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Genomic analysis reveals a new genus of Firetip skippers (Lepidoptera: Hesperiidae: Pyrrhopyginae)

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Abstract. We obtained whole genome shotgun sequence reads for a number of Firetip skippers (subfamily Pyrrhopyginae), including all known species from the genera *Yanguna* Watson, 1893 and *Gunayan* Mielke, 2002 and representative species of *Pyrrhopyge* Hübner, [1819]. Phylogenetic analysis of their protein-coding regions unexpectedly revealed that *Yanguna tetricus* Bell, 1931 was not monophyletic with the other species of *Yanguna* (type species *Pyrrhopyga spatiosa* Hewitson, 1870). Instead, *Y. tetricus* formed a phylogenetic lineage as ancient as other three genera in its clade (*Pyrrhopyge*, *Yanguna* and *Gunayan*) that rapidly diversified from their ancestor. Therefore a new genus, *Guyanna* Grishin, **gen. n.** (type species *Yanguna tetricus*), is proposed for this lineage. The specimen that we sequenced was the *Y. tetricus* holotype in the Natural History Museum, London, leaving no doubt that we are dealing with this species. Genomic sequencing and comparison of specimens from museum collections offers a powerful strategy to reveal unforeseen phylogenetic relationships, and sequencing of primary types ensures that the conclusions are accurate in terms of nomenclature.

Key words: biodiversity, butterflies, genomic sequencing, museomics, phylogeny.

INTRODUCTION

A genus is a taxonomic category that applies to a group of species that are more closely related to each other than to other such groups. While the precise criteria to outline a genus are not defined, most taxonomists agree that genera should be monophyletic, include closely related species, and be similar to other genera in term of evolutionary divergence of species within a genus. Species within a genus share some common morphological or ecological features that are not present in other genera. These features, or “characters”, are used to delineate genera in animals. For instance, a long process on the sacculus of male genitalic valvae is apparently a derived character (synapomorphy) that was used by Mielke (2002) to distinguish a genus *Gunayan* he proposed for a group of Firetip skippers (subfamily Pyrrhopyginae).

With the advent of DNA-based phylogenies, it has become more straightforward to outline reliable monophyletic groups and to estimate the age of taxa. Nodes in the phylogenetic tree can be dated using fossil records, tree branch lengths re-scaled, and this information can be used as an objective and consistent criterion to help delineate genera. For instance, an age of about 5 million years agreed well with genera as they were defined from morphology in a group of blue butterflies and was proposed as a guiding principle for the definition of genera (Talavera *et al*., 2012). Genetic differentiation over a period of a few million years is likely to lead to the phenotypic divergence that has been used to outline genera by morphology. Understanding the correlation between genomic differences and phenotypic divergence is an emerging field of research.

To study the distinction between closely related genera, we have chosen the Firetip skipper butterflies (Hesperiidae: Pyrrhopyginae). Named for the prominent tuft of red or orange scales at the end of the abdomen present in many species of this subfamily, the Firetips are Neotropical in distribution. Only one species, *Apyrrothrix araxes* (Hewitson, 1867), reaches southern United States. The type genus, *Pyrrhopyge* Hübner, [1819], is marked by the reddish-orange tuft, but its closest relatives, *Yanguna* Watson, 1893 and *Gunayan* Mielke, 2002 have a dark or grayish abdomen end. To understand their relationships better, we obtained and analyzed genomic sequences of all known species of *Yanguna* and *Gunayan*, and representative species of *Pyrrhopyge*, along with several outgroup taxa. Phylogenetic trees obtained from these sequences revealed a surprise. While, as expected, the three genera indeed formed distinct phylogenetic clusters, *Yanguna tetricus* Bell, 1931 was not monophyletic with *Yanguna*, and stood out as its own ancient phylogenetic group on par with the others.

MATERIALS AND METHODS

A leg was removed from the *Y. tetricus* holotype (specimen number NHMUK012824232 in the Natural History Museum, London, United Kingdom, NHMUK) using fine tweezers and placed in a plastic tube, being assigned the molecular code NHMUK0247272661, and later processing code NVG-18083F05 (Fig. 1). DNA was extracted from the leg non-destructively using Macherey-Nagel (MN) reagents; 70 µl buffer T1 and 10 µl protK were simply added to the tube without crushing the leg, and the mixture was incubated at 57°C for 24 hours. Then, 80 µl buffer B3 was added and incubation continued for 2 hours, after which 85 µl of absolute EtOH was added and thoroughly mixed. The resulting liquid was transferred to a different tube and DNA extraction continued according to MN protocol (Li *et al.*, 2019), leaving the leg intact. This procedure resulted in about 14 ng of genomic DNA of *Y. tetricus* dissolved in 35 µl. About 70% of the DNA extract was used to construct a mate-pair library according to our published protocols (Cong *et al.*, 2017). The library was sequenced for 150 bp from both ends targeting 6 Gbp of data on Illumina HiSeq x10 at GENEWIZ. The resulting reads were matched using Diamond (Buchfink *et al.*, 2015) to the exons of the reference genome of *Cecropterus lyciades* (Shen *et al.*, 2017) that we obtained previously, and exons assembled and aligned to other Hesperiidae genomes we obtained using the same methods. Coding regions of mitochondrial genome (including the COI barcode) were assembled similarly. For the COI barcode, due to its frequent use, a specialized procedure was developed (Li *et al.*, 2019), where all sequence reads matching this region were filtered for contamination, aligned, and this lineup inspected manually to check for possible errors. Exons expected to be from the Z chromosome were predicted assuming similar syntenic arrangement with *Heliconius* Kluk, 1780 (Heliconius Genome Consortium, 2012). Phylogenetic trees were generated from 4 sets of exons: whole nuclear genome, whole mitochondrial genome and Z-chromosome using RAxML-NG (Kozlov *et al.*, 2019) with default parameters (-m GTRGAMMA). PhyML (Guindon *et al.*, 2010) was used to construct the COI barcode tree. For additional technical details of experimental and computational protocols we refer to the SI Appendix of our recently published study (Li *et al.*, 2019). The data used in this project were deposited in the NCBI database <https://www.ncbi.nlm.nih.gov/> as BioProject PRJNA889040, and the COI barcode sequence of the *Y. tetricus* holotype in GenBank with accession ON480167. The supplementary file is deposited at <https://osf.io/n934q/>.

We assembled protein-coding regions from the whole genome shotgun reads of 36 Pyrrhopyginae species that we have sequenced. See Table S1 in supplementary file <https://osf.io/n934q/> for detailed specimen data in addition to brief information about the specimens shown in trees in Fig. 1. These species included all 6 known *Yanguna*, 3 *Gunayan* species and 21 representative *Pyrrhopyge* (out of 42 known species) (Mielke, 2005). In addition, 5 more distant Pyrrhopyginae genera were selected from close relatives of *Pyrrhopyge* as outgroups (Fig. 1b), and the entire tree was further rooted with *Mysoria* (*Sarbia*) *xanthippe spixii* (Plötz, 1879). The study included two holotypes from the NHMUK: *Yanguna tetricus* Bell, 1931 (see Methods above) and *Yanguna timaeus* Bell, 1931 (currently in *Gunayan*, specimen number NHMUK012824233, molecular code 0247278334, processing code NVG-18083F06). The lengths of resulting genomic regions were: nuclear total 7,481,792+/-3,155,310, Z-chromosome 305,487+/-130,366; mitogenomes 10,403+/-296. We considered Z-chromosome separately. Males of butterflies have two copies of Z, while females have Z and W. In Z, recombination is reduced to half of that in autosomes, and sexual selection acts differently on genes encoded by it. Thus a separate analysis of genes encoded by Z chromosome may offer additional insights about evolution of these species. Phylogenetic trees were constructed from coding regions of nuclear genome, Z chromosome and mitogenome. In addition, a COI barcode region dendrogram was also obtained.

RESULTS

All the trees lead to the same conclusions (Fig. 1b). First, the branch separating the ingroups from outgroups is the longest internal branch in the trees, suggesting phylogenetic closeness of the three ingroup genera (*Pyrrhopyge*, *Yanguna* and *Gunayan*). Second, each of the three genera forms a compact cluster well-separated from the others, with one exception. Third, the exception, *Yanguna tetricus*, is not monophyletic with other *Yanguna* species. Instead, while being a member of this group of relatives, it was well-removed from all ingroup Pyrrhopyginae taxa. This is an unexpected and interesting result. We sequenced the type species of all three genera: *Pyrrhopyge phidias bixae* (Linnaeus, 1758), *Yanguna spatiosa* (Hewitson, 1870), and *Gunayan rhacia* (Hewitson, 1875), and *Y. tetricus* didn't group with any of them. Therefore, it does not belong to these genera as currently defined, and to restore monophyly of *Yanguna*, a new genus is proposed for *Y. tetricus*.

