specimens in Nagaland based on a collection permit issued by the Principal Chief Conservator of Forests & Head of Forest Force, Nagaland (Letter no FG-4/2/2014/6552 dated 12.vii.2017). We collected moth specimens in Arunachal Pradesh based on a collection permit issued by the Principal Chief Conservator of Forests (Wildlife & Biodiversity) and Chief Wildlife Warden, Arunachal Pradesh Forest Department (Letter No. CWL/Gen/355/2021/3179, dated 28.ix.2021). Pinned specimens, along with their tissue (three legs and thoracic muscle tissue) in 100% molecular grade ethanol, are preserved in the Biodiversity Lab Research Collections (http://biodiversitycollections.in) at the National Centre for Biological Sciences, Tata Institute of Fundamental Research, Bengaluru, India.

Moth genitalia were dissected after dissolving extraneous abdominal tissue with 10% KOH (w/v) at 95°C. The dissected genitalia were preserved in 0.5 ml vials containing anhydrous Glycerol, which are maintained at room temperature (22-26°C) in an air-conditioned room. The genitalia were photographed using a Leica digital camera (MC 120 HD) mounted onto a Leica S8APO stereomicroscope (Leica Microsystems, Germany). We took multiple images and stacked them to improve depth of field, with CombineZM software (Hadley 2010). For all the pinned specimens illustrated in this paper, we photographed the dorsal and ventral sides along with a scale. In the figures with dissected male genitalia, we arranged the different views from left to right in the following order: ventral flattened, dorsal, lateral (left valva removed), left valva outer view and lateral view of aedeagus. For the female genitalia, we have presented the lateral, dorsal, and ventral views. The species are organised in the paper based on the phylogenetic arrangement of superfamilies and families proposed by Nieukerken *et al.* (2011) and Kawahara *et al.* (2019).

The primary survey sites in Nagaland are in Zunheboto District where the village cluster of Sukhai, Kivikhu and Ghukheyi have come together to form the Tizu Valley Biodiversity Conservation and Livelihood Network, a nature conservation community organisation. These villages have declared their forests as Community Conserved Areas (CCA's). In Arunachal Pradesh, the main survey sites are in the Mouling National Park and its surrounding areas in the Siang River Valley Basin. The surveyed areas on the west of the Siang River are Ramsing, Jengging, Kallek and Yemsing, while Gobuk and Pasighat lie the east of the Siang River. Most of the moth surveys were done on the borders of the Mouling NP and in community forests surrounding the villages named above (Table 1).

Abbreviations used are as follows: FWL: Forewing length, NCBS: National Centre for Biological Sciences - TIFR, Bengaluru, India, WLS: Wildlife Sanctuary, NP: National Park, SS: Sanjay Sondhi, RPS: Rachit Pratap Singh, KK: Krushnamegh Kunte, UP: Ujwala Pawar, YS: Yash Sondhi.

RESULTS AND DISCUSSION

Ten moth species that are new records for India are examined, their specimens studied and their genitalia dissected. The species' identities are discussed, and they are compared with similar taxa and their known global distributions. We follow the terminology used by Scoble (1992), Kristensen (2003) and Kunte *et al.* (2019) for all genitalia descriptions and notes. An additional three species, which have only a few published records from India, are also discussed.

Family Zygaenidae
Subfamily Chalcosiinae
Tribe Heteropanini

Chalcosiopsis variata **Swinhoe, 1894** (Figures 1A-B, 2A, 6A)

Chalcosiopsis variata Swinhoe, 1894. *The Annals and Magazine of natural history, botany and zoology* (6) 14 (84): 442. TL: Shillong, Meghalaya.

References: Hampson (1894: 468-9, Fig. 249); Smetacek (2019: 103).

Material examined: India, Arunachal Pradesh: 1 ♂, Upper Siang District, Jengging, 24.v.2022, *leg.* SS (IBC-BQ674), FWL: 16.5 mm. 1 ♂, East Siang District, Yingku, 26.v.2022, *leg.* SS (IBC-BQ730), FWL: 15 mm.

Diagnosis: This little-known species was described by Swinhoe in 1894, by examining four female specimens (Swinhoe, 1894), and Smetacek (2019) recorded what was possibly a male from Arunachal Pradesh. Two species of *Chalcosiopsis* Swinhoe, 1894 are known globally, with *Chalcosiopsis melli* Alberti, 1954 being an extralimital species known from China. *Chalcosiopsis variata* is easily identified by brown forewings with an oblique white band, and white hindwings with broad brown marginal borders.

We recorded two individuals of *Chalcosiopsis variata* and dissected one male to describe the features and show its genitalia in detail for the first time (Fig. 2A). Yen *et al.* (2005)

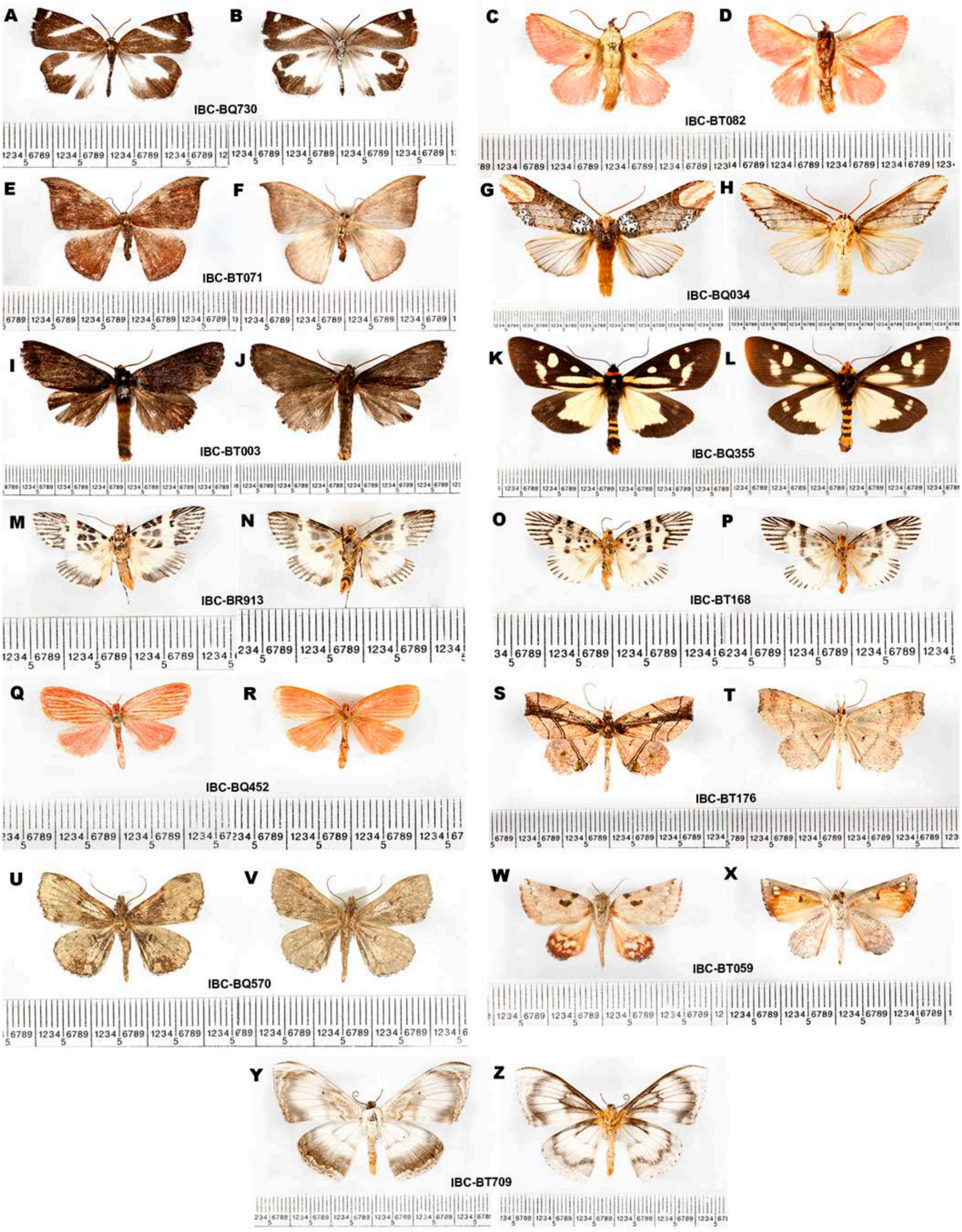


Figure 1: Dorsal and ventral views (left to right) of pinned moth specimens. **A-B.** *Chalcosiopsis variata,* male; **C-D.** *Monema coralina,* male; **E-F.** *Paralbara watsoni,* female; **G-H.** *Phalera eminens,* male; **I-J.** *Phalera argenteolepis*, male; **K-L.** *Macrobrochis flavicincta,* male; **M-N.** *Striatella nigralba*, male; **O-P.** *Striatella pluma,* female; **Q-R.** *Stigmatophora roseivena*; **S-T.** *Tamba lala*, female; **U-V.** *Mosopia kononenkoi*, male; **W-X.** *Chloroplaga pallida,* male; **Y-Z.** *Somatina densifasciaria,* male. Millimetres scale bar is shown under every image.

presented a distal view of the male genitalia, but a detailed description was not provided. The male genitalia examined here has a characteristic setose and sclerotized uncus with a pointed apex and smooth groove in the subapical region, as noted in Yen *et al.* (2005). The uncus has a narrow base and joins the broad, hooded tegumen with a medial ridge in the center. The saccus is not elongated and extends anterodorsally. The valvae are rounded, broad and heavily setose near the sacculus and taper gradually towards a flat costal margin curving outwards at the apex. The harpe are seen as digitiform projections arising from the cucullus area. The aedeagus has a characteristic, well-developed phallobase and bulbus ejaculatorius.

Distribution: India: Arunachal Pradesh (Jengging, Upper Siang District; Yingku, East Siang District, current paper; Lower Dibang District) (Smetacek, 2019), Meghalaya (Hampson, 1894).

Remarks: One of the individuals, IBC-BQ674, was collected at Jengging, during the day, while the second individual, IBC-BQ730, came to the moth screen at night, illuminated by a mercury vapour bulb.

Family Limacodidae
Subfamily Limacodinae
***Monema coralina* Dudgeon, 1895 (**Figures 1C-D, 2B, 6B)
Monema coralina Dudgeon, 1895. *Transactions Entomological Society of London* 1895 (2): 290; TL: Bhutan.

References: Yoshimoto (1993; 34, Pl. 39, fig. 15); Pan, Zhu & Wu (2013: 23).

Material examined: India, Arunachal Pradesh, Upper Siang District: 1 ♂, Gobuk, 30.viii.2022, *leg*. SS (IBC-BT082), FWL: 13.5 mm. Ramsing, 01.ix.2022, *leg*. SS (IBC-BT219), FWL: 15.5 mm.

Diagnosis: This unmistakable species was described from Bhutan. Its external morphology separates it from other extralimital congeners from China, *M. tanaognatha* Wu & Pan, 2013 and *M. meyi* Solovyev & Witt, 2009 (Pan *et al.,* 2013) as no other congener has the forewings and hindwings almost entirely pink, with the base and costa of the forewing, yellow, with a brown spot at base of the forewing, near the inner margin.

The male genitalia of IBC-BT082 (Fig. 2B) have an uncus forming a flat triangular hood with a pointed apex, dorsally. The gnathos is short and curved, the juxta is sclerotized and has two pointed tips, and the valvae are broad and sclerotized near the sacculus with a weakly sclerotized costal margin. The sacculus is distally extended into a forked and inwardly curved process. The aedeagus is straight and chitinized with a ventrally projected apical spur, unlike the other *Monema* spp. where it is either strongly curved or straight. The male genitalia examined here match well with the illustrations in Pan *et al.* (2013), except the saccular process is more pointed in the latter. In comparison to *M. coralina,* the male genitalia of *M. meyi* is characterized by an elongated gnathos and S-shaped juxta.

Distribution: India: Arunachal Pradesh (Gobuk and Ramsing, Upper Siang District; current paper). Elsewhere: Bhutan (TL) (Irungbam *et al.*, 2017), Nepal (Inoue, 1970; Yoshimoto, 1993), China (Yunnan and Xizang) (Pan *et al.*, 2013).

Remarks: New genus and species record for India. The species has been reported from Bhutan and Nepal in the Indian subregion, so these records extend its distribution eastwards.

Family Drepanidae
Subfamily Drepaninae
***Paralbara watsoni* (Holloway, 1976)** (Figures 1E-F, 2C, 6C)
Albara watsoni Holloway, 1976. Moths of Borneo with special reference to Mt. Kinabalu *Moths of Borneo Kinabalu* : 1-264. Pg. 92. TL: Borneo.

References: Holloway (1998: 57, Pl. 3/29).

Material examined: India, Arunachal Pradesh: 1 ♀, Upper Siang District, Gobuk, 29.viii.2022, *leg*. SS (IBC-BT071), FWL: 18 mm.

Diagnosis: Described from Borneo by Holloway (1976), this species differs from its congener, *Paralbara perhamata* (Hampson, [1893]), by the presence of a quadrate, pale patch at the middle of the costa on the upperside of the forewing, while the underside of the forewing is paler than *perhamata*, but becomes darker at the distal margin (Holloway, 1998).

The examined female genitalia (Fig. 2C) have a characteristically sclerotized 7th sternite and 8th tergite. The anal papillae are divided, with short, rounded lobes. A broad, sclerotized antevaginal plate is present, as seen in all *Paralbara* species (Holloway, 1976). The ostium is sclerotized, dorsally conical and ventrally rounded. The ductus bursae is narrow and short and the corpus bursae is ovate with an anterior, rounded, scobinate signum. The female genitalia of *P. perhampta*, as illustrated by Watson (1968), can be easily separated from those of *P. watsoni* by the absence of a signum, a more rounded antevaginal plate and the ostium being dorsally straight.

Distribution: India: Arunachal Pradesh (Gobuk, Upper Siang District; current paper). Elsewhere: Borneo, Indonesia, Peninsular Malaysia (Holloway, 1998).

Remarks: Joshi *et al.* (2020) do not report this species in the India checklist of Drepanoidea; hence this is the first record of this species from India.

Family Notodontidae
Subfamily Phalerinae
***Phalera eminens* Schintlmeister, 1997** (Figures 1G-H, 2D, 6D)
Phalera eminens Schintlmeister, 1997. *Entomofauna Supplement 9*: 136; TL: N. Vietnam, Fan-si-pan.

References: Fang & Wu (2004: 116, Fig. 13); Schintlmeister & Pinratana (2007: 224, Pl. 35, Fig. 249).

Material examined: India, Arunachal Pradesh: 1 ♂, East Siang District, Yemsing, 27.iii.2022, *leg*. SS (IBC-BQ034), FWL: 37.5 mm.

Diagnosis: This unmistakable species is best separated by the blackish-white chequered pattern at the base and the tornal area of the forewing (Schintlmeister & Pinratana, 2007).

The male genitalia (Fig. 2D) have a densely sclerotized and bifurcated uncus which is diagnostic for the species. A narrow yet distinct apical process originating from the center of the modified uncus can be observed. The valvae are broad, robust and basally densely hairy. The aedeagus is straight and contains numerous stellate spicules in the vesica. The genitalia of IBC-BQ034 match with the genitalia figure and diagnostic features

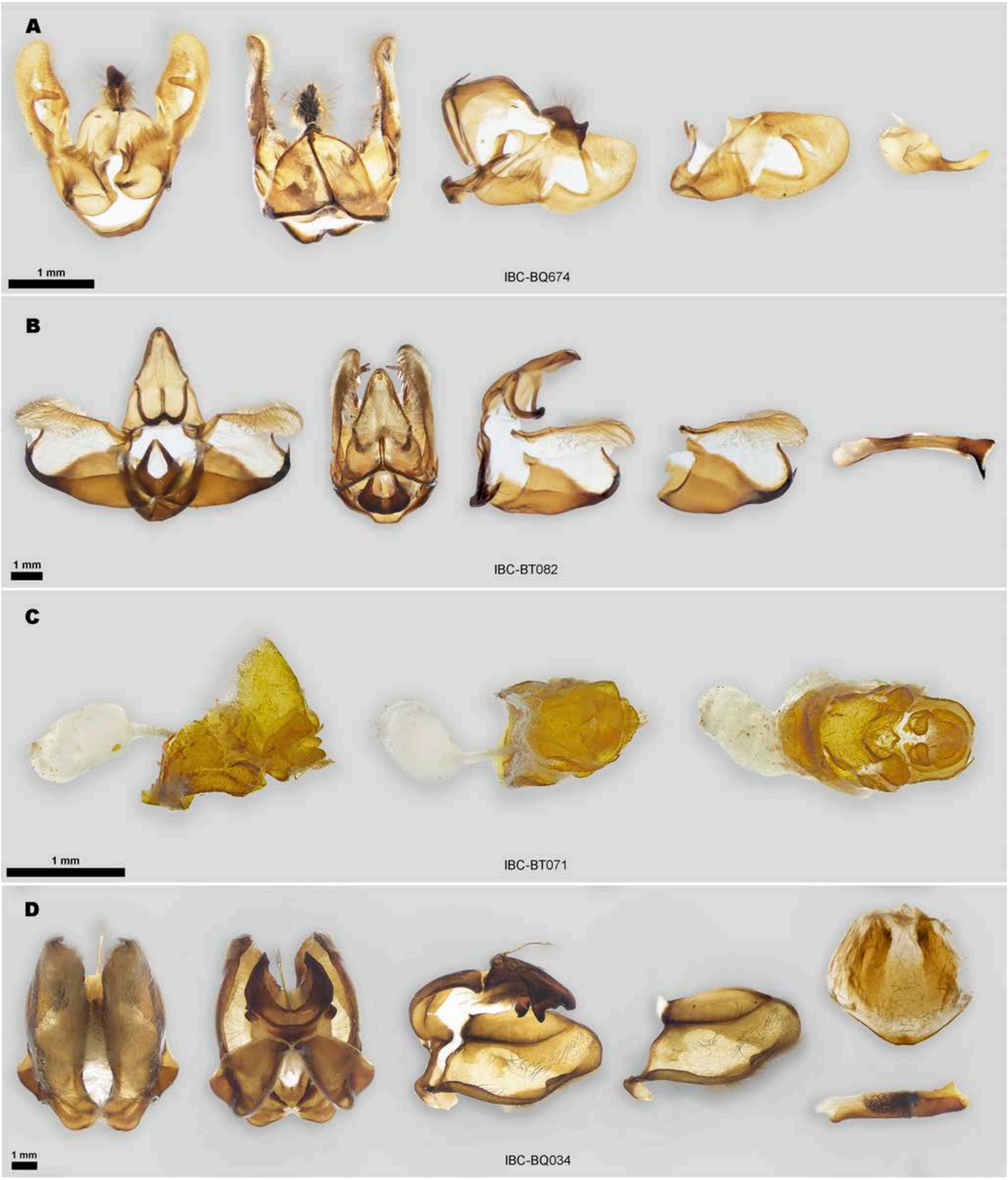


Figure 2: Male and female genitalia of the newly reported moths from northeast India. **A.** *Chalcosiopsis variata* (IBC-BQ674), male; **B.** *Monema coralina* (IBC-BT082), male; **C.** *Paralbara watsoni* (IBC-BT071), female; **D.** *Phalera eminens* (IBC-BQ034), male; 8th sternite shown above the aedeagus. For each male genitalia figure, left to right: genital capsule distal view, dorsal view, lateral view (left valva removed), left valva outer view, aedeagus. For each panel with female genitalia, left to right: lateral view, dorsal view, ventral view.

described by Schintlmeister (1997).