Guyanna Grishin, **gen. n.**

Zoobank registered: https://zoobank.org/80EBCB78-D65A-4317-AD1A-0994C6DEB640
Type species: *Yanguna tetricus* Bell, 1931

Diagnosis. Morphologically similar to *Yanguna* (see diagnosis in Mielke (2002)) but differs from it by the shortened tip of the aedeagus after the lobule (Mielke, 2002), an apparent synapomorphy of the new genus. Additionally, the costa-ampulla of the right valva is distally squared (as in many *Pyrrhopyge* species) rather than triangular (as in *Yanguna*) and the central tooth of the right harpe is broad and directed dorsad rather than dorsocaudad (Fig. 2, which is a reproduction of fig. 14 from Bell (1934)). The genus keys to A.1.49 in Evans (1951), and is distinguished from other genera of Pyrrhopyginae by the combination of the following characters: head with white lines and dots; abdomen black, striped gray; end of abdomen brown or grayish (not red or orange); legs black, only forecoxae orange, without white scales; fringes not checkered; male genitalic valvae asymmetric, sacculus without a long process that is present in *Gunayan* (see figs. 11-12 in (Bell 1934)). In nuclear DNA, a combination of the following base pairs is diagnostic (see supplementary file <https://osf.io/n934q/> for the sequences with these characters). This character unifies *Guyanna* with *Pyrrhopyge* and excludes others: aly728.44.1:G672C. The meaning is: position 672 in exon 1 of the gene 44 from the scaffold 728 of *Cecropterus lyciades* [formerly in *Achalarus*] (aly) reference genome

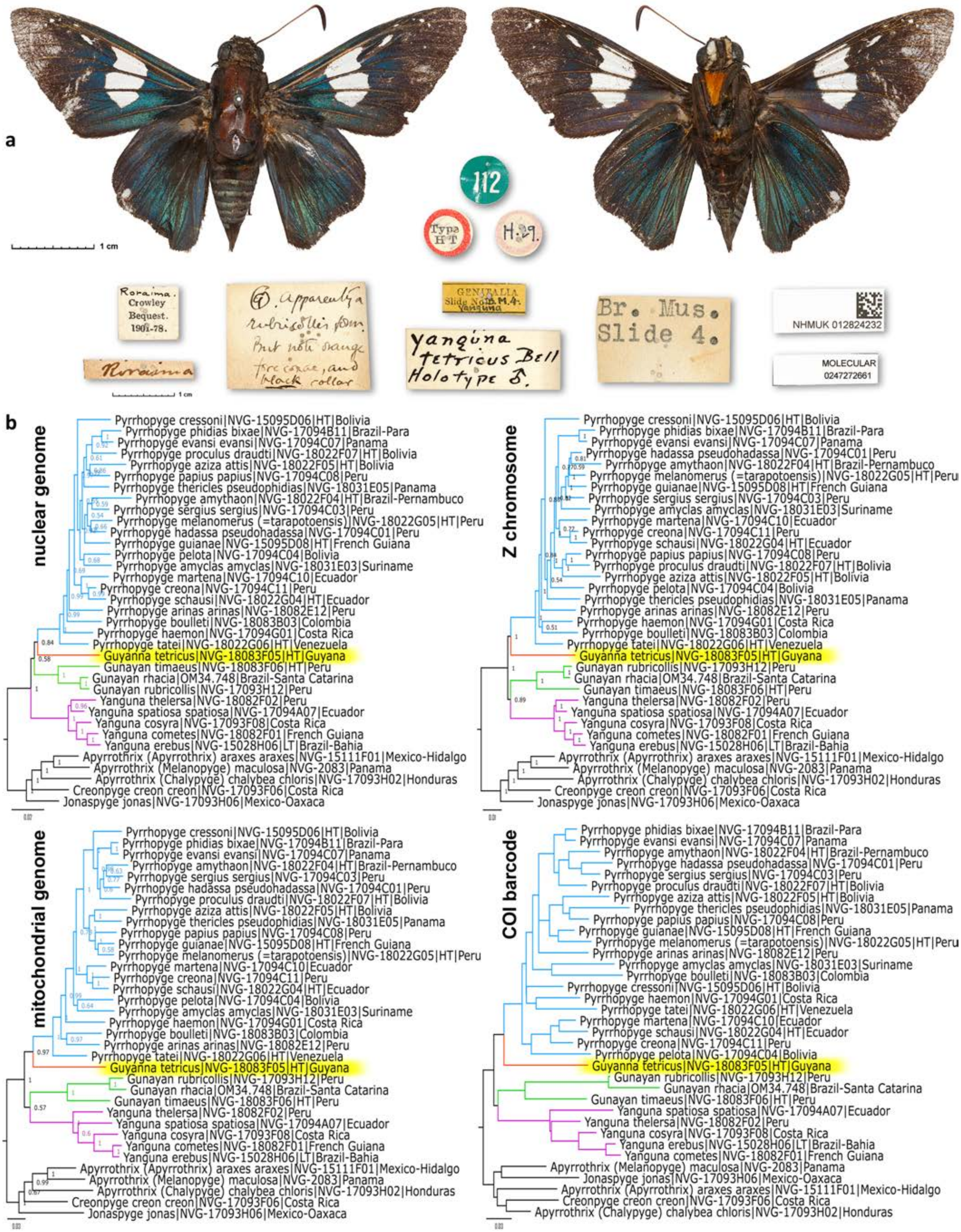

Figure 1. *Guyanna tetricus*: (a) holotype in dorsal (left) and ventral (right) views with its labels (below), both sides of the round "Type" label are displayed, labels are shown at 3/4 of the specimen scale; (b) phylogenetic trees constructed from various portions of nuclear and mitochondrial genomes. The trees were rooted with *Mysoria (Sarbia) xanthippe spixii* (NVG-17094E01), not shown and would refer to the stub-like root in the trees.

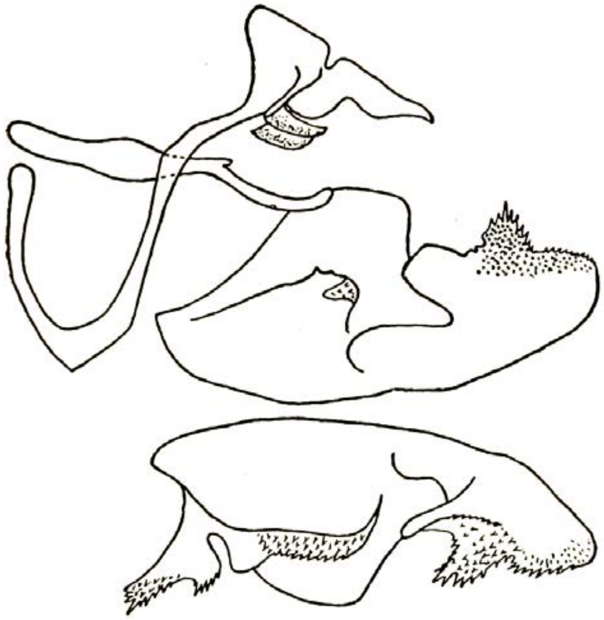

Figure 2. Genitalia illustration of the holotype of *Guyanna tetricus* reproduced from Bell (1934), Fig. 14, downloaded from <https://www.biodiversitylibrary.org/item/205826#page/549/> and modified to remove colors. Interior view of left valva rotated 180° along horizontal axis (dorsal side down, "opened book" view of both valvae) from its position within the genital capsule shown above, is shown below.

(Shen *et al.*, 2017) is C, changed from G in the ancestor. These characters separate *Pyrrhopyge* from others (character state in *Pyrrhopyge* is given after "not"): aly5196.6.2:T61T (not A), aly536.33.3:T477T (not C), aly770.15.10:T48T (not C). These characters separate *Gunayan* from others (character state in *Gunayan* is given after "not"): aly9588.6.1:G777G (not A), aly1244.1.2:T276T (not C), aly393.2.2:C91C (not T). These characters separate *Yanguna* from others (character state in *Gunayan* is given after "not"): aly27.7.1:A504A (not G), aly5729.9.1:C189C (not T), aly594.11.4:C288C (not T). These characters unify *Guyanna*, *Pyrrhopyge*, *Gunayan*, and *Yanguna* and exclude others: aly1539.14.4:A159T, aly1018.6.2:A267G, aly2178.13.1:T351C. This complex combination of characters was chosen to mitigate possible negative consequences of diagnosing a taxon without close relatives (*G. tetricus*) and to distinguish between synapomorphy and error or unique base pair in this particular specimen. Thus, we looked for possible synapomorphic characters in all other, more speciose clades and define the new genus by the lack of these synapomorphies combined with the synapomorphies for the clades that include it. In the COI barcode region, the following characters are diagnostic in combination: T56T (not A) (the meaning is: position 56 in the barcode is T, and is T in the ancestor, but not A as in other taxa), C81T, 82A (not C or T) (ancestral state could not be confidently deduced), G86G (not A), A214T, C287C (not T), T289T (not A), T319T (not A), G474A, T607T (not A).

Derivation of the name. The name is a feminine noun in the nominative singular. Similarly to *Gunayan*, it is an anagram of *Yanguna*. These three genera plus *Pyrrhopyge* are close relatives and form a prominent clade in the phylogenetic tree. The anagram is also a hint to the type locality of the type species (Roraima) suggested by Evans (1951: 34) as being in Guyana, the assessment followed by Mielke (2005). It should be noted that just "Roraima" present on the specimen label is not sufficient by itself to deduce Guyana (British Guiana at that time) as the type locality country, since prior to 1900 (Fig.1a, Crowley died in 1900) "Roraima" could also have referred to a locality in modern day Brazil or Venezuela.

Species included: Only the type species.