Distribution: India: Arunachal Pradesh (Yemsing, East Siang District; current paper). Elsewhere: China, Myanmar, Thailand, Vietnam (Fang & Wu, 2004; Schintlmeister & Pinratana, 2007).

Remarks: Chandra *et al.* (2018) do not report this species in the Catalogue of Indian Notodontidae; hence this is the first record of this species from India.

***Phalera argenteolepis* Schintlmeister, 1997** (Figures 1I-J, 3A, 6E)

Phalera argenteolepis Schintlmeister, 1997. *Entomofauna Supplement 9*: 137; TL: N.Vietnam, Fan-si-pan.

References: Fang & Wu (2004: 119, Fig. 29); Schintlmeister & Pinratana (2007: 228, Pl. 36, Fig. 256).

Material examined: India, Arunachal Pradesh: 2 ♂, Upper Siang District, Gobuk, 29.viii.2022, *leg.* SS (IBC-BT001 and IBC-BT003), FWL: 28 mm and 28.5 mm respectively.

Photographic records: India, Arunachal Pradesh, Upper Siang District, Ramsing, 21.iv.2022,

Diagnosis: The silvery scales at the base of the forewing are diagnostic for this species (Schintlmeister & Pinratana, 2007).

The male genitalia (Fig. 3A) are robust and heavily sclerotized with a prominent and characteristic pair of socii that are half the length of the valvae. The uncus has a broad triangular base and a setose, lobed apex. The tegumen and vinculum are fused with the valvae, which have a broad inwardly curved process originating from the cucullus. The aedeagus is curved and long with pointed ventral and dorsolateral processes. The genitalia of IBC-BT003 is a good match with the genitalia presented by Schintlmeister (1997, fig. 158). However, the diagnostic sclerotization of the 8th sternite could not be compared and the socii are not triangular and flap-like as seen in Schintlmeister (1997).

Distribution: India: Arunachal Pradesh (Gobuk and Ramsing, Upper Siang District; current paper). Elsewhere: China, Laos, Myanmar, Thailand, Vietnam (Fang & Wu, 2004; Schintlmeister & Pinratana, 2007).

Remarks: Chandra *et al.* (2018) do not report this species in the Catalogue of Indian Notodontidae; hence this is the first record of this species from India.

Family Erebidae
Subfamily Arctiinae
Tribe Lithosiini

***Macrobrochis flavicincta* Hampson, 1905** (Figures 1K-L, 3B-C, 6F)

Macrobrochis flavicincta Hampson, 1905. The Journal of Bombay Natural History Society, Vol. 16 (2): 202, Pl. D, fig 21. TL: Cachar, Assam.

References: Kishida (1997), Gekkan-Mushi 320: 3-5 (as *Macrobrochis notabilis*); Černý & Pinratana (2009: Vol. 6: 121) (as *Macrobrochis notabilis*).

Material examined: India, Arunachal Pradesh: 2 ♂, 1 ♀, East Siang District, Pasighat, Piiyu Tierra Resort, 19.v.2022, *leg.* SS (IBC-BQ354, IBC-BQ355, IBC-BQ360). FWL: 26 mm, 27 mm, 28 mm respectively.

Photographic records: India, Arunachal Pradesh, Upper Siang District, Pittung village, 22.v.2022.

Diagnosis: Six species of *Macrobrochis* Herrich-Schäffer, [1855] are known from India (Singh *et al.*, 2021; Sondhi *et. al.*, 2023). *Macrobrochis flavicincta* was described by Hampson with the type locality as "Cachar", which is now in Assam (Hampson, 1905). *Macrobrochis flavicincta* most closely resembles *M. prasena* (Moore, 1859), but can be differentiated by the presence of a cream-coloured basal streak and a narrower streak along the dorsum of the forewing. *Macrobrochis flavicincta* has two rounded forewing cell spots (single linear cell streak in *M. prasena*). In addition, *M. flavicincta* has a prominent black marginal border, which *M. prasena* lacks.

The species described as *M. notabilis* Kishida, 1997 from Chiang Mai, Thailand and reported by Černý and Pinratana (2009) as *M. notabilis,* matches the description and illustration of *M. flavicincta*. Hence, *M. notabilis* should be treated as a synonym of *M. flavicincta*. Holloway (2001) and Koçak & Kemal (2010) also mention that *M. notabilis* is a synonym of *M. flavicincta*.

The male genitalia of IBC-BQ355 (Fig. 3B) have a falcate uncus with a pointed apex, bent downwards. The tegumen is broad, fused, with a medial ridge visible, and a densely setose membranous tissue is bound ventrally to the tegumen. The valvae are long and narrow, apically broad with a weakly sclerotized costa. The sacculus is well-sclerotized with a saccular process and a distal spine. The aedeagus is short and straight with a dorsal spine at the distal end. A row of pectinate cornuti can be observed in the uneverted vesica. The genitalia of *M. prasena* have a broader sacculus and saccular process; the valvae are distally round and broader compared to *M. flavicincta*.

The female genitalia (Fig. 3C) are atypically large, ovoid and heavily sclerotized. The appendix bursae originates from the posterior region of the copulatrix bursae and is ventrally curved, heavily rugose and sclerotized. The distal region is especially rounded and broad. The copulatrix bursae is globular, well separated to the left side with spermatophore intact; the ductus seminalis seen arising from the bursa in lateral view. The female genitalia of *M. prasena* as illustrated in Kirti & Singh (2015) can be distinguished by the presence of larger corpus bursae and the absence of a large sclerotized appendix bursae. No other images or descriptions of the genitalia exist in published literature for *M. flavicincta*; hence this is the first detailed report on the male and female genitalia.

Distribution: India: Arunachal Pradesh (Pasighat, East Siang District; Pittung, Upper Siang District; current paper), Assam (Cachar). Elsewhere: Laos, Myanmar, Thailand (Chiang Mai) (Kishida, 1997; Černý & Pinratana, 2009).

Remarks: Singh *et al.* (2021) do not list this species in the catalogue of Indian Arctiinae and there have been no published records from India since its original description.

Subtribe Nudariina

***Striatella nigralba* (Hampson, 1894)** (Figures 1M-N, 3D, 6G)

Miltochrista nigralba Hampson, 1894. *The Fauna of British India, including Ceylon and Burma (Moths)*, 2: 109 (Type locality: [Myanmar] "Bernardmyo; E. Pegu").

References: Volynkin, Černý & Huang (2019: Pg. 15-16, Fig. 56-63) (as *Barsine nigralba*).

Material examined: India, Nagaland: 1 ♂, Zunheboto District, Kivikhu, 14.v.2018, leg. YS/SS (IBC-BR913), FWL: 12 mm.

Diagnosis: Based on external morphology, *Striatella nigralba* is very similar to its closest relative *S. fasciata* (Leech, 1889), but differs by the broader medial and antemedial line and spots of sub-basal area, the longer dentation of the postmedial line, the broader, more diffuse longitudinal linear streaks on

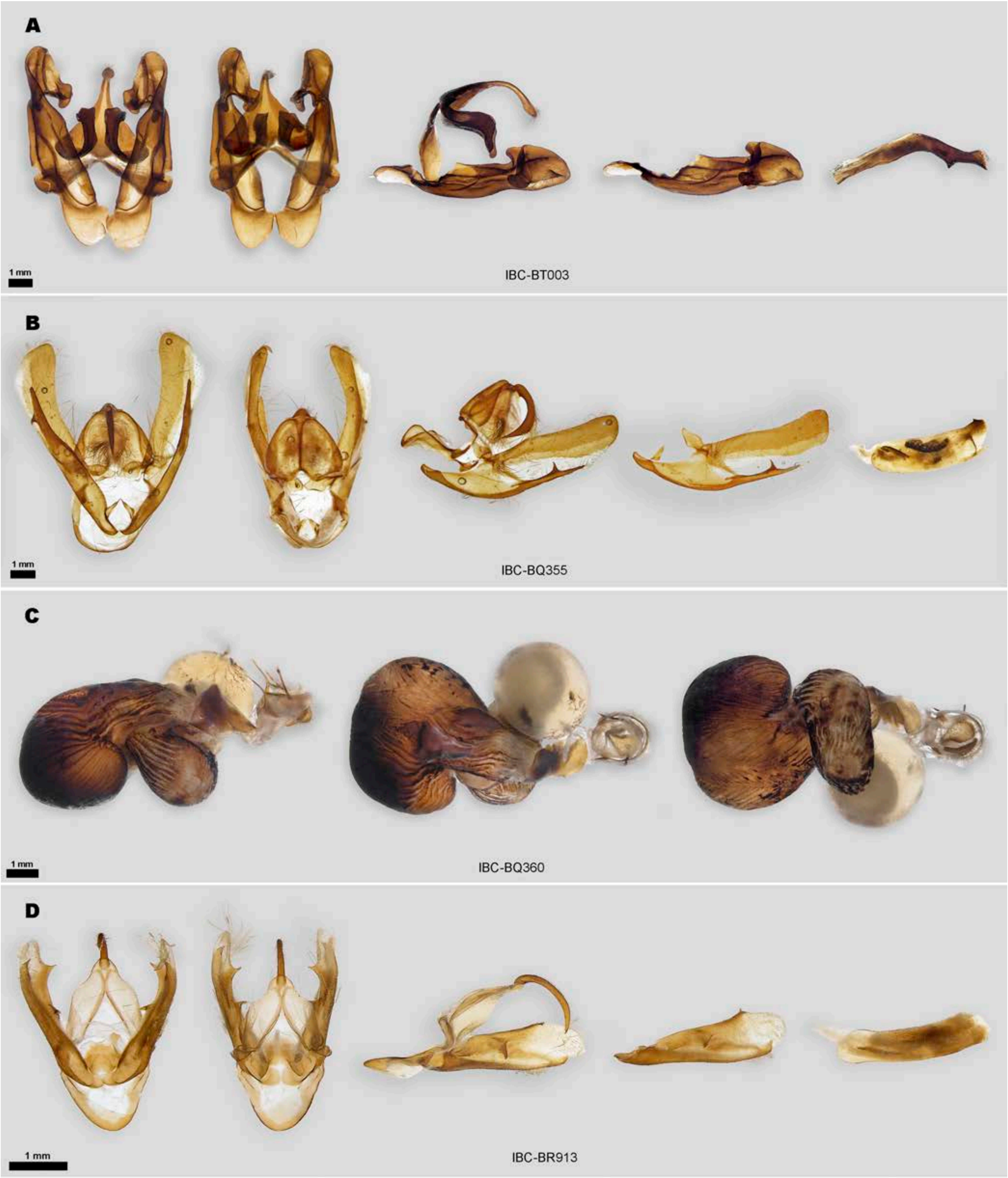


Figure 3: Male and female genitalia of the newly reported moths from northeast India. **A.** *Phalera argenteolepis* (IBC-BT003), male; **B.** *Macrobrochis flavicincta* (IBC-BQ355), male; **C.** *Macrobrochis flavicincta* (IBC-BQ360), female; **D.** *Striatella nigralba* (IBC-BR913), male. For each male genitalia figure, left to right: genital capsule distal view, dorsal view, lateral view (left valva removed), left valva outer view, aedeagus. For each panel with female genitalia, left to right: lateral view, dorsal view, ventral view.

veins in the submarginal area of hindwing and a series of black marginal spots at the end of the black longitudinal linear streaks (Volynkin *et al.*, 2019).

The male genitalia (Fig. 3D) have a visible harpe and two processes on the valvae, at the costa and cucullus. These are characteristic for the genus and the sister species in *Barsine*. The aedeagus is short and straight. The genitalia description by Volynkin *et al.* (2019) matches well with the individual examined here. The male genitalia of *S. nigralba* are very similar to those of *S. fasciata* and can be separated by the distally broader valva and a broader vesica (not examined here), with robust cornuti in the latter species.

Distribution: India: Nagaland (Kivikhu, Zunheboto District; current paper). Elsewhere: China, Laos, Myanmar, Thailand, Vietnam (Černý & Pinratana, 2009, Volynkin *et al.*, 2019).

Remarks: Singh *et al.* (2021) do not list this species in the catalogue of Indian Arctiinae; hence this is the first record of this species from India.

***Striatella pluma* (Černý, 2009)** (Figures 1O-P, 4A, 6H)

Barsine pluma Černý, *in* Černý & Pinratana (2009: Moths of Thailand 6: 73-74, pl. 16, fig. 146, pl. Genitalia 1, figs. T146f, T146v) (Type locality: "W. Thailand, 400 m, Uthai Thani Prov., Khao Nang Rum").

References: Volynkin, Černý & Huang (2019: 8. Figs 10-12, 154, 224) (as *Barsine pluma*); Volynkin, Huang & Ivanova (2019: 71).

Material examined: India, Arunachal Pradesh: 1 ♀, Upper Siang District, Gobuk, 31.viii.2022, *leg.* SS (IBC-BT168), FWL: 12.5 mm.

Diagnosis: Kirti & Singh (2016) and Singh *et al.* (2021) report this species from Mizoram, with a mention that, in the holotype, the medial band is made up of three spots, but the individual recorded from Mizoram, India had a continuous line. Our individual, IBC-BT168, matches the holotype and paratypes well, with three spots in the medial band (Černý & Pinratana, 2009).

The female genitalia (Fig. 4A) have narrow and angled papillae anales; the posterior and anterior apophyses are thin and of equal lengths. The ductus bursae is short and evenly membranous. The corpus bursae is round, sac-like, with characteristic dense spinulose scobination present and a small signum on the distal end. The appendix bursae is similarly scobinated (Fig. 4A, lateral view). The broad, T-shaped post-vaginal plate and size of the signum of *S. pluma* separates it from *S. zebrina,* which has a narrow, V-shaped plate and a larger signum (Volynkin *et al*., 2019).

Distribution: India: Arunachal Pradesh (Ramsing, Upper Siang District; current paper), Mizoram (Kirti & Singh 2016).

Remarks: This represents only the second published record from India and the first record from Arunachal Pradesh.

Subtribe Endrosina

***Stigmatophora roseivena* (Hampson, 1894)** (Figures 1Q-R, 6I)

Eugoa roseivena Hampson, 1894. The Fauna of British India including Ceylon and Burma. Moths, Volume 2, Taylor & Francis, London. 609 p - 325 figs.: 99. TL: Momeit, Burma ("Myanmar").

References: Volynkin, Dubatolov & Kishida (2018: 131, Figs. 3-4, 9-11).

Material examined: India, Arunachal Pradesh: 1 ♂, Upper Siang District, Ramsing, 21.iv.2022, *leg.* SS (IBC-BQ452), FWL: 11.5 mm.

Diagnosis: Singh *et al.* (2021) listed three species of *Stigmatophora* Staudinger, 1881 from India: *Stigmatophora palmata* (Moore, 1878), *S. palliduspalmata* N. Singh, Kirti & Joshi, 2016 and *S. zolotuhini* (Dubatolov & Bucsek, 2016). *Stigmatophora palliduspalmata* was synomized with *S. inanis* Seitz, 1913 by Volynkin *et al.* (2021). Sondhi *et al.* (2023) published records of *S. strigivenata* (Hampson, 1894) and *S. roseivena* on the Moths of India website based on images only; hence these records needed validation. *Stigmatophora roseivena* and *Planovalvata confusa* Volynkin, Dubatolov & Kishida, 2018 are similar species, best separated by the hindwing coloration, which is yellow in *P. confusa* and pink in *S. roseivena*. Kirti & Singh (2016) reported *S. roseivena* from Hunli, Arunachal Pradesh; however, this was based on an misidentification, as the species shown had yellow hindwings and was actually *P. confusa*. *Stigmatophora zolotuhini,* another similar species, has yellowish hindwings as well. The specimen IBC-BQ452, collected from Ramsing, matches the description of *S. roseivena*, with pink hindwings, validating its presence in India.