DISCUSSION

In the absence of DNA sequences it is not readily apparent that *Yanguna tetricus* is significantly more distinct from its former congeners than they are from one another. Indeed, its general genitalic morphology, body and wing patterns, and wing venation and shape, place it among *Yanguna* as originally described (Mielke, 2002). Nevertheless, Mielke (2002) noticed the uniqueness of this species in the shape of the aedeagus tip, the only exceptional character in *Yanguna* that he mentioned. However, it is hardly possible to put a time-scale on such a genitalic difference and predict when the *Y. tetricus* lineage split from others. DNA information is indispensible to reveal the magnitude of the distinction between *Y. tetricus* and other members of the *Pyrrhopyge* clade (*Pyrrhopyge*, *Yanguna*, and *Gunayan*). In fact, the genetic differentiation of *Y. tetricus* is sufficiently profound that the phylogenetic relationships among the four genera (*Guyanna* **gen. n.**, *Yanguna*, *Gunayan*, and *Pyrrhopyge*) remain unresolved and the relative order of their divergence from their ancestors is not clear (Fig. 1b). This lack of resolution is a result of these four genera being nearly equidistant from one another in genetic differentiation, with all four genera apparently diverging at about the same time, nearly 10 Mya (Li *et al.*, 2019; Sahoo *et al.*, 2017; Zhang *et al.*, 2019). Generic splits around that time have been suggested for other groups of animals, for instance, humans versus chimpanzees (Kumar *et al.*, 2005; Moorjani *et al.*, 2016). Thus the generic status for these four groups seems reasonable and is consistent with how genera are defined in other animals.

Even if dating divergence events has significant errors, unscaled and not-dated trees with branch lengths proportional to the number of base pair substitutions along them (Fig. 1b) suggest the same division into four groups (blue, red, green and magenta). These four clades together form a monophyletic group strongly supported in all trees (100% of partitions have this group). Each non-singular clade individually is a strongly supported monophyletic group: 100% of partitions support blue (*Pyrrhopyge*), green (*Gunayan*), and magenta (*Yanguna*) clades in all trees. However, the mutual arrangement of these clades differs among the trees and is more weakly supported. Therefore, we see two confident evolutionary levels in the trees. The first level unifies these four groups, corresponding to rapid diversification of the clade into these four groups, possibly complicated by incomplete lineage sorting and gene exchange through hybridization. These events and rapid diversification obscure phylogenetic relationships between the four groups, revealing a conflict between the gene trees that results in low statistical support for any topology. The second level is the diversification of each of these four groups into species. We do not observe a most confidently supported level in between these two. Therefore, we either treat the assemblage of the four groups as a single genus (*Pyrrhopyge s. l.*), or divide it into four genera, the solution adopted here, following recent treatments (Mielke, 2002; Zhang *et al.*, 2019). A solution that divides *Pyrrhopyge* sensu lato into two or three groups seems less meaningful, because such groups may not be monophyletic (due to lower statistical support) and they are supported by relatively shorter branches (fewer changes in genomic DNA). For example, all trees suggest that *Y. tetricus* is monophyletic with *Pyrrhopyge*, and while this relationships may be correct, it is not obvious from morphology: the common branch of the two groups is short and may not have genomic changes that encode significant morphological changes.

When sequencing a unique and old specimen, a question about data quality and its possible negative influence on the conclusions of the study comes up. For instance, DNA degradation and contamination may affect sequence quality and lead to faulty phylogenetic analyses. Indeed, DNA degradation results in miscalling of base pairs in individual sequence reads. However, due to the random nature of these events, higher coverage of genomic regions by sequence reads removes these individual and random errors in each read. For low coverage regions, these random errors would not correlate with phylogeny, and will mostly contribute to the length of the terminal branch of this specimen, because these incorrect base pairs will be mostly unique to this specimen. While we observed this effect for old specimens in a number of projects, the terminal branch of *Guyanna tetricus* **comb. n.** is not longer than most others (Fig. 1b), suggesting that its sequence is of a reasonable quality. Moreover, trees constructed from different genomic regions, nuclear and mitochondrial, result in the same conclusion. We also analyzed the COI barcodes, and they constitute one of the regions best-covered by sequence reads. The reads mapping to the barcode were inspected manually for consistency and overlap. The dendrogram from the barcodes placed the four taxa in the same topology, further supporting our conclusions. Furthermore, even if these sequencing results are flawed for some unknown reason, they pointed to the morphological uniqueness of *G. tetricus* **comb. n.** that was already noticed in the original description of the genus *Yanguna* by Mielke (2002). The structure of the aedeagus tip is likely synapomorphic and can be used to differentiate between the four taxa (*Guyanna* **gen. n.**, *Yanguna*, *Gunayan*, and *Pyrrhopyge*), as was suggested by Mielke (2002); he proposed names for the two genera (*Yanguna*, *Gunayan*), and mentioned the third (*Guyanna* **gen. n.**), including it in *Yanguna* as the only exception to the state of the character of the genus in which he placed it.

Finally, we note that it is optimal to sequence primary type specimens, which ensures that we are analyzing the correct species and there is no misidentification involved. In sum, DNA analysis has been instrumental to discover that *Yanguna tetricus* does not belong in *Yanguna* and, as hinted by morphological evidence, should be placed in the new genus that we named here.

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Notes on the immature stages of *Almeidella corrupta* (Schaus, 1913) (Lepidoptera, Saturniidae, Ceratocampinae)

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Abstract: The immature stages of the wild silk moth genus *Almeidella* Oiticica Filho (Saturniidae: Ceratocampinae) are illustrated, along with information pertaining to the life history, including host plants in captivity and in nature, for the first time. We reared *A. corrupta* (Schaus) from eggs obtained from a female collected in Paraíso do Sul, Rio Grande do Sul, Brazil. This location is the farthest west *Almeidella* has ever been reported in Rio Grande do Sul. An additional larva of *Almeidella*, preliminarily identified as *A. corrupta*, from Pedro Leopoldo, Minas Gerais, Brazil is figured along with its natural host plant, *Anadenanthera peregrina*. Both the captive host plants and the natural host plant belong to Fabaceae, a common host family for a wide range of Ceratocampinae species. General morphology is typical of Ceratocampinae, with silver, reflective scoli; we observed two color forms of the larvae: red and green.

Key words: *Anadenanthera peregrina*, Bombycoidea, Brazil, Fabaceae, Life history

INTRODUCTION

Wild silk moths, Saturniidae, include nearly 3,500 named species in 180 genera distributed globally (Lemaire & Minet, 1998; Kitching *et al.*, 2018). The Americas are home to six subfamilies of Saturniidae, five of which are endemic to this region (Lemaire & Minet, 1998). Most subfamilies of Saturniidae present in the Americas have been treated in the voluminous works of Lemaire (1978, 1980, 1988, 2002). One of the American endemic lineages, the Ceratocampinae, have had their life histories as the focus of an extensive literature (Packard, 1905; da Costa Lima, 1950; Dias, 1981; Lemaire, 1988; Furtado & Racheli, 1998; Lemaire & Minet, 1998; Furtado, 1999, 2000, 2001; Albertoni & Duarte, 2015; Zarco *et al.*, 2015). Despite this, many species, and even substantial numbers of genera, are completely lacking published life histories. As is the case for most Lepidoptera, all Saturniidae in the Americas are described from adult specimens, and thus there is a significant gap in our knowledge of life history traits such as larval morphology and host plant utilization.

The genus *Almeidella* Oiticica Filho, 1946 (type species: *A. almeidai* Oiticica Filho) was described to include three species of Ceratocampinae which, at the time, were only known to occur in southeastern Brazil: *A. almeidai*, *A. approximans* (Schaus, 1920), and *A. corrupta* (Schaus, 1913) (Oiticica Filho, 1946; Lemaire, 1988). These three species were most recently treated together by Lemaire (1988), who provided figures and descriptions of both sexes, their genitalia, as well as distribution maps of all three *Almeidella* species. Apart from the taxonomic and systematic treatments of authors such as Oiticica Filho (1946), Michener (1952), and Lemaire (1988), nothing has been published on the life history of *Almeidella*, with host plant associations and immature stages unknown.

Various efforts have been made to rear and publish images and larval descriptions for Ceratocampinae genera for which life history information was completely unknown, or for some genera where life histories were known for only very few species (Dias, 1981; Furtado & Racheli, 1998; Furtado, 1999, 2000, 2001; Albertoni & Duarte, 2015; Zarco *et al.*, 2015). The present article follows in the tradition of these studies and provides life history information for one of the three species of *Almeidella*, offering the first glimpse at the eggs and larvae of this genus. Such information is widely useful for those interested in locating this species in nature and presents an opportunity to understand the ecological requirements of *Almeidella* and may offer useful knowledge for the phylogeny of Ceratocampinae.

MATERIALS AND METHODS

The immature stages of the reared *Almeidella corrupta* figured in the present article were derived from eggs obtained from a single female (Fig. 1) collected in Paraíso do Sul, Rio Grande do Sul, Brazil on 8.X.2018 (29°37'6.168"S, 53° 8'38.3676"W). This location was a tobacco field on a slope surrounded by fragments of Mata Atlântica. This particular site was, therefore, highly disturbed by human interference. Numerous males of both *A. corrupta* and *A. approximans* were observed at this location on this night (Fig. 2), but only one female, the progenitor of the offspring reared here, was observed. An additional wild larva was observed by Wolfgang

Figure 1. Adult female *Almeidella corrupta* from Paraíso do Sul, Rio Grande do Sul, Brazil, progenitor of the offspring reared in the present article.

Figure 2. Adult males of sympatric *Almeidella* at Paraíso do Sul, Rio Grande do Sul, Brazil. Left: *A. corrupta*, right: *A. approximans*.