Distribution: India: Arunachal Pradesh (Ramsing, Upper Siang District; current paper). Elsewhere: Myanmar, Thailand, China, Vietnam (Černý & Pinratana 2009; Volynkin *et al.*, 2018).

Remarks: Singh *et al.* (2021) do not list this species in the catalogue of Indian Arctiinae; hence this is the first record of this species from India.

Subfamily Boletobinae

***Tamba lala* (Swinhoe, 1900)** (Figures 1S-T, 4B, 6J)

Zethes lala Swinhoe, 1900. *Catalogue of eastern and Australian Lepidoptera Heterocera in the collection of the Oxford University Museum,* 2: 189. pl. 4, f. 8; TL: Singapore.

References: Yoshimoto (2002: 45. Fig. 3); Holloway (2005: 357, Pl. 24. Fig. 17); Kononenko & Pinratana (2005: Vol. 3: 64, Pl. 16, fig. 1).

Material examined: India, Arunachal Pradesh: 1 ♀, Upper Siang District, Gobuk, 31.viii.2022, *leg.* SS (IBC-BT176), FWL: 18 mm.

Diagnosis: Tamba lala is similar to *T. mnionomera* Hampson, 1926. *Tamba mnionomera* was considered extralimital to India, with Kononenko & Pinratana (2005) reporting its distribution as Thailand and Indonesia. However, there are photographic records of *T. mnionomera* from India on the citizen science platforms Moths of India and iNaturalist (Sondhi *et al*., 2023; iNaturalist, 2023). *Tamba lala* is separated from *T. mnionomera* by the straighter double postmedials and a broader central, longitudinal dark brown streak on the forewing.

In the female genitalia (Fig. 4B), the 8th segment is distinctly sclerotized and oblong, extending beyond the posterior apophyses. The anal papillae are narrow, elliptical and ventrally angled. The antrum is sclerotized with a V-shaped ostium. The ductus bursa is fully sclerotized and straight, the corpus bursae is anteriorly curved, long, and slender, with minute signa in the caudal region. The genitalia examined here match well with the figure presented by Holloway (2005) and Yoshimoto (2002). The female genitalia of *T. mnionomera* have not been described and hence cannot be compared here. The genitalia of *Tamba venusta* (Hampson, 1898) lack the V-shaped ostium and the 8th

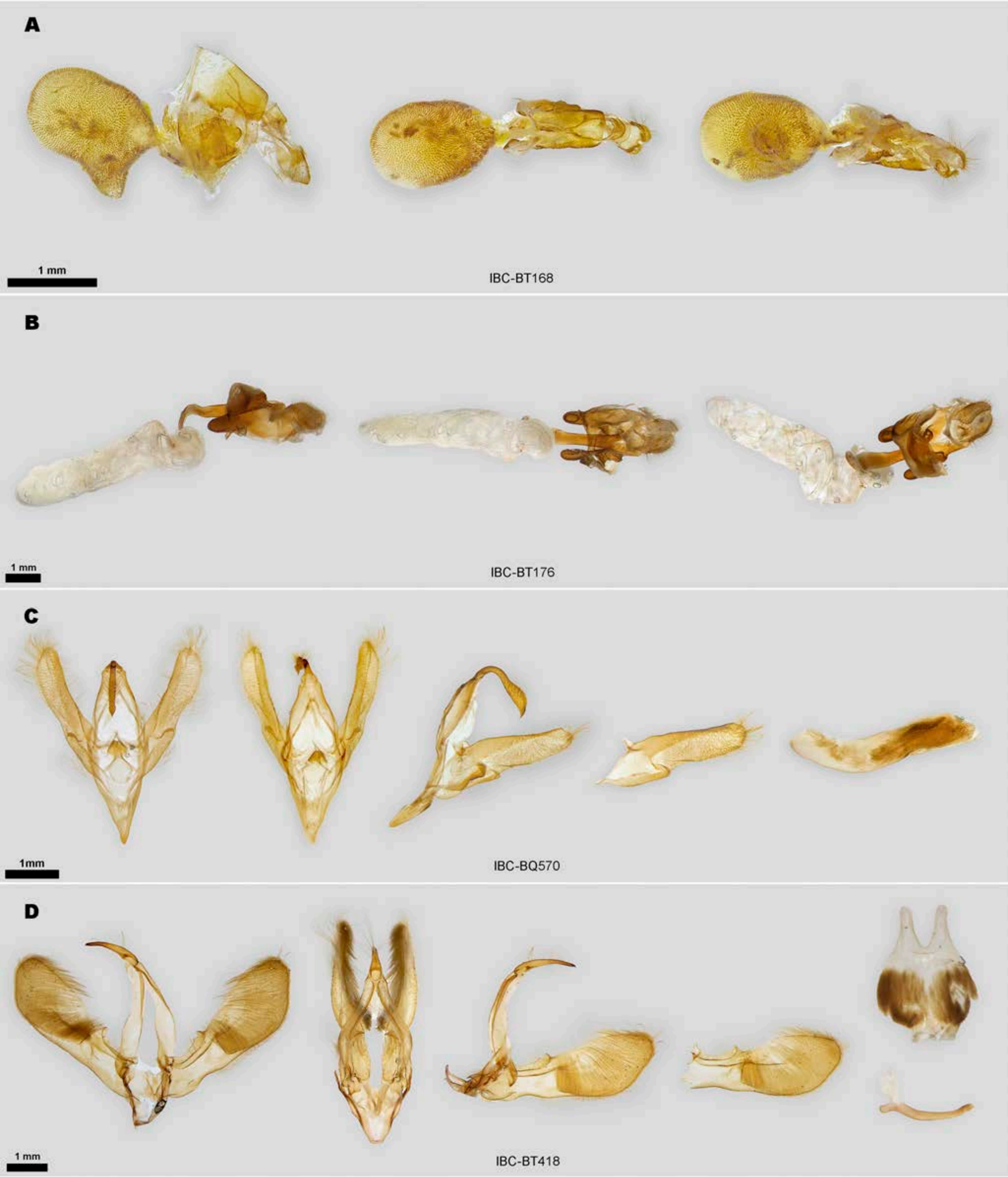


Figure 4: Male and female genitalia of the newly reported moths from NE India. **A.** *Striatella pluma* (IBC-BT168), female; **B.** *Tamba lala* (IBC-BT176), female; **C.** *Mosopia kononenkoi* (IBC-BQ570), male; **D.** *Chloroplaga pallida* (IBC-BT418), male. 8th sternite shown above aedeagus. For each panel with male genitalia, left to right: genital capsule distal view, dorsal view, lateral view (left valva removed), left valva outer view, aedeagus. Exceptions to this arrangement are noted individually. For each panel with female genitalia, left to right: lateral view, dorsal view, ventral view.

segment does not have an oblong sclerotization as seen in *T. lala*, thus separating the two species.

Distribution: India: Arunachal Pradesh (Gobuk, Upper Siang District; current paper). Elsewhere: Thailand, Vietnam, Malaysia, Borneo, Taiwan (Yoshimoto, 2002; Kononenko & Pinratana, 2005; Holloway, 2005).

Remarks: This is the first record of this species from India.

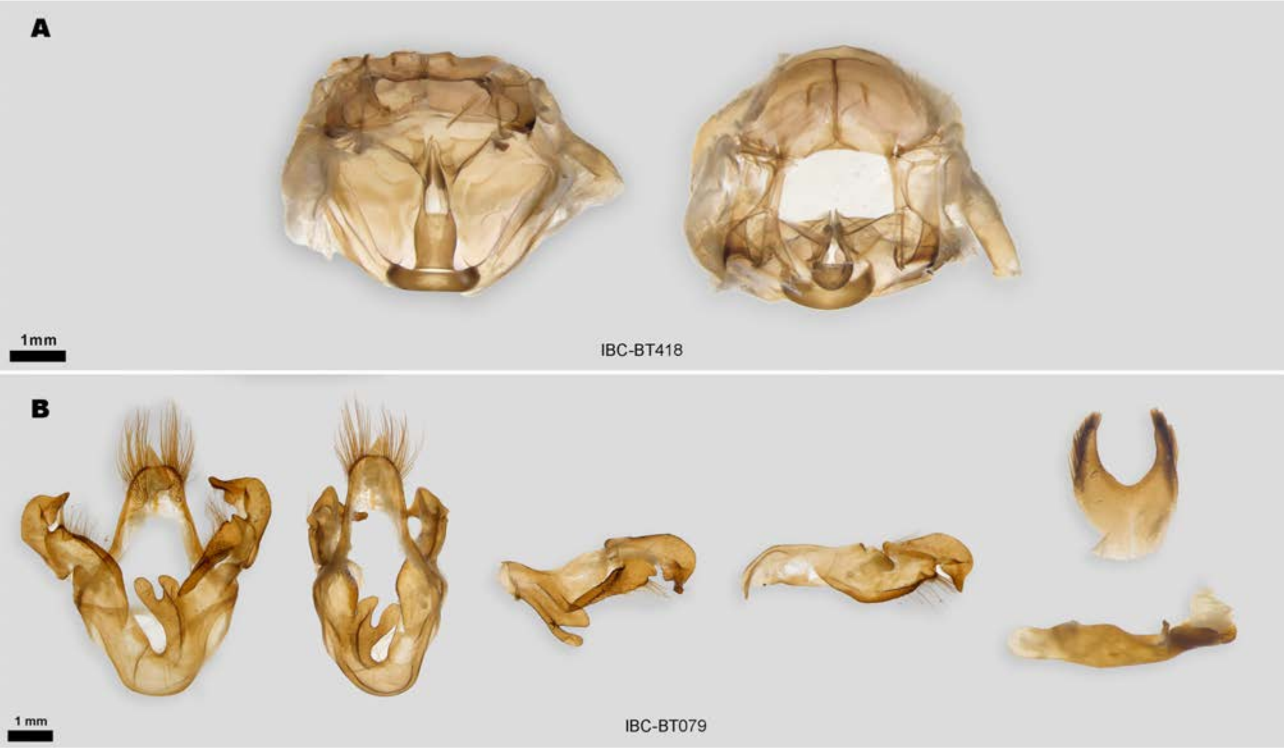


Figure 5: Male genitalia of the newly reported moths from NE India. **A.** Tymbal organ of IBC-BT418, *Chloroplaga pallida*; **B.** *Somatina densifasciaria* (IBC-BT079), male; 8th tergite shown above aedeagus. In the second panel, from left to right: genital capsule distal view, dorsal view, lateral/inner view of right valva, left valva outer view, aedeagus.

Subfamily Herminiinae

***Mosopia kononenkoi* Holloway, 2008** (Figures 1U-V, 4C, 6K)

Mosopia kononenkoi Holloway, 2008. *Malayan Nature Journal* 60 (1-4): 60, f. 139, 153, pl. 2; TL: Sabah, Borneo.

Material examined: India, Arunachal Pradesh: 1 ♂, Upper Siang District, Ramsing, 22.vi. 2022, *leg*. SS (IBC-BQ570), FWL: 15.5 mm.

Diagnosis: This species was described by Holloway (2008) from Sabah, Borneo. Previously, Kononenko & Pinratana (2005) (Pl. 1:33) had listed this moth as an undescribed species of *Bertula* Walker, 1859. The specimen matches the original description as well as images on BOLD (Ratnasingham & Hebert, 2007) and iNaturalist (2023). *Mosopia magniplaga* (Swinhoe, 1905) is the only other known species of this genus recorded from India. *Mosopia kononenkoi* is easily separated from this species and other congeners based on external morphology. Males of this species have a dark brown basal area with the rest of the wing being paler brown, other than a dark brown patch at the tornus, which encloses a small pale patch. The forewing costa of the male is distinctly sinuous. No other congener has these external features.

The male genitalia (Fig. 4C) have a curved, long uncus with a petiolate and pointed apical region. The valvae are simple, narrow, and elongated with a short, pointed vestigial costal spur, atypical for *Mosopia*. The sacculus has a rounded process near the center of the distal margin. The juxta is trapezoid with a slight invagination in the center. The aedeagus is tubular and proximally curved. The genitalia description and figure presented by Holloway (2008) match well with the genitalia of the specimen examined here. The male genitalia of the extralimital *M. megaspila* Walker, [1866] is similar but differs in having a distinct costal spur and heavily setose saccular process. The genitalia of *M. magniplaga* is not available in literature for comparison.

Distribution: India: Arunachal Pradesh (Gobuk, Upper Siang District; current paper). Elsewhere: Malaysia, Thailand, Indonesia, Borneo (Kononenko & Pinratana, 2005); Holloway, 2008; Ratnasingham & Hebert, 2007; iNaturalist, 2023).

Remarks: This is the first record of this species from India.

Family Nolidae

Subfamily Chloephorinae

Tribe Chloephorini

***Chloroplaga pallida* Warren, 1916** (Figures 1W-X, 4D, 5A, 6L)

Chloroplaga pallida Warren, 1916. *Novitates Zoologicae* 23: 217; TL: Penang, Selangor.

References: Holloway (2003: 92, Pl. 5, Fig. 3).

Material examined: India, Arunachal Pradesh: 1 ♂, Upper Siang District, Gobuk, 29.viii.2022, *leg*. SS (IBC-BT059), FWL: 14.5 mm. 1 ♂, Upper Siang District, Jengging, 04.ix.2022, *leg*. SS (IBC-BT418), FWL: 15 mm.

Diagnosis: Two species of *Chloroplaga* Hampson, 1912 are known; *C. pallida* and *C. nygmia* (Swinhoe, 1893). The hooked green mark of the center of the forewing is much narrower in *C. pallida* males when compared with *C. nygmia*, it is usually also broken into two patches and the base of the hindwing is usually whitish towards the base (deep pink in *nygmia*).

The male genitalia of IBC-BT418 (Fig. 4D) have a long, slightly curved uncus with a pointed apex. The valvae are flat,

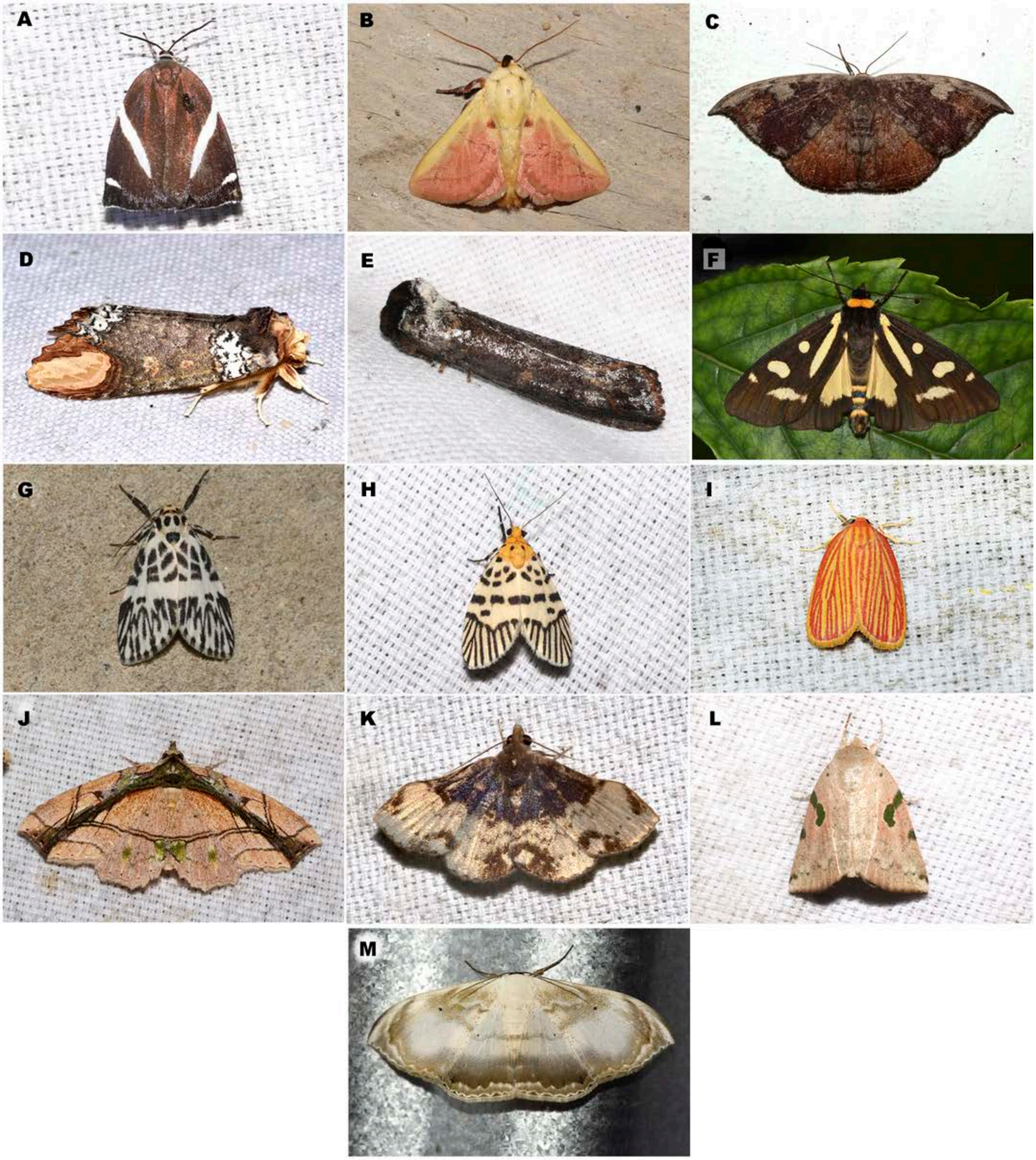


Figure 6: Images of the reported moth species photographed live in the field. **A.** *Chalcosiopsis variata,* male; **B.** *Monema coralina,* male; **C.** *Paralbara watsoni,* female; **D.** *Phalera eminens,* male; **E.** *Phalera argenteolepis*, male; **F.** *Macrobrochis flavicincta,* male; **G.** *Striatella nigralba*, male; **H.** *Striatella pluma,* female; **I.** *Stigmatophora roseivena*; **J.** *Tamba lala*, female; **K.** *Mosopia kononenkoi*, male; **L.** *Chloroplaga pallida,* male; **M.** *Somatina densifasciaria,* male.

obovate, and densely setose. An inwardly curved basal costal spine and a prominent dorsomedial ridge can be observed on the valvae. The aedeagus is slightly curved and has an oblong projection at the base. The 8th sternite is deeply invaginated at the center, resulting in a bilobed structure. A robust tymbal organ, characteristic for the tribe Chloephorini, was also observed (see Fig. 5A). The male genitalia presented by Holloway (2003) match closely with the genitalia of IBC-BT418. The genitalia of *C. pallida* are similar to *C. nygmia* but can be separated by the absence of basal costal spine.

Distribution: India: Arunachal Pradesh (Gobuk and Jengging, Upper Siang District; current paper). Elsewhere: Borneo (Holloway, 2003).

Remarks: Joshi *et al.* (2021) do not report this species in the Catalogue of Indian Nolidae; hence this represents the first record of this genus and species from India.

Family Geometridae

Subfamily Sterrhinae

***Somatina densifasciaria* Inoue, 1992** (Figures 1Y-Z, 5B, 6M)

Somatina densifasciaria Inoue, 1992. Twenty-four new species, one new subspecies and two new genera of the Geometridae (Lepidoptera) from East Asia. Bulletin of the Faculty of Domestic Sciences. Otsuma Women's University, 28:183. TL: Doi Suthep, Chiang Mei, Thailand.

Material examined: India, Arunachal Pradesh: 1 ♀, Upper Siang District, Gobuk, 28.viii.2022, *leg.* SS (IBC-BT079), FWL: 25 mm.

Diagnosis: This species was described by Inoue (1992) from Doi Suthep, Chiang Mei, Thailand. The specimen matches the images on BOLD (Ratnasingham & Hebert, 2007) and iNaturalist (2023). Six species of *Somatina* Guenée, [1858] are known from India (Sondhi *et al.*, 2023) and *Somatina densifasciaria* is easily separated from all of them by having a very broad white discal area on both wings and a strongly marked brown sub-marginal line on both wings. *Somatina anthophilata* Guenée, [1858], which it closely resembles, has a broad brownish medial band on the forewing which is absent in *S. densifasciaria.*

The male genitalia (Fig. 5B) have a prominent bilobed saccular projection exclusively on the right valva. The asymmetrical shape of the sacculi and valvae are characteristic for the genus. The cucullus region of the valvae has an ovate shape with a lobed apical projection and the valvas are fused with the saccus. The uncus is absent and the apical region is setose ventrally. The 8th tergite is characteristically concave with two sharp projections. The genitalia of IBC-BT079 match well with the general characteristics of *Somatina* species reported by Sihvonen (2005) and are similar to *S. anthophilata,* but differing in the absence of saccular and costal processes on the valvae.

Distribution: India: Arunachal Pradesh (Gobuk, Upper Siang District; current paper). Elsewhere: Thailand, Vietnam (Inoue, 1992; Ratnasingham & Hebert, 2007; iNaturalist, 2023).

Remarks: This is the first record of this species from India.

ACKNOWLEDGMENTS

We thank Mr. R. K. Singh, Chief Wildlife Warden, Dept. of Environment and Forests, Govt. of Arunachal Pradesh, for issuing the research and collection permit (letter reference CWL/GEN/190/355/2021/3179), Mr. Millo Tasser, Conservator of Forests, Dept. of Environment and Forests, Govt. of Arunachal Pradesh, for suggesting that we survey the landscape around Mouling National Park and facilitating issuance of a research and collection permit. We would also like to thank Mr. Abhinav Kumar and Mr. Bittem Darang, Divisional Forest Officer, Mouling National Park and Mr. A. Boli, Divisional Forest Officer, Yingkiong Forest Division and the Range Forest Officers and their staff in the survey areas, for their support during the field work. The March-April 2022 field survey by SS was supported by Felis Creations, Bengaluru and the National Geographic Society. The May 2022 field survey was supported by Titli Trust and a research grant from NCBS to KK. A CSR grant from the Eicher Group Foundation supported the subsequent surveys by SS. The Epum Sirum society at Gobuk village supported us on the ground at Gobuk village. A special thanks to Okit Sitek, Tarak Sitek and Tani Bolee for their support at Gobuk during surveys. SS would also like to acknowledge the support of Nandita Hazarika and Goutam Narayan at EcoSystems-India for providing local support in Guwahati. Priya Singh, Yash Sondhi, Viraj Nawge, Geetha Iyer and Vidya Venkatesh assisted in field surveys. The field work in Nagaland was supported by The Energy Research Institute (TERI). SS would like to thank Pia Sethi, then at TERI, who assisted with the surveys, and also helped getting a research and collection permit. Pia Sethi's project was supported by GEF Satoyama project via Conservation International. The Nagaland Forest Department supported our field visits and provided us with research and collection permits. We are grateful to Mr. I. Pangar Jamir, then Principal Chief Conservator of Forests and Head of Forest Force, Nagaland Forest Department for granting collection permits to TERI (letter no. FG-4/2/2014/6552 dated 7/12/2017). The Tizu Valley Biodiversity Conservation and Livelihood Network team supported us on the ground during our surveys in Zunheboto District, Nagaland, for which we are grateful. Special thanks to Ivan Zhimomi, Team Leader of the Tizu Valley Biodiversity Conservation and Livelihood Network, all the village heads and team members, and Vihoto Kiba for his special interest and support for the moth surveys and documentation. Museum work for the entire collection was supported by the Ramanujan Fellowship and NCBS research grants to KK.

Author contributions

SS and KK conceived the project, obtained permits for specimen collection, and conducted the field surveys. SS collected and identified moth specimens and wrote the manuscript. RPS assisted in moth surveys and specimen collection, pinned the specimens, dissected the genitalia, prepared the figures and contributed to writing the manuscript. UP assisted in specimen collection, pinning, curation and genitalia dissections. KK guided moth collections in the field and museum work at NCBS, and edited the manuscript.

LITERATURE CITED

Brehm, G. 2017. A new LED lamp for the collection of nocturnal lepidoptera and a spectral comparison of light-trapping lamps. *Nota Lepidopterologica* 40(1), 87–108.

Černý, K., Pinratana, A. 2009. *Moths of Thailand. Volume 6, Arctiidae.* Bangkok, Brothers of St Gabriel in Thailand. 283 pp., 56 pls.

Chada, P., Gogoi, M. J., Young, J. J. 2017. A new species of zygaenid moth *Elcysma ziroensis* (Lepidoptera: Zygaenidae: Chalcosiinae) from India. *Journal of Threatened Taxa* 9(12): 11060-11066.

Chandra, K., Mazumder, A., Sanyal, A. K., Ash, A., Bandyopadhyay, U., Mallick, K., Raha, A. 2018. Catalogue of Indian Notodontidae Stephens, 1829 (Lepidoptera: Noctuoidea). *Zootaxa* 4505(1): 1-84.

Wu, C. S., Fang, C. L. 2004. A review of the genus *Phalera* Hübner in China (Lepidoptera: Notodontidae). *Oriental Insects* 38(1): 109-136.

Joshi, R., Singh, N., Ahmad, J. 2020. An updated checklist of superfamily Drepanoidea (Lepidoptera) from India. *Records of the Zoological Survey of India* 120(1): 1-24.

Joshi, R., Singh, N., Kuni, N. 2021. A catalogue of Nolidae Bruand, 1846 from India (Lepidoptera, Noctuoidea). *Zootaxa* 5034(1): 1-112.

Hampson, G. F. 1894. *The Fauna of British India including Ceylon and Burma. Moths Vol. 4.* London, Taylor & Francis. xxviii+ 594 pp.

Hampson, G. F. 1905. The Moths of India (Supplementary paper to the volumes in "The fauna of British India series"), Series 3, Part 3. *The Journal of Bombay Natural History Society* 16(2): 192-398.

Holloway, J. D. 1976. *Moths of Borneo with special reference to Mt. Kinabalu*. Kuala Lumpur, Malayan Nature Society. 264 pp.

Holloway, J. D. 1998. The moths of Borneo Part 8, Castniidae, Callidulidae, Drepanidae, Uraniidae. *Malayan Nature Journal* 52: 1-155.

Holloway, J.D. 2001. *The moths of Borneo Part 7, Family Arctiidae, subfamily Lithosiinae*. Kuala Lumpur, Malayan Nature Society. 486 pp.

Holloway, J. D. 2003. *The Moths of Borneo Part 18, Family Nolidae*. Kuala Lumpur, Southdene Sdn Bhd. 279 pp., 611 figs., 10 pls.

Holloway, J. D. 2005. The Moths of Borneo Part 15 & 16, Noctuidae Catocalinae *Malayan Nature Journal* 58 (1-4): 1-529.

Holloway, J. D. 2008. The Moths of Borneo Part 17, Family Noctuidae, subfamilies Rivulinae, Phytometrinae, Herminiinae, Hypeninae and Hypenodinae. *Malayan Nature Journal* 60 (1-4): 1-268.

iNaturalist. 2023. https://www.inaturalist.org. Accessed on 14 February 2023.

Inoue, H. 1970. Limacodidae of eastern Nepal based on the collection of the Lepidopterological research expedition to Nepal Himalaya by the Lepidopterological Society of Japan in 1963. *Special Bulletin on Lepidopterological Society of Japan* 4: 189-201.

Inoue, H. 1992. Twenty-four new species, one new subspecies and two new genera of the Geometridae (Lepidoptera) from East Asia. *Bulletin Otsuma Women University* 28: 149-188.

Kawahara, A. Y., Plotkin, D., Espeland, M., Meusemann, K., Toussaint, E. F., Donath, A., Gimnich, F., Frandsen, P. B., Zwick, A., dos Reis, M., Barber, J. R. 2019. Phylogenomics reveals the evolutionary timing and pattern of butterflies and moths. *Proceedings of the National Academy of Sciences* 116(45): 22657-22663.

Kirti, J. S., Singh, N. 2015. *Arctiid Moths of India, Volume 1*. New Delhi, Nature Books India. 205 pp.

Kirti, J. S., Singh, N. 2016. *Arctiid Moths of India, Volume 2*. Nature Books India, New Delhi. 214 pp.

Kononenko, V. S., Pinratana, A. 2005. *Moths of Thailand, Volume 3: Noctuidae. An Illustrated Catalogue of the Noctuidae* (*Lepidoptera*) *in Thailand: Part 1.* Bangkok, Brothers of St. Gabriel in Thailand. 261 pp., 45 pls.

Koçak, A. O., Kemal, M. 2010. *Lepidoptera of Thailand*. CESA News. Nr. 60. 186 pp.

Kristensen, N. P. 2003. *Skeleton and muscles: adults*, pp 39-131. *In*: Kristensen, N. P. (Ed), *Handbook of zoology 4*: *Arthropoda: Insecta, part 36, Lepidoptera, moths, and butterflies, 2: morphology, physiology, and development*. Berlin, De Gruyter.

Kunte, K., Basu, D. N., Girish Kumar, G. S. 2019. *Taxonomy, Systematics, and Biology of Indian Butterflies in the 21st Century*, pp. 275-304. *In*: Ramani, S., Mohanraj, P., Yeshwanth, H. M. (Eds). *Indian Insects: Diversity and Science*, Taylor & Francis, UK. pp. 472.

Van Nieukerken, E. J., Kaila, L., Kitching, I. J., Kristensen, N. P., Lees, D. C., Minet, J., Mitter, C., Mutanen, M., Regier, J. C., Simonsen, T. J., Wahlberg, N. 2011. Order Lepidoptera Linnaeus, 1758. *In*: Zhang, Z.-Q. (Ed.), Animal biodiversity: an outline of higher-level classification and survey of taxonomic richness. *Zootaxa* 3148(1): 212-221.

Pan, Z., Zhu, C., Wu, C. 2013. A review of the genus *Monema* Walker in China (Lepidoptera, Limacodidae). *ZooKeys* 306: 23-36.

Ratnasingham, S., Hebert, P. D. N. 2007. BOLD: the barcode of life data system (www.boldsystems.org). *Molecular Ecology Notes* 7: 355-364.

Schintlmeister, A. 1997. Moths of Vietnam with special reference to Mt. Fan-si-pan. Family: Notodontidae. *Entomofauna* Suppl. 9: 33-248.

Schintlmeister, A., Pinratana, A. 2007. *Moths of Thailand Vol. 5. Notodontidae*. Bangkok, Brothers of St. Gabriel in Thailand. 320 pp., 45 pls.

Scoble, N. J. 1992. *The Lepidoptera. Form, Function and Diversity*. Oxford, Oxford University Press. 404 pp.

Sihvonen, P. 2005. Phylogeny and classification of the Scopulini moths (Lepidoptera: Geometridae, Sterrhinae). *Zoological Journal of the Linnean Society* 143: 473-530.

Singh, N., Joshi, R., Kirti, J. S., Bisht, S. S., Param, H. S. 2021. A catalogue of Indian Arctiinae (Erebidae, Lepidoptera). *Zootaxa* 5058(1): 1-118.

Smetacek, P. 2019. *Chalcosiopsis variata* (Insecta: Lepidoptera: Zygaenidae) in Arunachal Pradesh, India. *Bionotes* 21(3): 103.

Sondhi, S., Nath, D., Sondhi, Y., Kunte, K. 2020. A new species of *Metallolophia* Warren, 1895 (Lepidoptera: Geometridae: Geometrinae), and notes on *M. opalina* (Warren, 1893), from eastern Himalaya, India. *Zootaxa* 4838(2): 289-297.

Sondhi, S. Karmakar, T., Sondhi, Y., Kunte, K. 2021. Moths of Tale Wildlife Sanctuary, Arunachal Pradesh, India with seventeen additions to the moth fauna of India (Lepidoptera: Heterocera). *Tropical Lepidoptera Research* 31(Supplement 2): 1-53.

Sondhi, S., Sondhi, Y., Singh, R. P., Roy, P., Kunte, K. (Chief Editors) 2023. *Moths of India, v. 3.50*. Indian Foundation for Butterflies. https://www.mothsofindia.org. Accessed on 20 March 2023.

Sondhi, S., Efetov, K. A., Tarmann, G. M., Karmakar, T., Pawar, U., Kunte, K. 2023. A new species of Piarosoma Hampson, 1893 (Lepidoptera, Zygaenidae, Procridinae, Artonini) from Arunachal Pradesh, India. *Zootaxa* 5270(1): 139-145.

Swinhoe, C. 1894. New species of Eastern Lepidoptera. *Annals and magazine of natural history Series 6* 14(84): 429-443.

Volynkin, A. V., Dubatolov, V. V., Kishida, Y. 2018. On the taxonomy of the genera *Planovalvata* Dubatolov Kishida, *Stigmatophora* Staudinger and *Pseudomiltochrista* Dubatolov Bucsek, with description of one new species (Lepidoptera, Erebidae, Arctiinae, Lithosiini). *Zootaxa* 4394(1): 128-136.

Volynkin, A. V., Černý, K., Huang, S. Y. 2019. A review of the *Barsine hypoprepioides* (Walker, 1862) species-group, with descriptions of fifteen new species and a new subspecies (Lepidoptera, Erebidae, Arctiinae). *Zootaxa* 4618(1): 1-82.

Volynkin, A. V., Huang, S. Y., Ivanova, M. S. 2019. An overview of genera and subgenera of the *Asura* / *Miltochrista* generic complex (Lepidoptera, Erebidae, Arctiinae). Part 1. *Barsine* Walker, 1854 *sensu lato*, *Asura* Walker, 1854 and related genera, with descriptions of twenty new genera, ten new subgenera and a check list of taxa of the *Asura* / *Miltochrista* generic complex. *Ecologica Montenegrina* 26: 14-92.

Volynkin, A. V., Huang, S. Y., Dubatolov, V. V. 2021. A review of the *Stigmatophora palmata* (Moore, 1878) species-group (Lepidoptera: Erebidae: Arctiinae) with description of a new species from China. *Zootaxa* 4999(3): 243-257.

Watson, A. 1968. The taxonomy of the *Drepaninae* represented in China, with an account of their world distribution (Lepidoptera: Drepanidae). *Bulletin of the British Museum of natural History (Entomology)* Suppl. 12: 1-151.

Yen, S. H., Robinson, G. S., Quicke, D. L. J. 2005. The phylogenetic relationships of Chalcosiinae (Lepidoptera, Zygaenoidea, Zygaenidae). *Zoological Journal of the Linnean Society* 143: 161-341.

Yoshimoto, H. 1993. *Limacodidae* pp. 31-35. *In*: *Moths of Nepal*, *Part 2*. *Tinea* 13(Supplement 3). Tokyo, The Japan Heterocerists' Society. 160 pp., 32 pls.