Walz in Pedro Leopoldo, Minas Gerais, Brazil (Fig. 3) that we identified as *A. corrupta* based on our rearing efforts in Rio Grande do Sul, but we appreciate the fact that this may represent another *Almeidella* species (such as *A. approximans*, which also occurs in Minas Gerais).

The female *A. corrupta* was placed in a screened cage and maintained indoors at room temperature for three days and nights, with eggs collected each afternoon. Upon hatching, first instar larvae were offered two woody, small leaflet Fabaceae species: one was a species of *Mimosa* L. (R. Valka pers. comm.) and a second tree belonging to an unidentified genus. Considering the time of year (spring) much of the useful species-level identification characters of the host plants (e.g. flowers or fruits) were not present and thus identifications of the plants are preliminary. Both plants were accepted, but only the *Mimosa* sp. was used due to early larval die off on the second plant. A third Fabaceae species, a taxon near *Heteroflorum* M. Sousa (R. Valka pers. comm.), was used during the last two weeks due to a move to a new location where the original *Mimosa* sp. was not available.

Larvae were reared indoors in sealed plastic boxes, kept at room temperature. First and second instar larvae were maintained in small (2 liter) containers; third instar larvae were transferred to a larger plastic tote (35 liters) and then later split into two groups evenly separated into two of the larger plastic totes for the final instar. The food plant (regardless of which plant was used) was cut and a wet paper towel was rolled around the cut end of the plant. Plants were changed every third day, or when completely eaten (this occurred in the final instar only). Frass was removed whenever host plants were changed, and the containers rinsed with water and dried completely with paper towel before reintroducing fresh plant material and the larvae. Prepupal larvae were transferred to separate boxes with torn paper towels inside as a pupation medium.

In larval descriptions, thoracic segments are abbreviated T1-T3, abdominal segments A1-10.

RESULTS

We provide images and brief descriptions of all immature stages of *A. corrupta* to help aid in the recognition of *Almeidella* larvae in nature, and for others interested in using morphological characters of these genera of Saturniidae for other systematics studies.

The female *A. corrupta* that gave rise to the larvae reared in the present study (Fig. 1) was collected around midnight after observing numerous males of both *A. corrupta* and *A. approximans*. The specimen was in good condition and did not show significant signs of wear and was evidently recently emerged and mated. Males were seen flying from around 22:00 h until around 24:00 h when the female was collected and was also when the light set up was shut down due to inclement weather. We consider it noteworthy that these two species of *Almeidella* are sympatric and synchronic at this location in Paraíso do Sul, especially considering that our reports of these two species from this location are the farthest west either has been recorded in Rio Grande do Sul (Prestes *et al.*, 2009).

We were able to observe and photograph eggs and all five larval instars. The larvae mostly failed to pupate or the pupae did not survive, thus no resulting adults from the rearing efforts were observed. Some measurements were made, when possible, for each stage and are provided below, but we caution the reader that these measurements were only based on one to three larvae, with measurements made at variable periods during the span of a given instar due to the nature of our rearing efforts which occurred during ongoing fieldwork. Due to this, chaetotaxy studies of first instar larvae were not possible, nor were the focus of this study. Limited availability of larvae was a significant constraint and photographing all larval instars was the paramount goal of this study.

To complement our study, we include a photo of a larva observed in nature on 9.XI.2021 in Pedro Leopoldo, Minas Gerais, Brazil (Fig. 3). Our identification of the larva is based on our rearing efforts and the known presence of *A. corrupta* in nearby regions of Minas Gerais (Carlos Mielke pers. comm.). The discoverer of the larva, Wolfgang Walz, also provided

Figure 3. Final instar *Almeidella* larva observed in nature on *Anadenanthera peregrina* (Fabaceae) in Pedro Leopoldo, Minas Gerais, Brazil by Wolfgang Walz. We preliminarily identify this larva as *A. corrupta* but this has not been confirmed through rearing. Photo by Wolfgang Walz, used with permission.

Figures 4, 5. Natural host plant of *Almeidella*, *Anadenanthera peregrina* (Fabaceae), in Pedro Leopoldo, Minas Gerais Brazil. 4. Leaves. 5. Bark. Photos by Wolfgang Walz, used with permission.

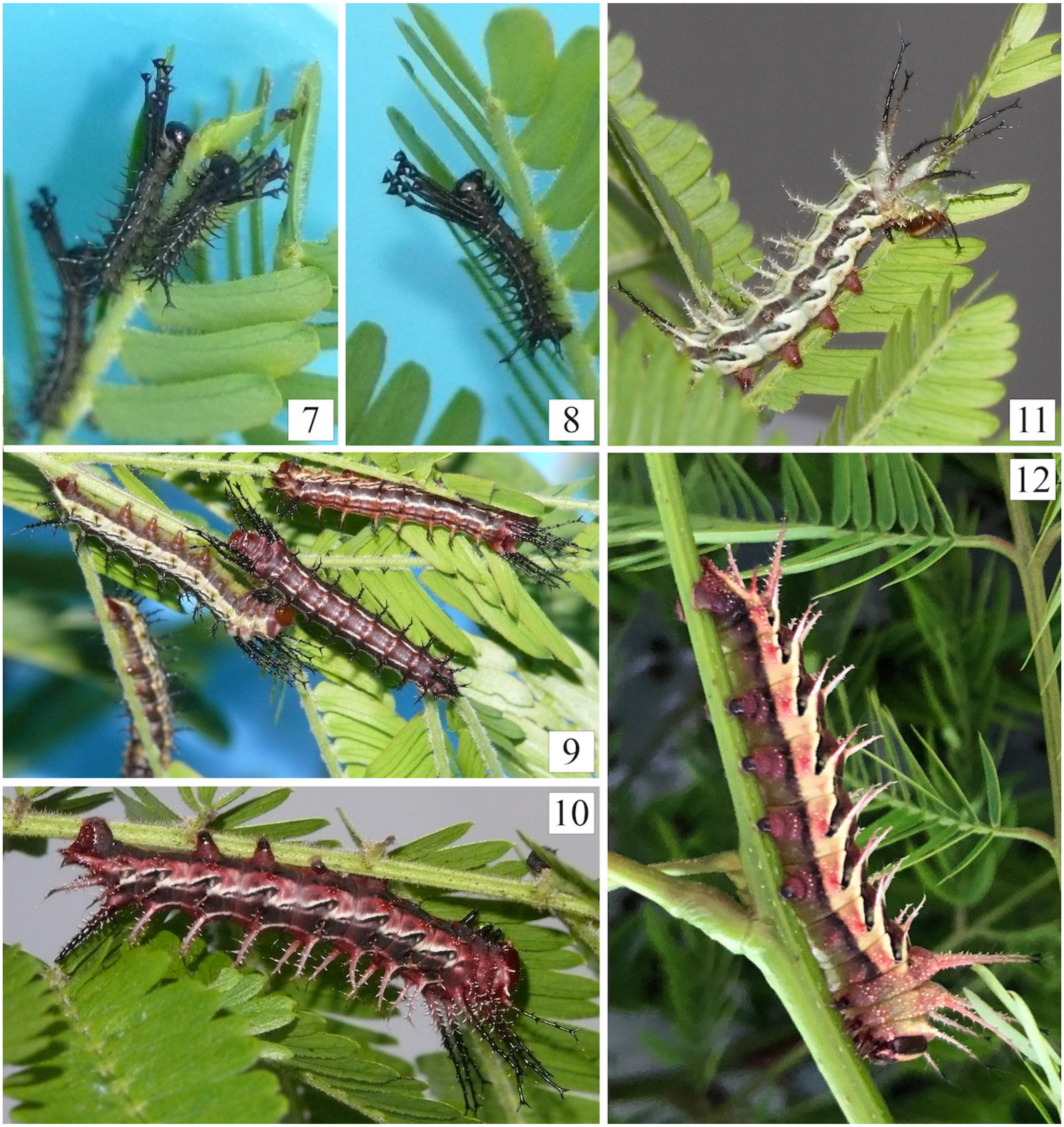
photographs of the host plant which are included in the present article (Figs 4, 5). The host plant was identified as the Fabaceae *Anadenanthera peregrina* L. (Speg.) (Geraldo Pereira pers. comm.) and is now known to be a natural host plant of *Almeidella* in Minas Gerais.

Egg (Fig. 6)

The first eggs (which were laid over the course of three consecutive nights) were noticed on 8.X.2018, with the bulk of eggs laid 9.X.2018. The first larval emergences occurred on 16.X.2018, with a majority of larvae hatching on 17.X.2018. Thus, egg development was eight to nine days at room temperature.

Eggs are ovoid in shape and slightly flattened. Two distinct color forms of the eggs were observed: dark brownish green and lighter green. The color differences were not a result of differential development since both colors were observed at the same times immediately after oviposition. The chorion is somewhat opaque such that larval development, while visible,

Figure 6. Eggs of *Almeidella corrupta* showing two distinct color forms, brown and green. Scale bars are each 1 mm.



Figures 7-12. Early instars of *Almeidella corrupta* reared in captivity on Fabaceae. 7. Group of First instar larvae. 8. Single first instar. 9. Several second instar larvae showing both red and green forms. 10. Third instar, red form. 11. Third instar, green form. 12. Fourth instar, red-green form.

was not as readily apparent as in other Ceratocampinae such as *Citheronia* Hübner, *Eacles* Hübner, *Syssphinx* Hübner which generally have much more transparent eggs (St Laurent pers. obs.). The diameter of the eggs at the widest distance: 2 mm (n = 7).

First instar (Fig. 7, 8)

The first instar larval integument is almost entirely black, with lighter gray dorso-lateral lines, coloration was consistent throughout the duration of the first instar. Legs, prolegs, head capsule, and scoli are all black. Scoli of T1-3 are more than one half length of the body of the unfed, recently eclosed larva. Thoracic scoli are each tipped by a globular structure which are apically spined at each distal angle. Arrangement of thoracic scoli are as follows: T1: one pair, T2 and T3: two pairs each. Primary scoli of A1-7 as three pairs on each segment, one pair subdorsally, one pair supraspiracullarly, and a third pair subspiracularly. The abdominal scoli are sharp and somewhat anteriorly directed. A8 bears a prominent singular dorsal scolus that is distally bifurcated. Scoli of A9 and A10 are roughly twice the thickness and length of dorsal and lateral scoli of A1-7. Length: 5 mm.

Although we were unable to formally characterize and describe chaetotaxy for *A. corrupta*, we note very similar morphological arrangement of scoli as described and figured for first instar *Adeloneivaia fallax* (Boisduval) in Albertoni & Duarte (2015). It would be desirable for future rearers of *Almeidella* to preserve first instar larval specimens for more in-depth morphological description of this crucial stage of development.

Second instar (Fig. 9)

The second instar was the phase at which different larval color forms first became evident. There are two forms in the second instar: one primarily green and another primarily deep red. The two forms did not differ in morphological structure, with both showing a similar scoli arrangement to the first instar, but with the sizes of scoli smaller overall relative to body size than in the first instar. Thoracic scoli are not tipped with enlarged globular structures, but instead are bifurcated apically. Dorsal and lateral scoli are sharply spined, with apical tips pointed anteriorly. The coloration of scoli remain mostly black.

Coloration of the two forms were as follows: in the green form the subspiracular region and prolegs are deep red, with a sharply contrasting light green lateral band. The light green lateral band is interrupted by seven diagonal dark red-brown streaks. Dorsally to the lateral green band is a darker, greatly contrasting, deep red band. This dorso-lateral red band is darker than the ventral red band. Dorsally the ground color is light green with three deep red longitudinal bands, the central of which is the most well-defined. The patterning of the red form is identical to that of the green form, but with the light green bands replaced by light red bands, the darkest lateral red band is the same shade in both larval color forms. In the red form the dorsal and ventral margins of the darkest red lateral band are cream colored.

The head capsule is reddish brown in both larval color forms. Larval length: 14-15 mm.

Third instar (Figs 10, 11)

As in the second instar, the third instar larvae display two distinct color forms: a red form (Fig. 10) and a green form (Fig. 11). Scoli arrangement is as in the prior instars, but in the third instar the coloration of the scoli differs depending on their location on the body. Thoracic scoli are mostly dark-brown to nearly black except for basally where the ground color of the integument is present along the basal quarter of the scolus length. Dorsal scoli are the color of the ground color whereas dorsolateral and lateral scoli are reddish-brown. The elongate scolus of A8 is entirely dark brown.

Larval coloration is largely as described for the second instar, but with slightly more intricate patterning laterally such that the lateral diagonal streaks are outlined by black and cream giving them a more contrasting appearance. The colored scoli also give the larvae a more complex patterning than those which were entirely dark-brown in the previous two instars.

The head capsule remains dark red-brown, but with a pair of cream-colored dorso-ventral streaks. The true legs remain black in this instar. Larval length: ~22 mm.

Fourth instar (Fig. 12)

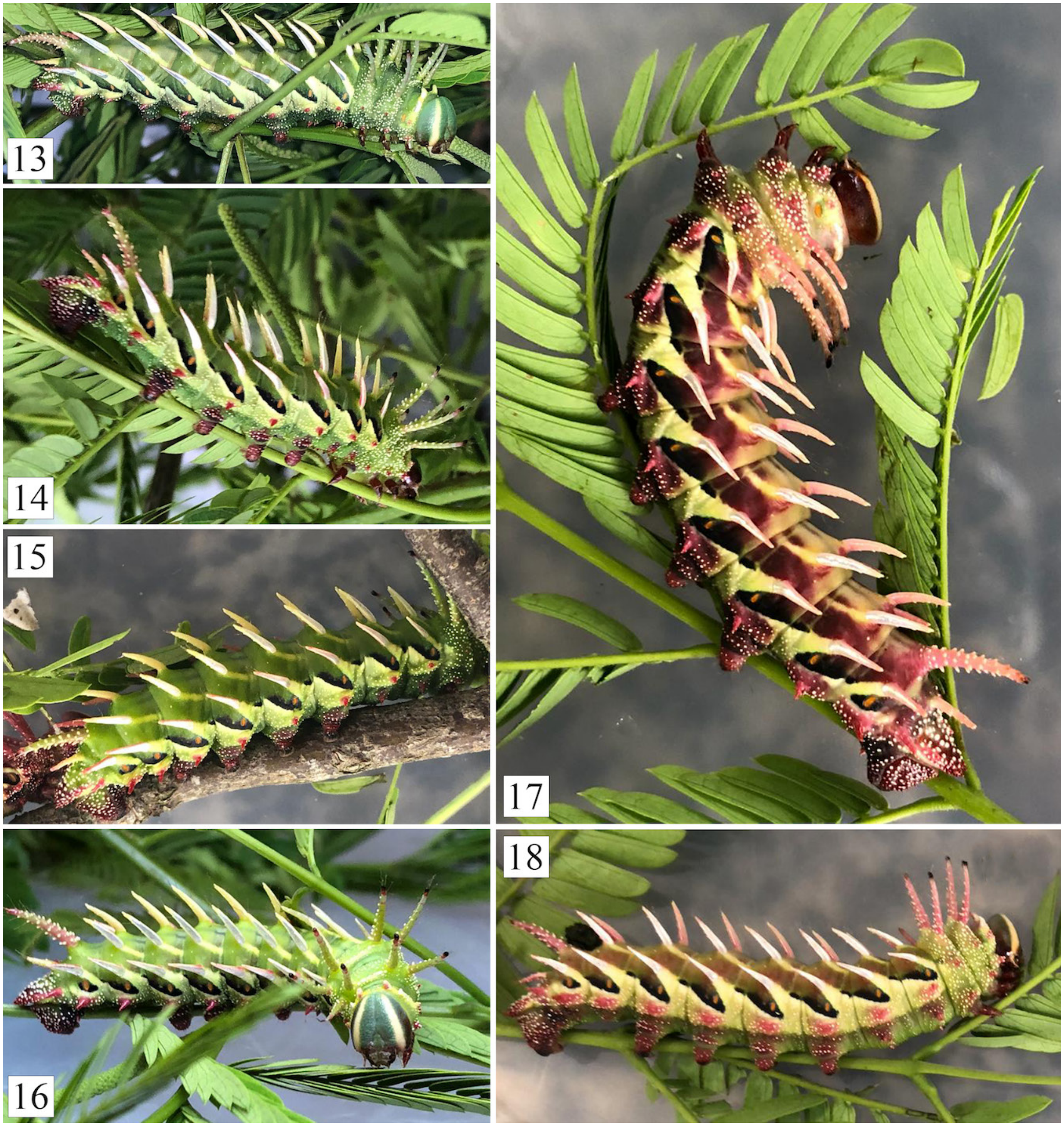
The fourth instar larvae displayed more complicated color forms that were not so easily binned into two distinct types. In general, there were still larvae that were greener and others that were redder, but a third category of coloration was intermediate between the two (Fig. 12). The scoli morphology in this form also underwent a more dramatic change upon the molt to the fourth instar. The thoracic and eighth abdominal scoli were noticeably thicker, and more distinctly colored to be more similar to the ground color of the integument. These scoli have more distinct white granules along their length, and distinct black tips. Very fine setae were noticeable apically on these scoli. The lateral and dorsolateral scoli undergo a more significant structural change between the third and fourth instar. Nearly the entire structure of these scoli become smooth, reflective triangular structures reminiscent of those observed in many Fabaceae feeding Ceratocampinae (e.g. as figured in Lemaire 1988, Janzen & Hallwachs 2022). These scoli have some smaller spines and auxiliary setae, particularly apically, but the bulk of the structure is a smooth, metallic, and somewhat widened structure.

All color forms retained the deep red ground color below the spiracles, such that the prolegs are deep red. Laterally the lighter coloration (lighter red, green, or green with an underlying reddish hue) is no longer a well-defined band narrowly interrupted by thin streaks but is instead fully interrupted along its dorsal margin at each invasion of a black diagonal streak. The light color of the lateral band runs uniformly along the contrasting interface with the ventral red region, and then constricts at the base of the dorsolateral scoli, giving the lateral band a jagged appearance. Dorsally the larvae are either light green or reddish.

In this instar the thoracic legs are more clearly reddish brown in color, the head capsule red-brown with a pair of well-defined dorso-ventral cream-colored streaks. Length: 30-35 mm.