Yoshimoto, H. 2002. A new and two unrecorded species of *Tamba* Walker (Noctuidae, Ophiderinae) from Taiwan *Tinea* 17 (1): 42-47.

Scientific Note: Predation of *Morpho helenor* (Cramer, 1776) by *Trichonephila clavipes* (Linnaeus, 1767) (Nephilidae, Arachnida)

Leila Teruko Shirai[1*], Luísa L. Mota[1], Larissa Pasquini Sarno[2], Alice Freiria Madureira[3], Lorena Santos Bonifácio[3] and Edson Montilha Oliveira[4]

1. Departamento de Biologia Animal, Instituto de Biologia, Universidade Estadual de Campinas, P.O. box 6109, CEP 13083-970 Campinas, SP, Brazil, e-mail: 2018dnb@gmail.com, lulismota@yahoo.com.br. 2. Fundação Florestal, Estação Ecológica e Floresta Estadual de Angatuba, Rodovia SP-268 km 06, Estrada Vicinal João Ciriaco Ramos, Bairro da Conquista, Angatuba, SP, Brazil, e-mail: larissapasquini.bio@gmail.com. 3. Universidade Federal de São Carlos - Campus Lagoa do Sino, Rodovia Lauri Simões de Barros, km 12 - SP-189 - Aracaçu, CEP 18290-000 Buri, SP, Brazil, e-mail: freiriaalice@gmail.com, lorenasantos@estudante.ufscar.br. 4. Fundação Florestal, Estrada Engenheiro Paulo Eugenio Broio 4164, Jardim Guaraí CEP 117843-64, Guaraú, SP, Brazil, e-mail: edson.montilha@fflorestal.sp.gov.br. *Corresponding author: 2018dnb@gmail.com.

Date of issue online: 5 April 2024
Electronic copies (ISSN 2575-9256) in PDF format at: https://journals.flvc.org/troplep; https://zenodo.org; archived by the Institutional Repository at the University of Florida (IR@UF), http://ufdc.ufl.edu/ufir; **DOI**: 10.5281/zenodo.10883824

Abstract: Helenor Blue Morpho butterfly, *Morpho helenor* (Cramer, 1776), and Golden Silk Orb Weaver spider, *Trichonephila clavipes* (Linnaeus, 1767) (Araneae, Nephilidae), are large, easily observable, and abundant arthropods in the Neotropics. Despite *Morpho* butterflies being a potentially important food resource for Orb Weavers, accounts about butterfly predation have focused mostly on vertebrates as predators, and accounts of the diet of Nephilidae are biased towards small prey. At best, there seem to be only observation records of *M. helenor* wings in *T. clavipes* webs. Here, we provide apparently the first published report with evidence of this specific interaction, highlighting that *T. clavipes* might be a relevant predator of large understory butterflies, including other *Morpho* species as well as brassolines.

Key words: Atlantic Forest; Brassolini; diet; escape mimicry; Morphini; Nymphalidae.

Resumo: A borboleta azul, conhecida como azulão ou capitão-do-mato, *Morpho helenor* (Cramer, 1776), e a aranha fio-de-ouro ou aranha-de-teia-dourada*, Trichonephila clavipes* (Linnaeus, 1767) (Araneae, Nephilidae), são artrópodes grandes, facilmente observáveis e abundantes nos Neotrópicos. Apesar das borboletas do gênero *Morpho* serem um recurso alimentar potencialmente importante para a aranha-fio-de-ouro, relatos sobre a predação de borboletas focam principalmente em vertebrados como predadores, e relatos sobre a dieta de Nephilidae tendem a se concentrar em presas pequenas. Na melhor das hipóteses, parece haver apenas registros de observação de asas de *M. helenor* nas teias de *T. clavipes*. Na presente contribuição, fornecemos provavelmente a primeira evidência na literatura acadêmica dessa interação específica, destacando que *T. clavipes* pode ser um predador relevante de grandes borboletas do sub-bosque, incluindo outras espécies de *Morpho,* bem como brassolíneos.

Palavras chave: Brassolini; dieta; Floresta Atlântica; mimetismo de escape; Morphini; Nymphalidae

---

The Golden Silk Orb Weaver *Trichonephila clavipes* (Linnaeus, 1767) is a common spider in the Neotropics, both in natural habitats and in cities (Ripp *et al*., 2018). The spider is known to feed on insects of all sizes, including butterflies, and perhaps even small bats and birds, that get trapped in the strong silk and large web of this Orb Weaver (Blackledge, 2011; Nyffeler & Knörnschild, 2013).

Knowledge about *T. clavipes* feeding on butterflies seems to have focused so far on experiments testing its preference for palatable *versus* unpalatable species of Heliconiinae and Danainae, especially ithomiines (*e.g*. Brown, 1984; Vasconcellos-Neto & Lewinsohn, 1984; Masters, 1990; Freitas *et al*., 1996; see also a review in Trigo, 2000). Many of these unpalatable species belong to Batesian or Müllerian mimetic rings. Butterfly species that belong to other types of mimicry complexes, such as evasive mimicry, have been less documented. To our knowledge, among all evasive mimics, there is only a written field observation of wings of the iconic *Morpho helenor* (Cramer, 1776) (Vasconcellos-Neto & Lewinsohn, 1984, from São Paulo state, Brazil, identified as *M. achillaeanus paulista* Fruhstorfer) found in *T. clavipes* webs.

Wings on spider webs are only indirect evidence that there was a predation event, but they suggest spiders as possibe controllers of butterfly population density. In this particular case, the role of Orb Weavers as predators of *Morpho* Fabricius, 1807 seems to be overlooked, instead of a rare event, since Orb Weavers would not be expected to be affected by important defense mechanisms of *Morpho* species, namely evasive mimicry (Llaurens *et al*., 2020; Bastide *et al*., 2023; see also Young, 1971) and flash coloration. The flash coloration in *Morpho* consists of sudden movements that expose a distinctive color or pattern (in this case, the blue bands of dorsal wings),

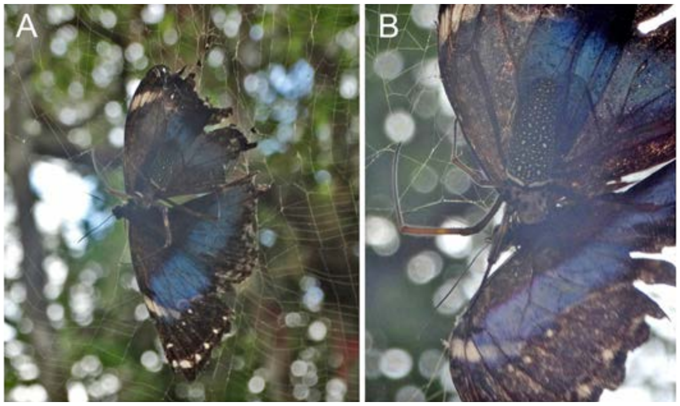


Figure 1. Attack of *Trichonephila clavipes* on a *Morpho helenor* recorded on 13 April 2023 at the Angatuba Ecological Station, São Paulo state, Brazil. The butterfly continuously flapped its wings (https://www.youtube.com/watch?v=9D8xMjFATEU) until apparently dying.

after which the animal "disappears" because it adopts a cryptic state (the cryptic ventral wing surface), which is a defense that is effective only against visually hunting predators, such as birds (Silva, 2022). Birds are often considered major predators of butterflies, palatable or unpalatable, mimetic or not (Gilbert & Singer, 1975; Vasconcellos-Neto & Lewinsohn, 1984; Vlieger & Brakefield, 2007; Kodandaramaiah, 2011; Pinheiro *et al.*, 2016). Therefore, documenting evidence of other predators of *Morpho* butterflies, such as spiders, is important for a more complete understanding of selective pressures, potentially contributing to ecological and evolutionary studies of both species involved. Here, we report apparently the first record of an attack of *T. clavipes* on a *M. helenor* butterfly (Fig. 1), and extend the importance of *T. clavipes* as predator of large understory species (of *Morpho* and even brassolines), based on additional sources of data (Table 1).

Both *M. helenor* and *T. clavipes* are large arthropods, easily observable in Neotropical forests. Spider predators that are likely to be significant for *Morpho* are those that are large, with webs at the flight height of the butterfly, in the forest understory. *Trichonephila clavipes* specializes in prey in flight at "areas of the forest that are in all probability flightpaths of insects (…) above the herb layer" (Robinson & Mirick, 1971). At this forest stratum, we (LPS, AFM, and LSB) observed the attack of *T. clavipes* on *M. helenor* (Fig. 1), while doing a linear transect for the primate monitoring program of the Fundação Florestal, on 13 April 2023, at Angatuba Ecological Station, São Paulo state, Brazil (S 23° 24' 06.4" W 48° 22' 39.6"). The Fundação

Table 1. Records of large Nymphalidae butterflies (*Morpho* spp. and Brassolini) entangled in spider webs. Acronyms in "Location" refer to Brazilian states: Amazonas (AM), Espírito Santo (ES), Mato Grosso (MT), Rio Grande do Sul (RS), and São Paulo (SP).

Butterfly species	**Spider species**	**Observer/ photographer**	**Source**	**Location**	**Observation date**	**Notes**
Morpho helenor	*Trichonephila clavipes*	LPS, AFM, and LSB	Present work	Angatuba Ecological Station, SP, Brazil	April 2023	
Morpho helenor	*Trichonephila clavipes*	J. Vasconcellos-Neto, T. Lewinsohn	Vasconcellos-Neto & Lewinsohn 1984	SP, Brazil	1991-1992	
Morpho helenor	*Trichonephila clavipes*	André V. L. Freitas	Personal communication	Santa Genebra, Campinas, SP, Brazil		Small individual, unworn wings
Morpho helenor	*Trichonephila clavipes*	Joseph Hollick	https://rb.gy/jbvz3	Iguazu Falls, Argentina	February 2010	
Morpho aega	*Trichonephila clavipes*	rodrigo_lazaro	https://rb.gy/8cemz	Embú das Artes, SP, Brazil	May 2023	Picture of male wing discarded by the spider
Morpho menelaus	*Trichonephila clavipes*	Leonardo Merçon	https://rb.gy/xykrp	Cariacica, ES, Brazil	2012	Male butterfly
Morpho epistrophus	*Trichonephila clavipes*	Lucas A. Kaminski	https://rb.gy/6jaig	Alvorada, RS, Brazil	February 1999	Butterfly escaped
Morpho epistrophus	*Trichonephila* sp.	Márcio Uehara-Prado	Personal communication	Santa Virgínia, Parque Estadual da Serra do Mar, SP, Brazil	March-April 2005	
Morpho helenor	*Trichonephila clavipes*	Benjamin Blonde	https://rb.gy/q82yk	Panama		
Morpho helenor	*Trichonephila clavipes*	Ann Becker	https://rb.gy/a5w0f	Corcovado National Park, Costa Rica	November 2012	
Morpho menelaus.	*Trichonephila clavipes*	Pedro Pablo Orozco	https://rb.gy/zbvzm	Puerto Nariño, Amazonas, Colombia	December 2016	Male butterfly
Morpho sp.	*Trichonephila clavipes*	Jay Pruett	https://rb.gy/42ook	Costa Rica	March 2019	Male butterfly
Morpho marcus	Unknown	Raymê Carvalho	https://rb.gy/lrpyk	Museu da Amazônia, Manaus, AM, Brazil	March 2022	Male butterfly found on the ground, alive, covered with spider web
Morpho sp.	Unknown	K.Verhulst	https://rb.gy/w5x0t		September 2013	
Opsiphanes sp.	*Trichonephila clavipes*	EMO	https://rb.gy/vk2xs	Itirapina, SP, Brazil	September 2019	
Caligo illioneus	*Trichonephila clavipes*	Harrison Wu	https://rb.gy/v9gh3	Madre de Dios, Peru	June 2022	Butterfly identified in the source as *Morpho* sp.
Caligo idomeneus	Unknown	Almir C. Almeida	Almeida & Freitas 2012 (p. 64)	Alta Floresta, MT, Brazil		Live butterfly with a piece of spider web in its wings
Blepolenis batea	*Argiope argentata*	Almir C. Almeida	Picture in personal collection	Intervales, SP, Brazil		

Florestal is responsible for the administration of protected areas in the state of São Paulo, including the Angatuba Ecological Station. The Ecological Station contains 1,394 hectares in a transition zone between Atlantic Forest and the Brazilian savanna, Cerrado. André V. L. Freitas (pers. comm.) also observed a similar interaction at Santa Genebra, Campinas, São Paulo, of a small *M. helenor* with fresh wings in a *T. clavipes* web, and M. Uehara-Prado (pers. comm.) observed an individual of White Morpho *Morpho epistrophus* (Fabricius, 1976) in a *Trichonephila* sp. web at Parque Estadual da Serra do Mar núcleo Santa Virgínia, São Paulo, in March-April 2005 (Table 1).

The *M. helenor* individual we observed got tangled in the web and, despite trying to escape with an agonistic flapping behavior, it was attacked by the spider until it ceased moving. The observed spider behavior was most similar to what Robinson & Mirick (1971) described as attack type 2: "a long bite in which the bite is not immediately followed by pulling out movements but is sustained *in situ*." The frequency with which large butterflies manage to escape, and which factors, such as size and age, play a role in the success of the butterfly, or of the spider, remain to be investigated. Other large butterflies have also been found in *T. clavipes* webs, including other *Morpho* species and brassolines (Table 1).

The literature concerning the diet of orb weavers tends to focus on small prey, but in fact 85% of the consumable biomass pertains to only 17% of the total prey number, corresponding to large insects (Blackledge, 2011). Here we show *M. helenor* being attacked (Fig. 1, see video available at https://www.youtube.com/watch?v=9D8xMjFATEU), but consumption could happen later, since a closely related *Trichonephila* species, *T. edulis* (Labillardière, 1799), attacked prey tangled in the web irrespective of the amount of unprocessed prey in its own web (Crespigny *et al*., 2001). One should consider the possibility that *M. helenor* might not be consumed at all, since *T. clavipes* has never been shown to actually feed on larger prey such as birds and bats (Nyffeler & Knörnschild, 2013). Being eaten or not, *Trichonephila* species might nevertheless act as important population density regulators of *M. helenor* and other large butterflies, if attacks are a frequent phenomenon. We thus encourage observers of this phenomenon to report their finding, either through publication in a scientific journal or in platforms such as iNaturalist (https://www.inaturalist.org/), to allow a better understanding of the role of spiders as butterfly predators.

ACKNOWLEDGMENTS

We would like to thank Agnaldo José Santos for field assistance; Lina Maria Almeida-Silva and Jefferson Camargo for identifying the spiders; Keith Willmott for identifying some butterflies of Table 1 and greatly improving the manuscript; Prof. André V. L. Freitas, Márcio Uehara-Prado, and Lucas A. Kaminski for sharing their field observations; Giulia Bagarolli D'Angelo for revising the manuscript; and support from the monitoring program (Programa de Monitoramento da Biodiversidade) of the Fundação Florestal.

LITERATURE CITED

Almeida, A. C., Freitas, A. V. L. 2012. *Lepidoptera: borboletas e mariposas do Brasil*. São Paulo, Grupo Direcional. 208 pp.

Bastide, H., López-Villavicencio, M., Ogereau, D., Lledo, J., Dutrillaux, A. M., Debat, V., Llaurens, V. 2023. Genome assembly of 3 Amazonian *Morpho* butterfly species reveals Z-chromosome rearrangements between closely related species living in sympatry. *GigaScience* 12: 1-11.

Blackledge, T. A. 2011. Prey capture in orb weaving spiders. *Journal of Arachnology* 39: 205-210.

Brown Jr, K. S. 1984. Adult-obtained pyrrolizidine alkaloids defend ithomiine butterflies against a spider predator. *Nature* 309: 707-709.

Crespigny, F. E. C., Herberstein, M. E., Elgar, M. A. 2001. Food caching in orb-web spiders (Araneae:Araneoidea). *Naturwissenschaften* 88: 42-45.

Freitas, A. V. L., Trigo, J. R., Brown, K. S., Witte, L., Hartmann, T., Barata, L. E. S. 1996. Tropane and pyrrolizidine alkaloids in the ithomiines *Placidula euryanassa* and *Miraleria cymothoe* (Lepidoptera: Nymphalidae). *Chemoecology* 7: 61-67.

Gilbert, L. E., Singer, M. C. 1975. Butterfly ecology. *Annual Review of Ecology and Systematics* 6: 365-395.

Kodandaramaiah, U. 2011. The evolutionary significance of butterfly eyespots. *Behavioral Ecology* 22: 1264-1271.

Llaurens, V., Le Poul, Y., Puissant, A., Blandin, P., Debat, V. 2020. Convergence in sympatry: evolution of blue-banded wing pattern in *Morpho* butterflies. *Journal of Evolutionary Biology* 34: 284-295.

Masters, A. R. 1990. Pyrrolizidine alkaloids in artificial nectar protect adult ithomiine butterflies from a spider predator. *Biotropica* 22: 298-304.

Nyffeler, M., Knörnschild, M. 2013. Bat predation by spiders. *PloS one* 8: e58120.

Pinheiro, C. E., Freitas, A. V., Campos, V. C., deVries, P. J., Penz, C. M. 2016. Both palatable and unpalatable butterflies use bright colors to signal difficulty of capture to predators. *Neotropical Entomology* 45: 107-113.

Ripp, J., Eldakar, O. T., Gallup, A. C., Arena, P. T. 2018. The successful exploitation of urban environments by the golden silk spider, *Nephila clavipes* (Araneae, Nephilidae). *Journal of Urban Ecology* 4: 1-6.