Fifth (final) instar (Figs 3, 13-18)

In the final instar the coloration of the larvae is in general more green than red, with some larvae being almost entirely devoid of any red coloration (Figs 13-16). This became more apparent as the larvae fed such that fully fed red form larvae all had at least some degree of green coloration on the post-feeding expanded integument (Figs 17, 18). Those that retained more red coloration are more effectively described as light pink. However, the coloration of the pink forms was quite variable such that no two larvae were exactly alike in red:green color ratio. There are, however, fully green larvae that are devoid of red except for along small regions below the spiracles (including the now greatly reduced lateral scoli), parts of the scoli, the prolegs, the anal plate, and the anal prolegs. The dorso-lateral and dorsal scoli are thicker, glossier, and more metallic in appearance in the fifth instar. Thoracic scoli are also thickest in this instar, and range in color from green to pink, always



Figures 13-18. Fifth, final instar of *Almeidella corrupta* reared in captivity on Fabaceae. 13-16. Green form. 17, 18. Red-green form.

display white spinules and have distinct black tips. The large scolus of A8 is also greatly thickened, particularly basally, and covered in white spinules. The single wild-observed larva from Minas Gerais (Fig. 3) displays the same nearly all green color form that we observed in some larvae from the Rio Grande do Sul rearing efforts.

Head color ranges from green-blue to red, with a pair of dorso-ventral cream-colored streaks. Length: 42 mm (feeding) to 50 mm (nearly fully fed).

Prepupal larvae commenced wandering behavior roughly two weeks after the onset of molting to the fifth instar. Coloration of red form larvae was not noticeably different in the prepupal stage; however, green form larvae became decidedly pinkish-red when prepupal. Most larvae perished in the prepupal stage.

Pupa

The few larvae that pupated later died, therefore, it is possible that this species has specific requirements regarding pupation. It is also possible that the provided food plants or paper towel pupation medium were not appropriate for the larvae, resulting in poor success in pupation and pupal survival. The few pupae that were formed quickly died and were not photographed, but were otherwise typical of Ceratocampinae with a rough, thick cuticle and an extended, sharp cremaster. Others that discover *Almeidella* larvae should provide a wide range of different pupation media to encourage pupation.

DISCUSSION

Although the life history of *Almeidella* was previously unknown, we made an educated guess that they would be Fabaceae feeders considering the wide use of this family of plants by the Ceratocampinae (e.g. *Adeloneivaia* Travassos, *Adelowalkeria* Travassos, *Megaceresa* Michener, *Syssphinx*, among others) (Balcázar-Lara & Wolfe, 1997; Furtado & Racheli, 1998; Furtado, 1999, 2000, 2001; Albertoni & Duarte, 2015; Janzen & Hallwachs, 2022). Thus, the acceptance of various Fabaceae species by the larvae that we reared was expected.

We did not observe *Almeidella* larvae in nature, and thus cannot conclusively determine their natural host plants in Rio Grande do Sul. The observation by W. Walz in Pedro Leopoldo, Minas Gerais provides further confirmation that the natural host plant(s) belong to the Fabaceae. It is worth noting however, that according to Giehl (2021), there are no native *Anadenanthera* in Rio Grande do Sul, thus *A. corrupta* must utilize other Fabaceae host(s) in the state.

The larvae of *A. corrupta* have reflective scoli, which is often observed in Fabaceae-feeding Lepidoptera. It has been hypothesized that the reflective scoli of Ceratocampinae and certain other Lepidoptera that feed on Fabaceae have evolved these as a strategy of disruptive camouflage (Tuskes, 1985). We therefore encourage others to search Fabaceae in the natural range of *Almeidella* for larvae that are similar to the ones that we figure here, so that additional information on the natural host plant(s) can be gathered. Importantly, the other two species of *Almeidella* still have unknown life histories, and thus any discovery of larvae in nature that are similar to what we figure here should be reared.

Balcázar-Lara & Wolfe (1997) mentioned that *Almeidella* was a phylogenetically critical genus, whose inclusion in morphological phylogenetics was of interest. So far this genus has not been included in any published molecular phylogenies of Saturniidae and, in the morphological phylogeny of Balcázar-Lara & Wolfe (1997), its placement was unclear. Phylogenomic evidence suggests that *Almeidella* is sister to *Giacomellia* Bouvier (Kawahara pers. comm.; Rougerie *et al.* 2022), another Fabaceae feeder with somewhat similar larvae as per photos available at iNaturalist.org.

Though we were unable to fully document the life history of *A. corrupta* using more standardized techniques and more systematic documentation, we believe that by providing images and some observational data on a poorly understood species of saturniid, is significant. Of the 29 genera of Ceratocampinae (Kitching *et al.*, 2018) many of them have unknown, or at least, unpublished life histories, particularly species-poor genera endemic to Brazil and adjacent countries (St Laurent, pers. obs.), thus we present an important contribution in narrowing the uncertainties about the natural history of this subfamily. It is our hope that the provided images and an apparent host plant association with Fabaceae will enable others interested in locating *Almeidella* (of any of the three species) in nature, to do so, and to further study these moths.

In addition to the life history data reported here, we provide a new locality for both *A. corrupta* and *A. approximans* in Rio Grande do Sul. Prestes *et al.* (2009) treated all Ceratocampinae known from Rio Grande do Sul at the time, and included both *A. corrupta* and *A. approximans*, but had records for these species only from the northeastern quadrant of the state, near Porto Alegre. Lemaire (1988) reported *A. corrupta* from Santa Cruz do Sul, which is nearer to where we found these species, but still farther eastwards. We here report these species from the mountainous region in the center of Rio Grande do Sul. Despite the location being particularly disturbed by human activity, *Almeidella* were common at our lights. Both of the *Almeidella* species that we observed have since been discovered in Argentina, and *A. corrupta* from Paraguay and thus they are more widely distributed than previously known (Zapata *et al.*, 2012; Díaz & Smith, 2013; Núñez Bustos, 2015). Carlos Mielke informs us of the presence of *A. corrupta* from Minas Gerais, which has also not been previously reported.

ACKNOWLEDGMENTS

This study would not have been possible without the Carvalho family, who permitted us access to their land where the female *A. corrupta* was found. Carlos Mielke provided data for *A. corrupta* in Minas Gerais. Ruy Valka and Geraldo Periera aided in the identification of Fabaceae mentioned in this article. The female *A. corrupta* was collected with the SISBio permit number 11990-1. We thank two anonymous reviewers for their constructive feedback on the manuscript.

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First record of *Anereuthina renosa* Hübner, 1823 (Lepidoptera: Erebidae) from Bangladesh and *Terminalia* sp. (Combretaceae) as a new larval host plant record

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Abstract: In the present study, *Anereuthina renosa* Hübner, 1823 is recorded for the first time from Bangladesh. Detailed morphological features of the final instar caterpillar as well as of the adult are provided along with photographic illustrations. A new host plant record for *A. renosa*, *Terminalia* sp. (Combretaceae), is also reported here.

Keywords: caterpillar, Chittagong University, ecology, Erebinae, Mathbaria (Barisal division), palm, tibiae.

INTRODUCTION

The genus *Anereuthina* Hübner, 1823, a member of Erebidae, was described with type species *Anereuthina renosa* Hübner, 1823 from Java. *Anereuthina* is externally similar to *Serrodes* Guenée, 1852 and *Avatha* Walker, [1858] in having a similar type of forewing black patch (Holloway, 2005). It is characterized by features of the forewing black patch and the ‘hairy’ legs, notably the forelegs which are easily visible in nature. In the male genitalia, the tip of the uncus is of the ‘ball and claw’ type having a scaphium; the juxta is of the inverted ‘Y’ type; and the valvae are rather paddle-like, with a moderate but slender harpe on the sacculus; the vesica is small and globular (Holloway, 2005).

Currently, the genus contains three species, *Anereuthina atriplaga* (Walker, 1869) from Congo (type locality), *A. renosa* from Java (type locality), Sundaland, Philippines, Myanmar, and India, and *A. somaliensis* (Berio, 1985) from Somalia, Afgoi (type locality). Apart from *A. renosa*, two other species are known only from their type localities. Of the three species, the life history and host plant data are known only for *A. renosa*, whose caterpillars are known to feed on palms (Arecaceae) (Holloway, 2005).

In the present study, *A. renosa* is recorded for the first time from Bangladesh. Morphological features of the final instar caterpillars as well as of the adults are provided. A new larval host plant, *Terminalia* sp. (Combretaceae) is also reported for *A. renosa*.

MATERIALS AND METHODS

Study area: The data were collected from two locations in Bangladesh: Chittagong University campus, located at Zobra village under the Hathazari Upazila, Chittagong (22°28'17.66"N and 91°47'15.65"E), and Mathbaria (Pirojpur, Barisal) of Bangladesh. Mathbaria is located at 22°17'31.32"N and 89°57'29.10"E and is adjacent to the Sundarbans Mangrove.

Species record, identification and analysis: Data on immature stages along with the adult moths were collected from both locations. The immature stages were collected and reared inside plastic boxes with ventilation and moisture levels monitored. The adult which emerged from the rearing was killed and prepared for further study following standard procedures. The identification was confirmed using external morphological and genitalia characteristics (Hampson, 1894; Holloway, 2005). Genitalia dissection was performed following Robinson (1976). The genitalia was photographed and studied using a L-101 student compound microscope. A Redmi Note 10 Pro Max cell-phone was used for photography.

RESULTS

The life history was observed and recorded from the final instar caterpillar. Two caterpillars, both in the final instar, were observed from the study areas. The one observed from the Chittagong University campus was not collected, whereas another caterpillar observed at Mathbaria was in the pre-pupal stage and was collected for study. The caterpillar started to pupate on the same day joining two leaves of the host plant together, one over another with silk threads. Inside the leaf shelter, a silken cocoon was created. The adult male emerged after almost 20 days of pupation.