Robinson, M. H., Mirick, H. 1971. The predatory behavior of the golden-web spider *Nephila clavipes* (Araneae: Araneidae). *Psyche* 78: 123-139.

Silva, A. V. 2022. *The importance of flash coloration in reducing avian predation on* Morpho *butterflies: an experimental study in Atlantic rainforest*. MSc thesis. Universidade Estadual de Campinas. 53 pp. [in Portuguese]

Trigo, J. R. 2000. The chemistry of antipredator defense by secondary compounds in neotropical Lepidoptera: facts, perspectives and caveats. *Journal of the Brazilian Chemical Society* 11: 551-561.

Vasconcellos-Neto, J., Lewinsohn, T. M. 1984. Discrimination and release of unpalatable butterflies by *Nephila clavipes*, a neotropical orb-weaving spider. *Ecological Entomology* 9: 337-344.

Vlieger, L., Brakefield, P. M. 2007. The deflection hypothesis: eyespots on the margins of butterfly wings do not influence predation by lizards. *Biological Journal of the Linnean Society* 92: 661-667.

Young, A. M. 1971. Wing coloration and reflectance in *Morpho* butterflies as related to reproductive behavior and escape from avian predators. *Oecologia* 7: 209-222.

Scientific Note: First record of Pearl Crescent, *Phyciodes tharos* (Drury, 1773) (Lepidoptera: Nymphalidae: Nymphalinae), from Cuba

Yosiel Álvarez[1*], Marc C. Minno[2] and Douglas M. Fernández[3]

1. Departamento de Colecciones Zoológicas, Instituto de Ecología y Sistemática, Carretera de Varona km 3; 5, Capdevila, Boyeros, CP 11900, La Habana, Cuba; https://orcid.org/0000-0002-0687-3094; alvarezyosiel@gmail.com. 2. 600 NW 35th Terrace, Gainesville, FL 32607, USA; marccminno@gmail.com. 3. B No. 61 e/2da y 3ra, Caridad de Méndez, Camagüey, CP 71100, Cuba; douglasmanuelfernandez@gmail.com. *Author for correspondence.

Date of issue online: 5 April 2024
Electronic copies (ISSN 2575-9256) in PDF format at: https://journals.flvc.org/troplep; https://zenodo.org; archived by the Institutional Repository at the University of Florida (IR@UF), http://ufdc.ufl.edu/ufir; **DOI**: 10.5281/zenodo.10883879

The genus *Phyciodes* (Hübner, [1819]) (Lepidoptera: Nymphalidae; Nymphalinae) is found across the Neartic Region and currently includes 15 described species; many of these have similar morphology, some of them are sympatric, and hybridization has been documented between sympatric, closely related species (Scott, 1994, 1998, 2006; Wahlberg *et al*., 2003; Zhang *et al*., 2022). One of the best-known species of the genus is Pearl Crescent, *Phyciodes tharos* (Drury, 1773), a widespread and common generalist butterfly that ranges from Mexico to southern Canada and across the eastern United States. This quite variable insect can be found in moist meadows, open fields, prairies, streamsides and ruderal vegetation in suburban areas; caterpillars feed on several composite species (Scott, 1986; Glassberg, 1999). Across its range this butterfly is sympatric with other congeners such as Dark Crescent *P. batesii* (Reakirt, 1865), and Phaon Crescent *P. phaon* (Edwards, 1864) (Glassberg, 1999; Wahlberg *et al*., 2003; Zhang *et al*., 2022), and has been detected once in the Bahamas, the only known locality outside continental North America (Rindge, 1952).

On 26 June 2023, two females of *P. tharos* were observed

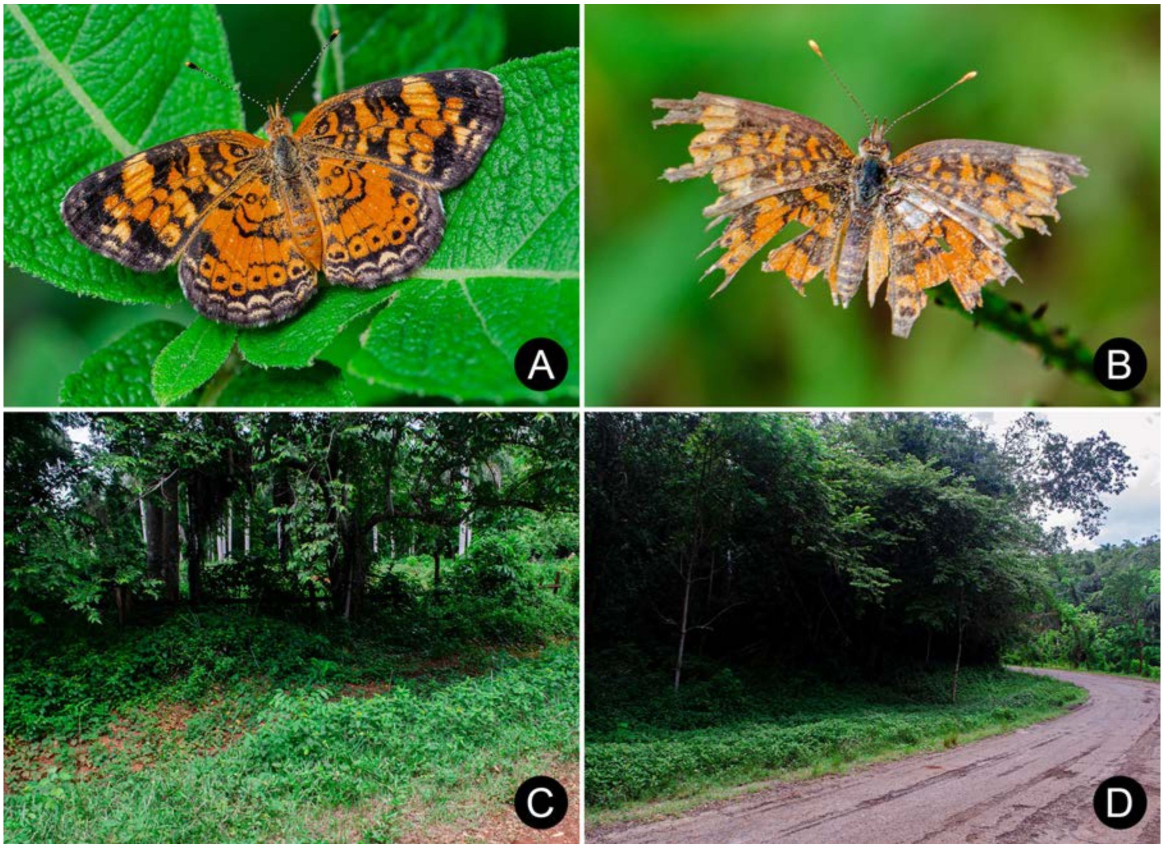


Figure 1. Photographs of live adult females of *Phyciodes tharos* (Drury, 1773) (Lepidoptera: Nymphalidae; Nymphalinae) (A and B) and the observed moist evergreen forest roadside habitat in which they were observed (C and D) at Escaleras de Jaruco, Jaruco municipality, Mayabeque province, western Cuba, on 26 June 2023. Photographs © Yosiel Álvarez.

at Escaleras de Jaruco, Jaruco municipality, Mayabeque province, western Cuba (Figs. 1A-B, 2A-B and 3A). The first individual was observed in flowering patches of ruderal vegetation along a roadside at the edge of the humid evergreen forest (Fig. 1C-D) (23° 1' 44.68" N, 82° 4' 52.97" W) flying swiftly and low to the ground, but occasionally settling on leaves or visiting the flowers of *Bidens pilosa* L. (Asteraceae), *Phyla nodiflora* L. (Verbenaceae) and *Acmella* sp. (Asteraceae). In this habitat the butterfly was accompanied by *P. phaon* and also *Calisto disjunctus hersheyi* Álvarez & Núñez, 2021 (Nymphalidae), *Hemiargus ceraunus filenus* (Poey, 1832), *Ministrymon azia* (Hewitson, 1873) (Lycaenidae), *Pyrisitia larae* (Herrich-Schäffer, 1862), *P. dina* (Poey, 1832) (Pieridae) and *Burnsius crisia* (Herrich-Schäffer, 1865) (Hesperiidae). The second individual was located perching in the mown lawn at Restaurante Arabe (23° 2' 39.58" N, 82° 3' 6.13" W). This individual was located about 2 miles (3 km) directly northeast of the first site of discovery. The first individual was fresh whilst the other one was very worn. The fresher specimen was collected and it is deposited at the Douglas Manuel Fernández Research Collection, Camagüey, Cuba (Fig. 2).

These observations constitute the first record of the species from Cuba and the Antilles. The record, from an inland location, and the observation of two adult females, one of them notably fresh, may suggest that the species has successfully colonized Cuba, most likely from southern Florida, where it is common (Scott, 1986; Glassberg, 1999). Similar colonization events from North America have occurred several times in the past; examples include the related species *P. phaon* in the 1930s (Alayo & Hernández, 1987), and more recently Eastern Tailed Blue *Cupido comyntas texana* (Chermock, 1945), which was first detected in 2015 in Viñales, Pinar del Río province (Ñúñez, 2015). The latter species has now been found to be abundant at the National Botanical Garden in Havana (Álvarez & Barro, 2022) and other locations of Havana Province, as well as on the Isle of Youth (Álvarez, & Daguerre, 2023). The absence of previous records of *P. tharos* from the island might be partly accounted for by its similarity with two other Crescents, *P. phaon* and *Anthanassa frisia* (Poey, 1832) (Fig, 3), which are widespread and abundant in western Cuba in similar habitats (Alayo & Hernández, 1987; Núñez *et al*., 2020). However, and despite its variability, *P. tharos* can be distinguished from *P. phaon* by the absence of the cream-colored forewing median band of the latter species and the reduction of the forewing's upperside black markings. From *A. frisia* it can be separated by the arrangement of the black spots and markings on the forewing and hindwing, and also by its smaller size, especially in females (see Fig. 3).

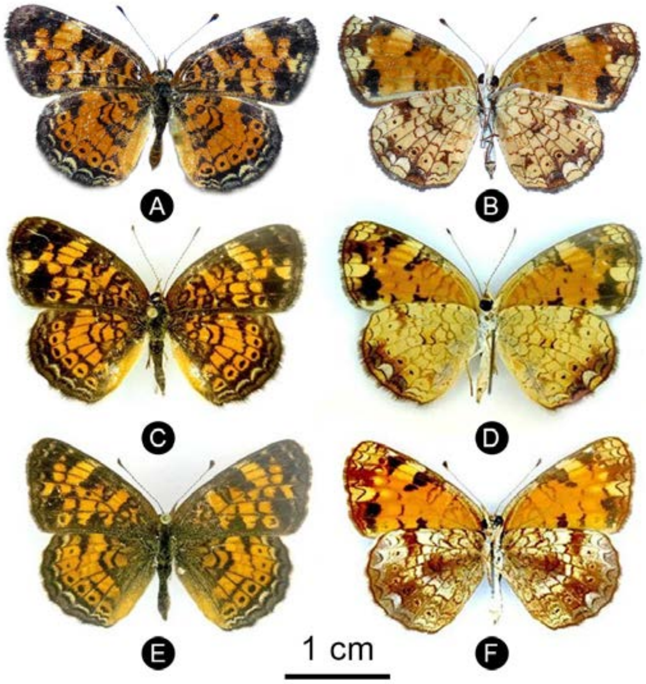


Figure 2. Photographs of pinned adults of *Phyciodes tharos* (Drury, 1773) (Lepidoptera: Nymphalidae; Nymphalinae). A-B: First specimen collected at Escaleras de Jaruco, Jaruco municipality, Mayabeque province, western Cuba, on June 26, 2023. C-D: Summer form from Valle Mines, Missouri, USA, Jefferson Co., August 1, 2011. E-F: Winter form from Gulf Hammock, Florida, USA, Florida, Levy Co., March 8, 1980. Left, upperside; right, underside. Photographs © Douglas Manuel Fernández and Jeffrey R. Slotten.

The first specimen of *P. tharos* from Escaleras de Jaruco (Figs. 1 and 2) is somewhat different from typical specimens from the USA (Fig. 2). The ground color is a richer orange and the underside of the hindwings is paler. Females from the USA have a yellowish-orange ground color and yellower hindwing

Figure 3. Photographs of live adults of *Phyciodes tharos* (Drury, 1773) (Lepidoptera: Nymphalidae; Nymphalinae) and similar species in Cuba. A: *P. tharos* (Escaleras de Jaruco, Mayabeque province, June 2023). B: *P. phaon* (Edwards, 1864) (Jardines de Hershey, Mayabeque province, August 2022). C: *Anthanassa frisia* (Poey, 1832) (Jardines de Hershey, Mayabeque province, July 2020). Photographs © Yosiel Álvarez.

undersides in the summer form. This species is known to be quite variable in wing pattern, and genetic analyses will likely be necessary to assess the region of origin of the Cuban *P. tharos*.

We were unable to find the host plant of *P. tharos* at Escaleras de Jaruco. Larvae of *P. tharos* are known to feed on *Symphyotrichum* species (formerly *Aster*, Asteraceae) in North America (Scott, 1986). At least eight species of *Symphyotrichum* have been reported from Cuba (Greuter & Rankin, 2022) and perhaps one of these is present at Escaleras de Jaruco. More field observations are needed to verify the current status of the species in Cuba, as well as which hostplant it is using on the island.

ACKNOWLEDGMENTS

We thank Carolann Sharkey, Richard Keefe, and the TREE Institute International Inc. (https://treeinstitute.org/) for providing support for our field work in Cuba. Guide Renier Rodríguez Pérez and driver Jorge Ivan Cordero Martínez with Havanatour S.A. provided our transportation. Jeffrey R. Slotten of Gainesville, Florida allowed access to his extensive collection of North American butterflies and gave permission to photograph specimens of *P. tharos* from the USA for this publication. Roger Hammer of Homestead, Florida identified digital images of a nectar plant as probably an *Acmella*, and we thank a reviewer for comments on the manuscript.

LITERATURE CITED

Alayo, P., Hernández. L. R. 1987**.** *Atlas de las mariposas diurnas de Cuba (Lepidoptera: Rhopalocera).* La Habana, Editorial Científico-Técnica. 148 pp.

Álvarez, Y., Barro, A. 2022. New records of *Cupido comyntas* Godart (Lycaenidae, Polyommatinae) from the National Botanical Garden, Havana, confirm its presence in Cuba. *Journal of the Lepidopterists' Society* 76(4): 279-280.

Álvarez, Y., Daguerre, J. C. 2023. Nuevos registros y extensiones del rango conocido de mariposas diurnas (Lepidoptera: Papilionoidea) de la Isla de la Juventud, Cuba. *Boletín de la Sociedad Entomológica Aragonesa* 73: 188-190.

Glassberg, J. 1999. *Butterflies through Binoculars-The East: a Field Guide to the Butterflies of North America*. Oxford, Oxford University Press. 242 pp.

Greuter, W., Rankin, R. 2022. *Plantas Vasculares de Cuba: Inventario de Espermatófitos de Cuba.* 3rd Edition. Havana, Botanischer Garten und Botanisches Museum Berlin & Jardín Botánico Nacional, Universidad de La Habana. 679 pp.

Núñez, R. 2015. An American blue in Cuba, the first West Indian record of *Cupido* Schrank (Lepidoptera, Lycaenidae, Polyommatinae). *Journal of the Lepidopterists' Society* 69(2): 142-143.

Núñez, R., Neyra, B., Caballero, H., Fernández, D. M., Norriss, T., Mancina, C. A. 2020. Nymphalidae, pp. 116-163. *In*: Mancina, C. A., Núñez, R., Neyra, B. (Eds.), *Mariposas de Cuba: Guía de Campo.* La Habana, Sello Editorial AMA. 237 pp.

Rindge, F. H. 1952. The butterflies of the Bahamas Islands, British West Indies (Lepidoptera). *American Museum Novitates* 1563: 1-18.

Scott, J. A. 1986. *The Butterflies of North America; A Natural History and Field Guide*. Stanford, Stanford University Press. 583 pp.

Scott, J. A. 1994. Biology and systematics of *Phyciodes* (*Phyciodes*). *Papilio* (New Series) 7: 1-120.

Scott, J. A. 1998. *Phyciodes* (*Phyciodes*): new discoveries, new subspecies, and convergence. *Papilio* (New Series) 10: 1-42.

Scott, J. A. 2006. *Phyciodes* (*Phyciodes*): more progress. *Papilio* (New Series) 13: 1-34.

Wahlberg, N., Oliveira, R., Scott, J. A. 2003. Phylogenetic relationships of *Phyciodes* butterfly species (Lepidoptera: Nymphalidae): complex mtDNA variation and species delimitations. *Systematic Entomology* 28: 257-273.

Zhang, J., Cong, Q., Shen, J., Song, L., Gott, R. J., Boyer, P., Guppy, C. S., Kohler, S., Lamas, G., Opler, P. A., Grishin, N. V. 2022. Taxonomic discoveries enabled by genomic analysis of butterflies. *The Taxonomic Report of the International Lepidoptera Survey* 10(7): 1-59.