Description

Final instar caterpillar (Fig. 1). Caterpillar approximately 70 mm in length. Ground color pale gray. Three pairs of prolegs present, first one in third abdominal segment rudimentary. Whole body covered with rectangular black spots of two kinds, one elongated, another somewhat oval. Head covered with oval black rectangles while rest of body covered mostly with elongated black rectangles between which a small number of oval rectangles. Black rectangles

Figures 1-6. *Anereuthina renosa*. **1.** Final instar caterpillar; **2.** Leaf shelter on *Terminalia* plant; **3.** Pupa with silken cocoon; **4.** Pupa (abdomen showing three orange bands); **5.** Pupa abdominal tip (showing wrinkles and hook-like cremaster); **6.** Imago.

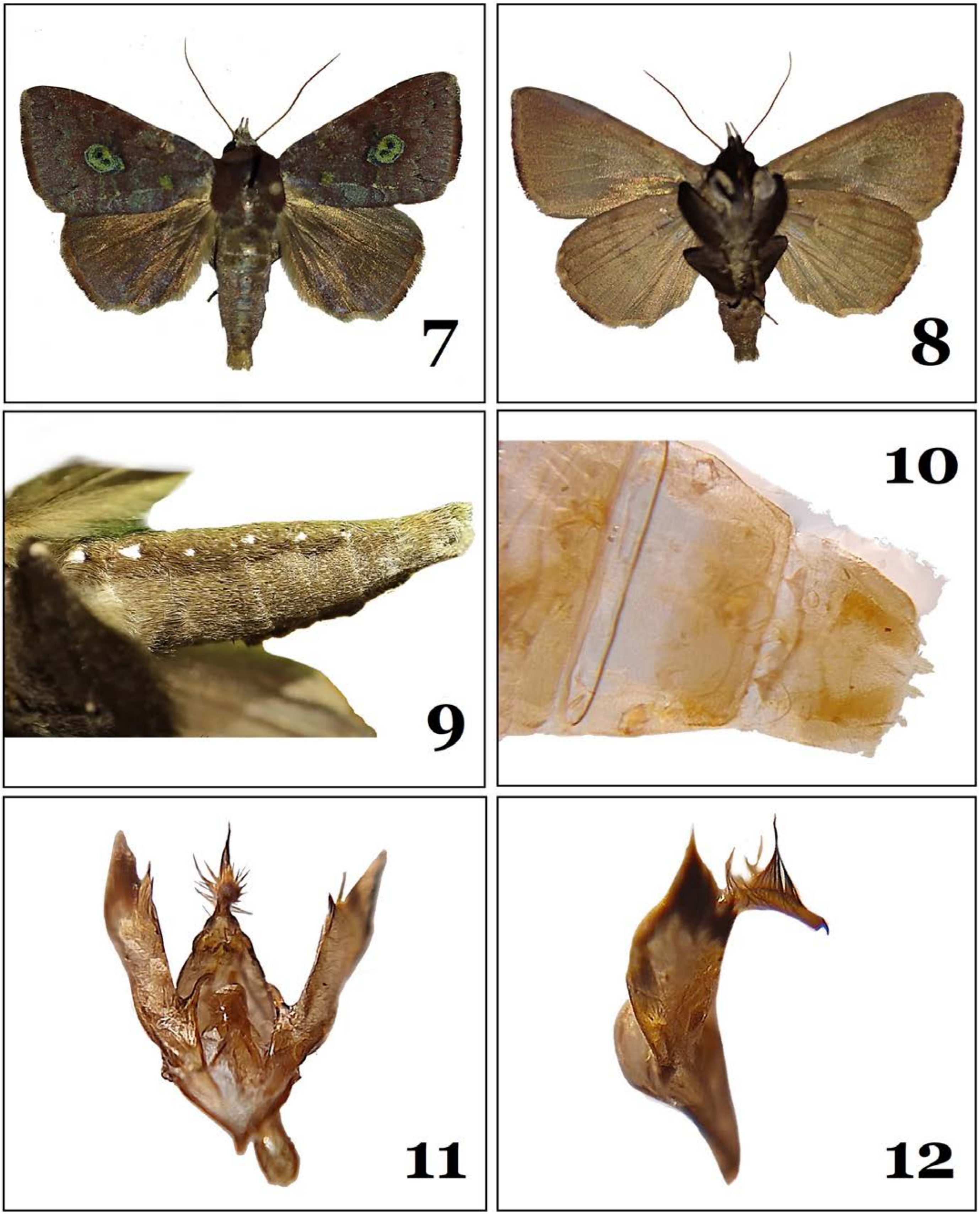
arranged in parallel-chain fashion resulting in ground color appearing as longitudinal and ring-like lines. Black spots and lines create a reticulated pattern on whole body. Orange marks present in various places: one at first abdominal segment, where orange ring-like band present, three orange blotches on each side of body with three sets of abdominal prolegs, eighth abdominal segment strongly humped dorsally, orange in color, two more orange bands present, one before hump and another one after hump. All orange marks spotted with black rectangles and circular spots.

Pupa (Figs. 2-5). Pupa 24 mm in length, black with a slight shiny bluish tinge, but lacking powdery bloom. Fourth to sixth abdominal segments with dark orange bands, each band situated on lower part of segment before joint with next segment. Last abdominal segment with cremaster, wrinkled on tip and cremaster having several curved hook-like spines of two sizes, some larger than others.

Adult (Figs. 6-8). Adult 45 mm in wingspan, deep caramel brown or chocolate. Head gray, thorax and abdomen dark brown, latter with white spots laterally on each segment (Fig. 9). White spots larger and triangular in proximal segments of abdomen. Antennae reddish-brown and minutely ciliated. Labial palpi black with third segment grayish white, proboscis (Fig. 16) chocolate-colored, relatively short, 7 mm in length. Legs (Figs. 13-15) darker, smoky black with a grayish tinge, all legs with grayish-white 'hairy' femur. Fore-tibiae covered with easily noticeable dense 'hairs' of whitish-gray color, mid-tibiae with one pair of spurs of unequal sizes (outer one shorter), hind-tibiae with two pairs of spurs, each pair consists of two unequal-sized spurs (outer ones shorter). Spurs and tarsi of all legs gray in some areas. Forewings triangular with rounded tornus, slightly irrorated with gray, especially on outer margin, wings with indistinct subbasal, antemedial, medial, postmedial, and submarginal crenulate pale lines. Antemedial line with a pale green circular patch on it below discal cell. A complex marking present on postmedial line at lower angle of discal cell, consisting of two black spots enclosed in a large green reniform ocellus emarginated with dark color anteriorly. Area before ocellus pale green and darker with part of adjacent line pale green and with a dark border giving a crescent-shaped impression. Submarginal line having a series of black specks. Wing veins clearly visible because of being whitish near inner margin and darker in rest of wing. Hindwings duller brown with tornus slightly truncate. Cilia of both wings chocolate-dark brown. underside of both wings dark brown with chocolate-colored fringe leaving apex and tornus. Trace of a dark medial band on underside of hindwing with a pale lunulate marking next to discal cell.

Male abdominal eighth segment with shallow and widely spaced apodemes on tergum. Genitalia (Figs. 11-12) with uncus curved, hook-like, and uncus-tip of 'ball and claw' type with a finger-like scaphium. Saccus ends in a finger-like projection having a blunt and rounded tip. Juxta with inverted 'Y' shape. Valvae rather paddle-like with a moderate-sized and moderately curved harpe on sacculus. Aedeagus elongated with small, globular vesica.

Hostplant: *Elaeis guineensis* Jacq. (Arecaceae) is the known larval host plant for *A. renosa* from West Malaysia (Yunus & Ho, 1980; Holloway, 2005; Robinson *et al.*, 2010). Apart from this, there is no other report of the life history or host plant of this species. In the present study, the caterpillars from both the



Figures 7-12. *Anereuthina renosa*. **7.** Adult male in dorsal view; **8.** Adult male in ventral view; **9.** Abdomen in lateral (showing white spots); **10.** Distal abdominal segments **11.** Male genitalia (with aedeagus); **12.** Male genitalia in lateral view.

Figures 13-16. *Anereuthina renosa*. **13-14.** Hindleg; **15.** Midleg; **16.** Proboscis.

study areas were found to feed on the leaves of *Terminalia* sp. (Combretaceae). Pupation also took place inside the leaf shelter on the same plant as discussed above. Thus, we report a new host plant for *A. renosa*.

Distribution: *Anereuthina renosa* was described from Java (type locality). The distributional ranges given by Hampson (1894) and Holloway (2005) are Sundaland, Philippines, and Myanmar. The species has not yet been formally reported from India, but there are two observations of this species from Meghalaya (Siju Eco Camp, South Garo Hills District) and Andaman Islands (Haddo, Port Blair, South Andaman District) on the Moths of India website (Anonymous, 2022). The present study reports this species for the first time from Bangladesh (Chittagong and Pirojpur).

DISCUSSION AND CONCLUSION

Reporting of *Terminalia* sp. as a new host plant indicates that *A. renosa* is not exclusively a palm-feeder; possibly, in different geographic locations, the species may be adapted to different host-plants, but much more data are obviously needed. These host-plant relationships, along with the ecology and evolution of this species, focusing on features such as the noticeably short proboscis, may be topics of future study. We suggest that the species has a wider distribution than currently appreciated, and that populations from different geographical areas need to be studied both at a morphological as well as at a molecular level.