Scientific Note: An addition to the Indian butterfly fauna, *Neptis philyra* (Lepidoptera: Nymphalidae), from Tale Valley Wildlife Sanctuary, Arunachal Pradesh

Atanu Bose[1], Mahesh Baruah[2], Abhishek Dutta Choudhury[2], Anitava Roy[3] and Tarun Karmakar[4]*

1. Sadananda Nagar, Salbari, Ward No-25, Bongaigaon, Assam, 783380, India; 2. Mount View Colony, R-139-A, New Bongaigaon, Bongaigaon, Assam, 783381, India; 3. Birsingha, Bon Birsingha, Bankura, West Bengal, 722207, India; 4. National Centre for Biological Sciences, Tata Institute of Fundamental Research, Bellary Road, Bengaluru, 560065, India; *Corresponding author: Karmakar.tarun07@gmail.com

Date of issue online: 5 April 2024
Electronic copies (ISSN 2575-9256) in PDF format at: http://journals.fcla.edu/troplep; https://zenodo.org; archived by the Institutional Repository at the University of Florida (IR@UF), http://ufdc.ufl.edu/ufir; **DOI**: 10.5281/zenodo.10883963

Abstract: *Neptis philyra* Ménétriés, 1859 (Long-streak Sailor), a member of the family Nymphalidae, was recently documented for the first time in India, representing a new record for the country. The documentation is from Tale Valley Wildlife Sanctuary, Arunachal Pradesh, based on photographic evidence.

Keywords: Eastern Himalaya, Neptini, First record, Lower Subansiri, range extension, Ziro valley.

INTRODUCTION

The genus *Neptis* Fabricius, 1807 (Nymphalidae: Limenitidinae: Neptini) comprises a remarkably diverse group with approximately 160 recognized species (Ma *et al*., 2020). This genus is widely distributed across Africa (including the Indian Ocean islands) to Australasia through the Oriental and Palearctic region; within these regions, approximately 83 species are found in Africa, three in Australasia, around 44 in the Oriental region, and approximately 36 in the Palearctic region. The genus *Neptis* exhibits a wide range of ecological adaptations, with some species, like *N. sappho* (Pallas, 1771), displaying an extensive distribution across vast areas in the Palearctic and Oriental regions (Ma *et al.,* 2020). Conversely, other species, such as *N. gracilis* (Kirsch, 1885) from Tanimbar, Indonesia, are highly localized and restricted to a single island. These features make *Neptis* an intriguing subject for research into their evolutionary history, distribution patterns, and adaptation strategies (Ma *et al*., 2020). In India, a total of 26 species of *Neptis* are recorded (Varshney & Smetacek, 2015), namely: *N. ananta* Moore, 1858, *N. armandia* (Oberthur, 1876), *N. capnodes* Fruhstorfer, 1908, *N. cartica* Moore, 1872, *N. clinia* Moore, 1872, *N. cydippe* Leech, 1890, *N. harita* Moore, [1875], *N. hylas* (Linnaeus, 1758), *N. ilira* Kheil, 1884, *N. jumbah* Moore, [1858], *N. magadha* C. & R. Felder, [1867], *N. mahendra* Moore, 1872, *N. manasa* Moore, [1858], *N. miah* Moore, 1857, *N. namba* Tytler, 1915, *N. narayana* Moore, 1858, *N. nashona* Swinhoe, 1896, *N. nata* Moore, [1858], *N. nemorum* Oberthur, 1906, *N. nycteus* de Niceville, 1890, *N. pseudovikasi* (Moore, 1899), *N. radha* Moore, 1857, *N. sankara* (Kollar, [1844]), *N. sappho* (Pallas, 1771), *N. soma* Moore, 1858, *N. zaida* Doubleday, [1848].

In this paper, we report the first record of *N. philyara* from Arunachal Pradesh, adding to the existing checklist of the Indian butterfly fauna. This finding is important for informed conservation efforts and strategic management decisions, contributing to the preservation of biodiversity within the sanctuary and its surrounding ecosystems.

Neptis philyra Ménétriés, 1859

Etymology: In Greek mythology, Philyra was a nymph who was the daughter of Oceanus and Tethys.

Description: Serrated wings with rich brownish-black on the upper side and yellow-brown on the underside. Fore wing white cell streak forming “hockey stick” marking with spots in space 2 and 3 (Figure A).

Distribution: *Neptis philyra* was first described by M. Ménétriés in 1859 from the Amur region, Russia (Ménétriés, 1859). This species has been found to be well distributed across various regions in East Asia, including eastern Siberia, Korea, Japan, Taiwan, Central and Southeast China, Tibet, Northwest Yunnan, and Northern and Central Vietnam (Eliot, 1969; Lang, 2012; Monastyrskii, 2019). The subspecies of *Neptis philyra* are: *N. p. philyra* Ménétriés, 1859, *N. p. melior* Hall, 1930, *N. p. splendens* Murayama, 1941, and *N. p. zhejiangensis* Murayama, 1980 (Lang, 2012).

Habit and Habitat: *Neptis philyra* prefers evergreen forests, riverine vegetation, and rocky streams (Monastyrskii, 2019).

Observation: We observed several individuals flying near the

Figure A. *N. philyra* photographed from Pange, Lower Subansiri district, Arunachal Pradesh, India. 1-3: Photographed on 5 June 2023; 4. Photographed on 2 June 2023.

Figure B. Habitat at Pange, Arunachal Pradesh. 1. Way to Pange camp. 2. Pange Campsite.

stream and forest trail from 2-5 June 2023 (Figure A), at Tale Valley Wildlife Sanctuary. Tale Wildlife Sanctuary features a diverse range of primary vegetation, encompassing temperate conifers, temperate and subtropical broadleaved forests. This rich floral tapestry includes a variety of oak and rhododendron species, complemented by bamboo and conifer varieties. Conifers find their niche in the valley area, while hilltops are adorned with thriving broadleaved forests in the Tale Valley (Sondhi *et al.*, 2021).

The initial observation occurred on the 2 June 2023, en route to the Pange forest camp, of a solitary individual perched atop the hill's wall. The second sighting occurred on the 3 June 2023, near the Pange forest camp, of two individuals, and on 5 June 2023 we observed a single individual mud-puddling for an extended duration near the Pange camp (Figures A, B, C). Based on photographic evidence, the recent discovery of this species in India indicates a remarkable range extension, highlighting the ecological importance of the sanctuary. This

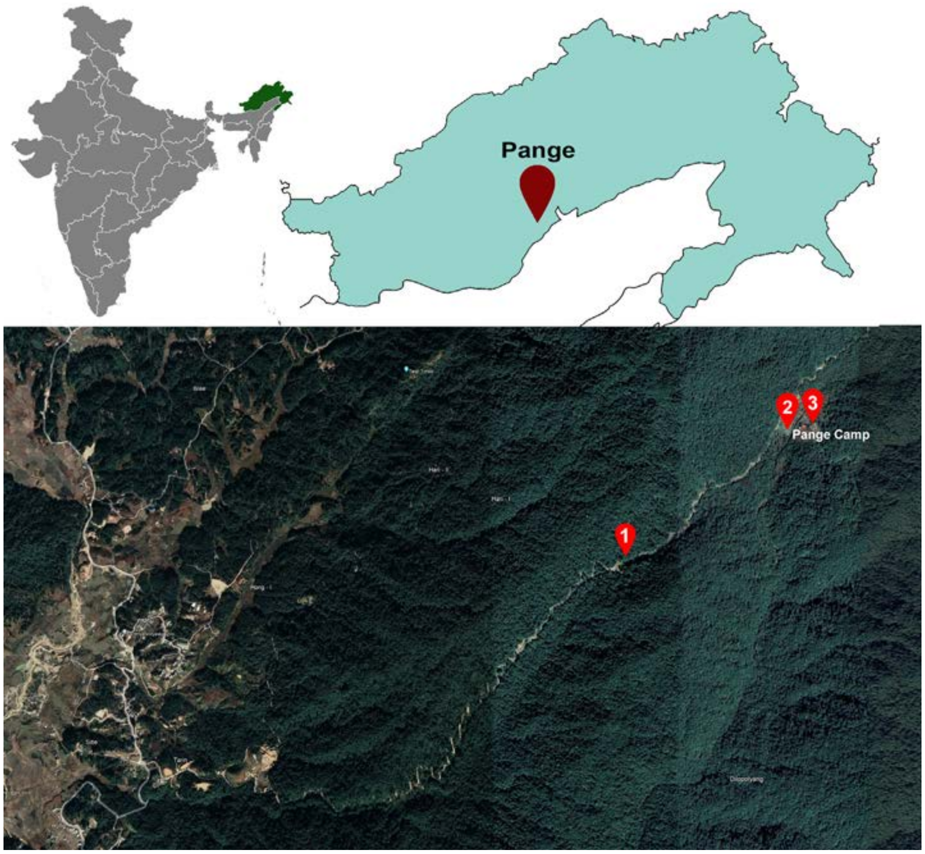


Figure C. Map depicting *N. philyra* sightings and photographs in Pange, Arunachal Pradesh. 1. 2 June 2023. 2,3. 5 June 2023.

record potentially indicates a new subspecies, which can be confirmed with the collection of further specimens, and also underscores the sanctuary's potential as a vital habitat for diverse butterfly species.

Neptis philyra, a new record for India, invites further investigations and encourages the scientific community to expand our understanding of butterfly distribution patterns and their potential implications for ecosystem dynamics. We hope to inspire further research and conservation initiatives that protect and sustain India's diverse butterfly fauna for generations to come. Furthermore, the newly discovered presence of *N. philyra* underscores the need for continued monitoring and conservation efforts in Arunachal Pradesh to protect and preserve its unique flora and fauna. The Tale Valley Wildlife Sanctuary serves as a vital stronghold for various butterfly species, including this newly recorded Nymphalidae species.

ACKNOWLEDGMENTS

We are grateful to Wikimedia Foundation for sponsoring Tale Valley expedition via Wiki Loves Butterfly Project, with West Bengal Wikimedians. Special thanks to Mrs. Ananya Mondal, lead of Wiki Loves Butterfly Project, for vital support, also extend our heartfelt gratitude to Mr. Kojmama Taman and Mr. Punyo Chada for their exceptional guidance throughout our journey. We would like to extend our sincere thanks to Dr. Shinichi Nakahara and Gaurab Nandi Das for their meticulous review and insightful suggestions, which greatly enhanced the quality and clarity of this manuscript.

LITERATURE CITED

Eliot, J. N. 1969. An analysis of the Eurasian and Australian Neptini (Lepidoptera: Nymphalidae). *Bulletin of the British Museum (Natural History) (Entomology)* Supplement 15: 155 pp.

Lang, S. Y. 2012. The Nymphalidae of China (Lepidoptera, Rhopalocera). Part I. Libytheinae, Danainae, Calinaginae, Morphinae, Heliconiinae, Nymphalinae, Charaxinae, Apaturinae, Cyrestinae, Biblidinae, Limenitinae. *Tshikolovets Publications*, Pardubice, 454 pp.

Ma, L., Zhang, Y., Lohman, D. J., Wahlberg, N., Ma, F., Nylin, S., Janz, N., Yago, M., Aduse-Poku, K., Peggie, D., Wang, M., Zhang, P., & Wang, H. 2020. A phylogenomic tree inferred with an inexpensive PCR-generated probe kit resolves higher-level relationships among *Neptis* butterflies (Nymphalidae: Limenitidinae). *Systematic Entomology* 45(4): 924-934.

Ménétriés, E., 1859. Lepidoptères de la Siberie orientale et en particulier des rives de l'Amour. *Bulletin de la Classe physico-mathématique de l'Académie impériale des sciences de Saint-Pétersbourg* 17: 212-221.

Monastyrskii, A. L. 2019. *Butterflies of Vietnam. Limenitidinae. Vol. 4(II).* Hanoi, Plan-o-rama Media Co., Ltd. 182 pp.

Sondhi, S., **Karmakar, T., Sondhi, Y., Kunte, K.** 2021. Moths of Tale Wildlife Sanctuary, Arunachal Pradesh, India with seventeen additions to the moth fauna of India (Lepidoptera: Heterocera). *Tropical Lepidoptera Research* 31(Supplement 2): 1-53.

Varshney, R. K., Smetacek, P. (Eds.) 2015. *A Synoptic Catalogue of the Butterflies of India*. New Delhi, Butterfly Research Centre, Bhimtal and Indinov Publishing. ii + 261 pp.

Scientific Note: First host plant record for the Cuban endemic Holguin Skipper *Holguinia holguin* Evans, 1955 (Lepidoptera: Hesperiidae: Hesperiinae)

Yosiel Álvarez

Departamento de Colecciones Zoológicas, Instituto de Ecología y Sistemática, Carretera de Varona km 3. 5, Capdevila, Boyeros, CP 11900, La Habana, Cuba; alvarezyosiel@gmail.com; https://orcid.org/0000-0002-0687-3094.

Date of issue online: 5 April 2024
Electronic copies (ISSN 2575-9256) in PDF format at: https://journals.flvc.org/troplep; https://zenodo.org; archived by the Institutional Repository at the University of Florida (IR@UF), http://ufdc.ufl.edu/ufir; **DOI**: 10.5281/zenodo.10883996

The monotypic genus *Holguinia* Evans, 1955 is the only butterfly genus endemic to Cuba, and its unique species, *H. holguin* Evans, 1955 remains as one of Cuba's least-known butterflies (Alayo & Hernández, 1987; Smith *et al.*, 1994; Fernández *et al.*, 2020). Apparently very rare and currently considered Endangered (Núñez & Barro, 2016), this elusive insect has been located in the foothills of Sierra Maestra, eastern Cuba (Alayo & Hernández, 1987), at the base of the "mogotes" at Viñales, western Cuba (Fontenla, 1987), and throughout the Nipe-Sagua-Baracoa mountain range, also at eastern Cuba (Álvarez *et al.*, 2023), with no known records from the center of the island. The butterfly is morphologically and genetically distinct from other hesperine skippers, and DNA data suggests that it belongs to the subtribe Hesperiina (tribe Hesperiini), forming a well-defined, old and isolated lineage unrelated to other Greater Antilles genera (Núñez *et al.*, 2020). Besides its preference for gallery forest, the "mogote" vegetation complex and serpentine scrub-woodlands, very little is known about its biology and its life history remains a mystery (Fernández *et al.*, 2020).

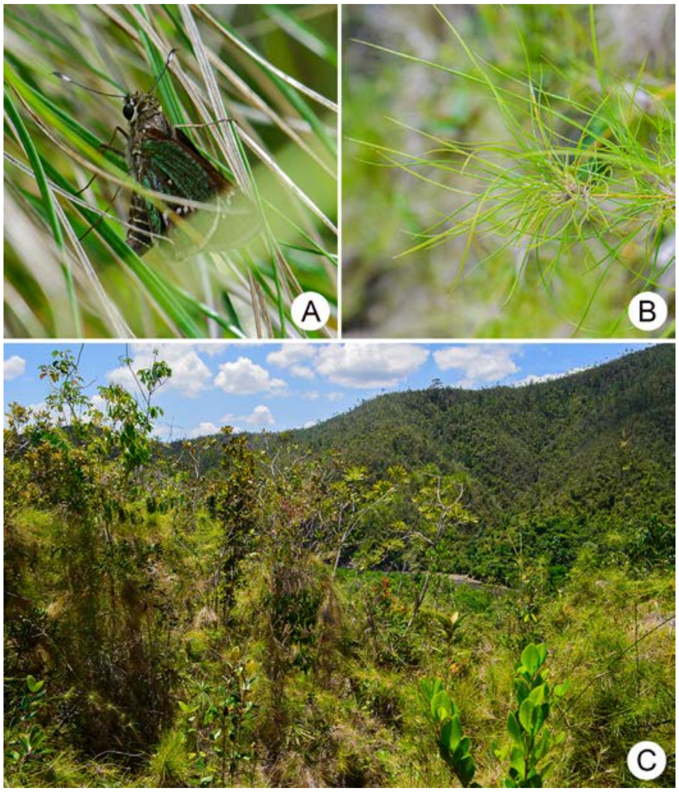


Figure 1. *Holguinia holguin* Evans, 1955 (Lepidoptera: Hesperiidae: Hesperiinae), its host plant and habitat at Alto de Florida, Baracoa, Guantánamo, on 14 May 2023. **A**: Female *H. holguin* ovipositing on *Tibisia farcta* (Aubl.) C. D. Tyrrell & L. G. Clark (*Poaceae*). **B**: Culm of *T. farcta*. **C**: Dry serpentine scrub-woodland of Alto de Florida, Baracoa, Guantánamo. Note the dominance of *T. farcta* in the vegetation. Photographs © Yosiel Álvarez.

On 14 May 2023, a female *Holguinia holguin* was observed and photographed while ovipositing on fresh leaves of a climbing grass in the foothills of Alto de Florida, Baracoa, Guantánamo province (20°18'03.04"N, 74°29'54.54"W) (Fig. 1A). The location consisted of a dry serpentine-scrub woodland on the southern slope of a small hill nearly 50 m above sea level and approximately 150 m north of Río Miel (Fig. 1C). The *Holguinia* female was accompanied in this highly diverse and endemic-rich habitat by the endemic skipper *Oarisma bruneri*

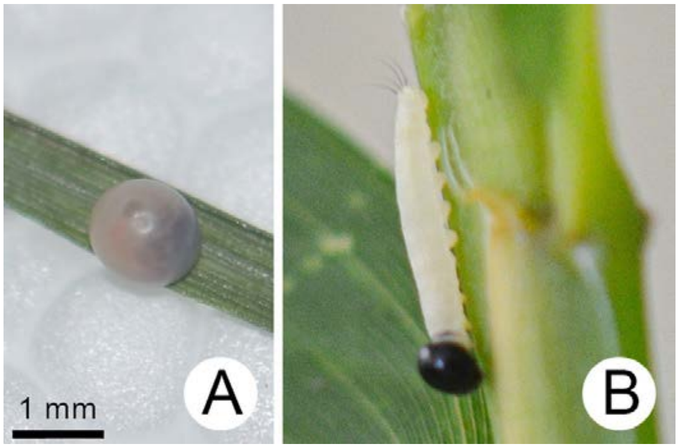


Figure 2. Immature stages of *Holguinia holguin* Evans, 1955 (Lepidoptera: Hesperiidae: Hesperiinae) collected at Alto de Florida, Baracoa, Guantánamo, on May 14, 2023. **A**: Egg before hatch. **B**: First instar larva. Photographs © Yosiel Álvarez.

Bell, 1959, *Parachoranthus magdalia* (Herrich-Schäffer, 1863) (Hesperiidae), *Pyrisitia proterpia* (Fabricius, 1775) (Pieridae) and the endemic taxa *Calisto bruneri* Michener, 1949, *Calisto lastrai* Núñez, 2019 (previously unrecorded from Baracoa) (Nymphalidae) and *Urania fulgens poeyi* (Herrich-Schäffer, 1866) (Uraniidae). The grass was later identified as the climbing bamboo *Tibisia farcta* (Aubl.) C. D. Tyrrell & L. G. Clark (Poaceae), by Dr. Eldis Bécquer and Dr. José Luis Gómez (Fig. 1B). An egg laid by the female was collected; it was 1.2 mm in width and cream white in color, turning darker before hatching (Fig. 2A). The larva hatched seven days after the egg was laid, but the lack of equipment and further unavailability of leaves of *T. farcta* prevented complete rearing and description of immature stages. The first instar larva measured 2.8 mm long with a head capsule width of 0.8 mm. The body is cream-beige in color with black head and prothoracic shield, and four black setae emerging from the anal plate (Fig. 2B).

This constitutes the first host plant record for *Holguinia holguin*. The grass *T. farcta*, previously known as *Arthrostylidium capillifolium* Grisebach and commonly known as "tibisí", is widespread in serpentine and karstic locations throughout Cuba, and the Nipe-Sagua-Baracoa mountains are home to the two other members of the genus *Tibisia*, which are regional endemics restricted to serpentine soils (Catasús, 1987; Tyrrell *et al*., 2018). This plant's distribution could explain the apparently broad distribution of *Holguinia* across this mountain range in both serpentine and karstic habitats (Álvarez *et al*., 2023). The larva did not accept leaves from another climbing bamboo species and it is possible that it may only utilize *T. farcta* as a host plant. The distribution of *Holguinia* may reflect that of *T. farcta*, given that the plant inhabits the other known locations in which the butterfly is found. Given the threatened status of *Holguinia holguin*, further field work is necessary to provide a better picture of the current distribution of the species in Cuba and to obtain additional information about its life cycle and immature stages.

ACKNOWLEDGMENTS

The author wants to recognize the tireless company of Adrián Serrano on the field, as well as Noel Coutín for kindly providing company, housing and guidance during the field expedition in Baracoa in which this discovery took place. Many thanks to Dr. Eldis Bécquer and Dr. José Luis Gómez for their help identifying *Tibisia farcta*. A special recognition to Dr. Rayner Núñez for reviewing the manuscript and for his suggestions to improve it.

LITERATURE CITED

Alayo, P., Hernández. L. R. 1987**.** *Atlas de las mariposas diurnas de Cuba (Lepidoptera: Rhopalocera).* La Habana, Editorial Científico-Técnica. 148 pp.

Álvarez, Y., Fernández, D. M., Minno, M. C., Núñez, R. 2023. The butterflies (Lepidoptera: Papilionoidea) of the Nipe-Sagua-Baracoa mountains: a preliminary checklist of the most biodiverse Cuban region. *Tropical Lepidoptera Research* 33(1): 50-63.

Catasús, L. J. 1987. Revisión del género *Arthrostylidium* (Poaceae) en Cuba. *Acta Botánica Cubana* 37: 1-7.

Fernández, D. M., Álvarez, Y., Barro, A., Núñez, R., Mancina, C. A. 2020. *Hesperiidae*, pp. 34-67. *In*: Mancina, C. A., Núñez, R., Neyra, B. (Eds.), *Mariposas de Cuba: Guía de Campo.* La Habana, Sello Editorial AMA. 237 pp.

Fontenla, J. L. 1987. Características zoogeográficas de las ropalóceras (Insecta, Lepidoptera) de Viñales, Pinar del Río, Cuba. *Poeyana* 339: 1–11.

Núñez, R., Barro, A. 2016. Holguinia holguin, pp. 180-181. *In*: Hidalgo-Gato, M. M., Espinosa, J., Rodríguez-León, R. (Eds.), *Libro Rojo de Invertebrados Terrestres de Cuba*. La Habana, Editorial Academia. 241 pp.

Núñez, R., Alegre-Barroso, A., Hausmann, A. 2020. Redescription and evolutionary relationships of the Cuban endemic monotypic genus *Holguinia* Evans, 1955 (Lepidoptera, Hesperiidae, Hesperiinae). *Systematics and Biodiversity* 19:1, 1-12.

Smith, D. S., Miller, L. D., Miller, J. Y. 1994. *The Butterflies of the West Indies and South Florida*. New York, Oxford University Press. 256 pp.

Tyrrell, C. D., Londoño, X., Oviedo, R., Attigala, L., McDonald, K., Clark, L. G. 2018. Molecular phylogeny and cryptic morphology reveal a new genus of West Indian woody bamboo (Poaceae: Bambusoideae: Bambuseae) hidden by convergent character evolution. *Taxon* 67(5): 916-930.

Scientific note: Observations of *Cryptobotys zoilusalis* (Crambidae: Herpetogrammatini)

Jason P. Hernandez

Cambium, La Yagua, Espaillat, Dominican Republic; ORCID: 0000-0002-1806-7540; jason.p.hernandez73@gmail.com

Date of issue online: 5 April 2024
Electronic copies (ISSN 2575-9256) in PDF format at: http://journals.fcla.edu/troplep; https://zenodo.org; archived by the Institutional Repository at the University of Florida (IR@UF), http://ufdc.ufl.edu/ufir; **DOI**: 10.5281/zenodo.10884006

Abstract: *Cryptobotys zoilusalis* has been little studied. Larvae and pupae collected from a residential garden in the Dominican Republic were observed over a two-month period. Two new host plant species are reported: *Eleutheranthera ruderalis* (Sw.) Sch.Bip. and *Synedrella nodiflora* (L.) Gaertn. (Asteraceae). The individuals exhibited 17% survival to eclosure, and parasitoids accounted for 14% of observed mortality.

Resumen: *Cryptobotys zoilusalis* ha sido poco estudiado. Larvas y pupas coleccionadas de jardín residencial en la Republica Dominicana se observan por dos meses. Dos especies nuevas de plantas hospedajes se reportan: *Eleutheranthera ruderalis* (Sw.) Sch.Bip. y *Synedrella nodiflora* (L.) Gaertn. (Asteraceae). Los especímenes mostraron 17% sobrevivencia para eclosión, y parasitoides representaron 14% de la mortalidad observada.

Key Words: Asteraceae; *Cryptobotys zoilusalis*; host plant.

INTRODUCTION

Cryptobotys zoilusalis (Walker, 1859) (Crambidae: Herpetogrammatini) has been little studied. Its known range includes the West Indies, Central America, and South America, and in 2005 the species was recorded for the first time in the Galápagos islands (Landry, 2016). Although the species is included in regional checklists in various locations, little information is available on its habitat or ecology. For instance, the species inventory for Bahia Honda State Park in the Florida Keys (Barber, 2003) included this species in its insect list; that inventory included habitat codes for the mammals and birds, indicating in which habitat types they were recorded, but no such codes were provided for this or any insect. Several other checklists, including those for Guana in the British Virgin Islands (Becker & Miller, 2005), North America north of Mexico (Scholtens & Solis, 2015), Venezuela (Clavijo-Abiertos & Arias-Clis, 2017), and the North Grande Terre Directed Biological Reserve in Guadeloupe (Toroult *et al*., 2021), simply noted the presence of the species without further information.

The known larval host plants are *Xanthium strumarium* L. (Bendicho-Lopez, 1998) and *Sphagneticola trilobata* (L.) Pruski (as "*Wedelia trilobata*" in Landry, 2016), both weedy Asteraceae with wide distributions and known to become invasive. Little other ecological or life history information is available. The species is not catalogued in Martorell (1976) or in the HOSTS database of lepidopteran host plants (Robinson *et al*., 2023). Herein, I therefore report new observations of *Cryptobotys zoilusalis*.

METHODS

On 25 December 2016, a heavy infestation of webworms was discovered on a stand of *Eleutheranthera ruderalis* (Sw.) Sch.Bip. (Asteraceae) in a residential garden in the municipality of Gaspar Hernandez, Espaillat, Dominican Republic. The surrounding landscape comprised dairy pastures with remnants of riparian woodland. Extensive surveys of the pastures as part of another study (Hernandez, 2021) revealed no *Eleutheranthera* outside this garden, where they grew on a recently installed rock drain. The webs completely covered the plants.

On the following day, 26 December 2016, ten shoots were collected for close examination. Dissection of the shoots revealed that most were unoccupied by webworms, with only two pupae found. On returning to the garden on 28 December 2016 to examine the plants *in situ*, most were found to be unoccupied, covered with webs containing only frass, but five larvae and six pupae were found. Additional collections of shoot tips were made every few days, ten shoot tips at each collection, with all larvae and pupae found on each collecting date retained for rearing. The final collecting date was 12 February 2017; on that date, a small stand of *Synedrella nodiflora* (L.) Gaertn. (Asteraceae) was found along a roadside a short distance from the initial site, and two larvae were collected from it. All larvae and pupae were kept in rearing jars with the larvae receiving fresh food plant every two days. Dates of collection, pupation, and eclosure were recorded.

On 26 February 2017, gardeners eradicated the *Eleutheranthera*, and no further collections were possible.

Figure 1. A newly emerged adult of *Cryptobotys zoilusalis* in the rearing jar.

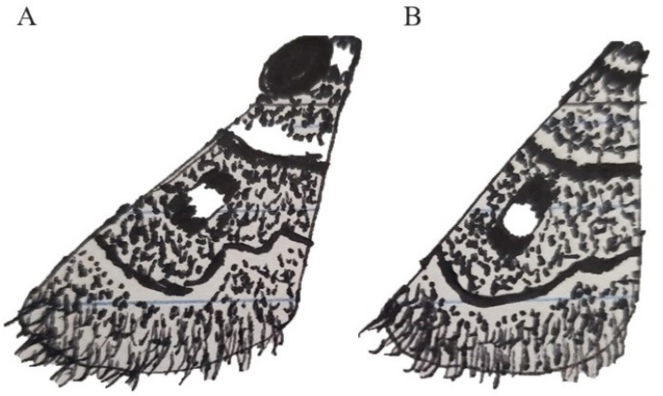


Figure 2. Forewing pattern of *Cryptobotys zoilusalis*: (A) male reared from *Eleutheranthera ruderalis* and (B) female reared from *Synedrella nodiflora.*

RESULTS

Caterpillars were encountered in different instars throughout the collection period, including pupae collected directly from the host plants on 26 December 2016 and the first early-instar larvae on 12 January 2017. The pattern of the webs differed between the two host plants: on *Eleutheranthera*, the leaves bent downward, whereas on *Synedrella*, the leaves bent upward. The larvae also differed in color between the two host plants, with the earliest instars of those collected on *Eleutheranthera* banded black and white, with later instars an olive-green shade, and those on *Synedrella* a bright green. The adults, however, were indistinguishable between host plants. By the end of the collecting period the *Eleutheranthera* was almost entirely defoliated, with approximately 75% of the plants having only the subfloral bracts, and nearly all the rest having only one pair of leaves below the subfloral bracts. Of the total shoots examined, 35% were occupied by caterpillars.

Table 1 shows the numbers of larvae and pupae collected, number of larvae pupating, and numbers of adults and parasitoids eclosing. Of 35 larvae and pupae collected, 6 (17%) survived to the adult stage. Parasitoids emerged from 4/29 larvae and pupae that did not reach the adult stage, thus accounting for 14% of the observed mortality. The parasitoids have not been identified. Both of the larvae collected from *Synedrella* survived to the adult stage, with one in the pupal stage for 5 days, the other for 10-13 days. Similarly, two individuals collected from *Eleutheranthera* were in the pupal stage for 9 days.

Table 1. Numbers of individuals of *Cryptobotys zoilusalis* collected and present during different life stages.

Date	Larvae collected	Pupae collected	Pupating	Adults	Pupae eclosing parasitoids
26/12/2016		2			
28/12/2016	5	6			
31/12/2016				1	
2/1/2017			2		
11/1/2017				2	
12/1/2017	1				
20/1/2017					4
21/1/2017	7				
28/1/2017			3		
5/2/2017	10	1			
11/2/2017			1		
12/2/2017	3				
14/2/2017			1		
18/2/2017				1	
26/2/2017				2	
Total	26	9	7	6	4

The host plants exhibited both growth and mortality: at the initial observation on 25 December 2016, all *Eleutheranthera* were alive and covered with webs, whereas on 12 January 2017, approximately 40% of the plants had died and 80% were covered with webs.

Images of the adult moths and infested host plants are available on iNaturalist at https://www.inaturalist.org/observations/188077209. Figure 1 shows a newly emerged adult. Figure 2 is a line drawing of the forewing patterns. Two specimens are in the author's private collection in Greenville, North Carolina, USA.

DISCUSSION

This study expands the list of known host plants of *Cryptobotys zoilusalis* to include *Eleutheranthera ruderalis* and *Synedrella nodiflora*. Like the previously reported host plants, these are widespread, weedy Asteraceae known to become invasive. Moreover, all are in the tribe Heliantheae, and *Eleutheranthera*, *Synedrella*, and *Sphagneticola* are in the subtribe Ecliptinae.

Given the ubiquity of *Sphagneticola trilobata* in meadows surrounding the study site (Hernandez, 2021), the intense infestation limited to a single stand of *Eleutheranthera ruderalis* requires some explanation. Since the collection site was a newly installed rock drain, it may be that the host plants and caterpillars were newly introduced during construction and had not yet had time to spread. The later appearance of a single web on *Synedrella nodiflora* a short distance away may support this assumption, as early waves of adults emerging from the *E. ruderalis* stand would by then have had time to disperse. The presence of multiple age cohorts simultaneously suggests that not all adults dispersed before ovipositing.

One limitation of this study is the irregular frequency of caterpillar collection, and that not all instar changes were tracked. These limitations prevent the drawing of conclusions about larval and pupal periods, although the pupae that were tracked from pupation to eclosure suggest a variable pupal period from as few as 5 to as many as 10-13 days. The survivorship was also influenced by the fact that some caterpillars were found in later instars and had had more time to be exposed to parasitoids, whereas those collected in earlier instars were protected from parasitoids during development. It should be noted that parasitoids accounted for only 14% of the observed mortality, with larvae and pupae periodically being found dead of unknown causes.

Like many small, inconspicuous moths lacking economic importance, *Cryptobotys zoilusalis* has been little studied. This brief observation adds to the understanding of this species.

ACKNOWLEDGMENTS

I thank the iNaturalist users Matthew Cock (@matthewcock) and Matthew Barnes (@tropicalmoths) for identifying the species, and a reviewer for comments on the manuscript.

LITERATURE CITED

Barber, D. T. 2003. *Bahia Honda State Park Unit Management Plan: Approved Plan*. State of Florida, Department of Environmental Protection.

Becker, V. O., Miller, S. E. 2005. *Moths: Lepidoptera*, pp. 303-309. *In*: Lazell, J. (Ed.), *Island: Fact and Theory in Nature*. Berkeley, University of California Press.

Bendicho-Lopez, A. 1998. New distributional and foodplant records for twenty Cuban moths. *Journal of the Lepidopterists' Society* 52(2): 214-216.

Clavijo-Abiertos, J., Arias-Celis, Q. 2017. Catálogo de los Spilomelinae de Venezuela (Lepidoptera: Crambidae). *SHILAP Revista de Lepidopterología* 45(177):129-141.

Hernandez, J. P. 2021. *Pyrisitia lisa* and its guild in tropical meadows (Pieridae). *Tropical Lepidoptera Research* 31: 80-85.

Landry, B. 2016. Taxonomic revision of the Spilomelinae (Lepidoptera, Pyralidae s. l.) of the Galápagos Islands, Ecuador. *Revue Suisse de Zoologie* 123(2): 315-399.

Martorell, L. F. 1976. *Annotated food plant catalog of the insects of Puerto Rico.* Rio Piedras, Agricultural Experiment Station, University of Puerto Rico, Dept. of Entomology.

Robinson, G. S., Ackery, P. R., Kitching, I., Beccaloni, G. W., Hernández, L. M. 2023. *HOSTS - a Database of the World's Lepidopteran Hostplants [Data set]*. Natural History Museum. https://doi.org/10.5519/havt50xw. Accessed 6 January 2024.

Scholtens, B. G., Solis, M. A. 2015. Annotated check list of the Pyraloidea (Lepidoptera) of America North of Mexico. *Zookeys* 535: 1-136.

Touroult, J., Poirier, E., Jourdan, T. 2021. Inventaire entomologique de la Réserve Biologique Dirigée Nord Grande Terre, Guadeloupe, 2020. *Rapport de la Société Entomologique Antilles-Guyane* 2: 34.

TROPICAL LEPIDOPTERA

Research

VOLUME 34, NUMBER 1 June 2024

TABLE OF CONTENTS