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Synopsis of *Athis thysanete* (Dyar, 1912) (Castniidae: Castniinae) populations, courtship behavior and other observations on its biology

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Abstract: *Athis thysanete* (Dyar, 1912) is one of the Mexican endemic species of Castniidae distributed in the Tehuacán-Cuicatlán Valley. Based on collected material and field studies carried out in recent years, biological aspects and distribution of the species are clarified, and previously unknown bionomic details are provided. The species is recorded for the first time in the state of Oaxaca. Its intrapopulation variability and the phenotypic variation between the Puebla and Oaxaca populations are analyzed.

Key words: bionomics, endemism, Lepidoptera, Mexico, Oaxaca, Puebla, Tehuacán-Cuicatlán Valley, *Tillandsia*, variability.

Resumen: *Athis thysanete* (Dyar, 1912) es una de las especies de Castniidae endémicas de México que se distribuye en el Valle de Tehuacán-Cuicatlán. A partir de la obtención de material y estudios de campo realizados en los últimos años, se aclaran aspectos biológicos de la especie junto con su distribución y se proporcionan detalles bionómicos previamente desconocidos. Se registra la especie por primera vez en el estado de Oaxaca. De igual manera, se analiza su variabilidad intrapoblacional y variación fenotípica entre las poblaciones de Puebla y Oaxaca.

Palabras clave: aspectos bionómicos, endemismo, Lepidoptera, México, Oaxaca, Puebla, *Tillandsia*, Valle de Tehuacán-Cuicatlán, variabilidad.

INTRODUCTION

Castniidae is a pantropical family with records in the Malayan Peninsula, Australia and in the American continent (Miller, 2000; González & Hernández-Baz, 2012). The majority of species are found in the Americas, and are distributed from Mexico to Argentina, including the Caribbean (Miller, 1986; González & Cock, 2004; López-Godínez & Porion, 2012; García-Díaz *et al.*, 2020). Despite being a family that is poorly represented in entomological collections worldwide (Vinciguerra *et al.*, 2011; Moraes & Duarte, 2014; Worthy *et al.*, 2017; González & Domagała, 2019), interest in Castniidae on the part of Mexican researchers and collectors has increased considerably in the last two decades (García-Díaz *et al.*, 2019; García-Díaz & Turrent-Carriles, 2022). Following Vinciguerra *et al.* (2011), López-Godínez & Porion (2012), Moraes & Duarte (2014), Worthy *et al.* (2019) and González *et al.* (2021), *Athis* Hübner, [1819] is the most speciose genus within the Neotropical Castniidae, comprising 17 species of which seven are distributed in Mexico. The descriptions of *Athis pirrelloi* Vinciguerra, 2011 and *A. jaliscana* López-Godínez & Porion, 2012, as well as the re-establishment of *A. miastagma* (Dyar, 1925) as a valid species, have increased the number of known species in the genus. To date, there are eight known castniid species endemic to Mexico. Within the Gulf slope only three species are endemic to the country. Among them is *Athis thysanete* (Dyar, 1912), which is regarded as one of the 'rarest' and least known members of the genus (De la Maza-Elvira, 2001; Vinciguerra, 2011; Vinciguerra & González, 2011; Vinciguerra *et al.*, 2011). The species was described by Harrison Gray Dyar based on a female collected in June 1910 by Roberto Müller (Dyar, 1912), who was the first to collect and carry out field studies in the Tehuacán Valley, Puebla, Mexico (Hoffmann, 1932; De la Maza-Elvira *et al.*, 2017; García-Díaz *et al.*, 2021).

In the past few years I have been able to study the habits of *A. thysanete* in the vicinity of Tehuacán, specifically in the La Lobera area, located northeast of the city. Observations have also been made in Santiago Miahuatlán, Puebla, and in Puerto Mixteco, Tepelmeme Villa de Morelos municipality, Oaxaca. Males as well as females were observed, but only once was a copulation witnessed. On two occasions females were observed ovipositing on their host plant. The present work is based not only on recent observations but on prior knowledge from consulted collectors and a revision of numerous specimens and appropriate references.

MATERIALS AND METHODS

For ten years, between the months of May and August, weekly or fortnightly excursions were made with the purpose of studying the habits and behavior of *A. thysanete* in La Lobera, Tehuacán, Puebla. On two occasions, sites within the municipality of Tepelmeme Villa de Morelos, Oaxaca, were visited. During May 2021, a small population of the species was discovered in Santiago Miahuatlán, Puebla.

To examine specimens of the species, the following collections, both institutional and private, were consulted: Private collection of José de Jesús García-Díaz, Tehuacán, Puebla, Mexico (JJGD); Private collection of the Haghenbeck Family, Tehuacán, Puebla, Mexico (CFH); Private collection of the De la Maza Family, Mexico City, Mexico (CDM); Private collection of Bernardo López-Godínez, Guadalajara, Mexico (BLG); Private collection of the Turrent Family, Mexico City, Mexico (CFT); Private collection of the Villarreal Family, Oaxaca, Oaxaca, Mexico (CFV); Private collection of Robert Worthy, Caterham, Surrey, U.K. (RW); Private collection of Dirk Casteleyn, Brugge, West Flanders, Belgium (DC); Private collection of Daniel J. Curoe, Mexico City, Mexico (DJCC); Colección Entomológica del Instituto de Biología de la Universidad Nacional Autónoma de México, Mexico City, Mexico (IBUNAM); Museo de Historia Natural de la Ciudad de México, Mexico City, Mexico (MHNCM); Colección Entomológica de la Facultad de Ciencias Agronómicas de la Universidad Autónoma de Chiapas, Villaflores, Chiapas, Mexico (UNACH); Yale Peabody Museum of Natural History, New Haven, USA (YPM); Museum für Naturkunde, Berlin, Germany (ex-ZMHB: Zoologisches Museum der Humboldt Universität zu Berlin, Germany) (MfNB); American Museum of Natural History, New York, USA (AMNH); Natural History Museum, London, U.K. (NHMUK).

All photos, except for those of the predators of *Athis thysanete* illustrated in Fig. 2, were taken with a Fujifilm FinePix HS20EXR camera. The distribution map of *A. thysanete* was prepared using SimpleMappr (Shorthouse, 2010). Georeferencing of localities was done by means of Google Earth. Adobe Photoshop 2020 was used for editing figures.

RESULTS

Habitat. The Tehuacán-Cuicatlán Valley, located in the states of Puebla and Oaxaca (Fig. 1), corresponds to the southernmost, smallest, and most isolated arid region in North America (Rzedowski, 1973, 1978; Canseco-Márquez & Gutiérrez-Mayen, 2010; Rojas *et al.*, 2013; García-Díaz & Turrent-Carriles, 2020; García-Díaz *et al.*, 2020; García-Díaz *et al.*, 2021; González *et al.*, 2021). Predominant vegetation consists of xerophilous scrub in the northern part, and subdeciduous dry tropical forest in the south. The valley is of considerable biological interest as it harbors great numbers of endemic species of flora and fauna. Regarding vegetation, the predominant species belong to the families Cactaceae, Bromeliaceae, Asparagaceae and Fabaceae, among others. García-Díaz & Turrent-Carriles (2019a, 2019b, 2020) listed species present within the study area. The species of Bromeliaceae that are mainly distributed in the localities where *A. thysanete* has been observed are: *Hechtia aquamarina* I. Ramírez & C. F. Jiménez, *H. tehuacana* B. L. Rob., *H. roseana* L. B. Sm., *H. bracteata* Mez, *H. caulescens* López-Ferr., Espejo & Mart. C., *H. sphaeroblasta* B. L. Rob., *Tillandsia tehuacana* Ramírez & Carnevali, and *T. inopinata* Espejo, López-Ferrari & Till (López-Ferrari & Espejo-Serna, 2014).

Figure 1. Geographic distribution of *Athis thysanete* in the Tehuacán-Cuicatlán Valley.

Ecology and behavior. *Athis thysanete* coexists with *A. hechtiae* (Dyar, 1910) at various localities in the dry region of the valley between 1200 and 2000 masl and with an abundance of Bromeliaceae, mainly in the genera *Hechtia* Klotzsch, 1835 and *Tillandsia* L., 1753 (González *et al.*, 2021). In two localities it is sympatric with *Escalantiana chelone mendozai* García-Díaz & Turrent-Carriles, 2022. Records for *A. thysanete* range from mid-May to early August, depending on the beginning and duration of the rainy season as well as the population's locality, since each locality has particular environmental conditions (Table 1). Unlike *A. hechtiae*, it often flies in ravines and small canyons, where its host plant, *Tillandsia inopinata* Espejo, López-Ferrari & Till (Fig. 2C), is found mainly on cliff walls or medium-sized to large trees (3-5 m).

Generally, males eclose 10-15 days before females. Males and females begin to fly between 10:30-11:00 on sunny days with temperatures between 20-25 °C, and between 11:00-12:00 on cloudy days with temperatures between 16-20 °C. At all times males are more frequently observed than females, especially during the first hours of flight activity, between 10:30-12:00. As the temperature increases (26-35 °C, between 12:30-13:30), the number of individuals increases and between 4 and 7 males can be observed in a ravine at the same time; these become more active at higher temperatures. On two occasions males were observed during light drizzle, yet no changes in their daily habits were observed. Neither males nor females fly during rain. Unlike *A. hechtiae*, females of *A. thysanete* are less frequently observed and are much scarcer.

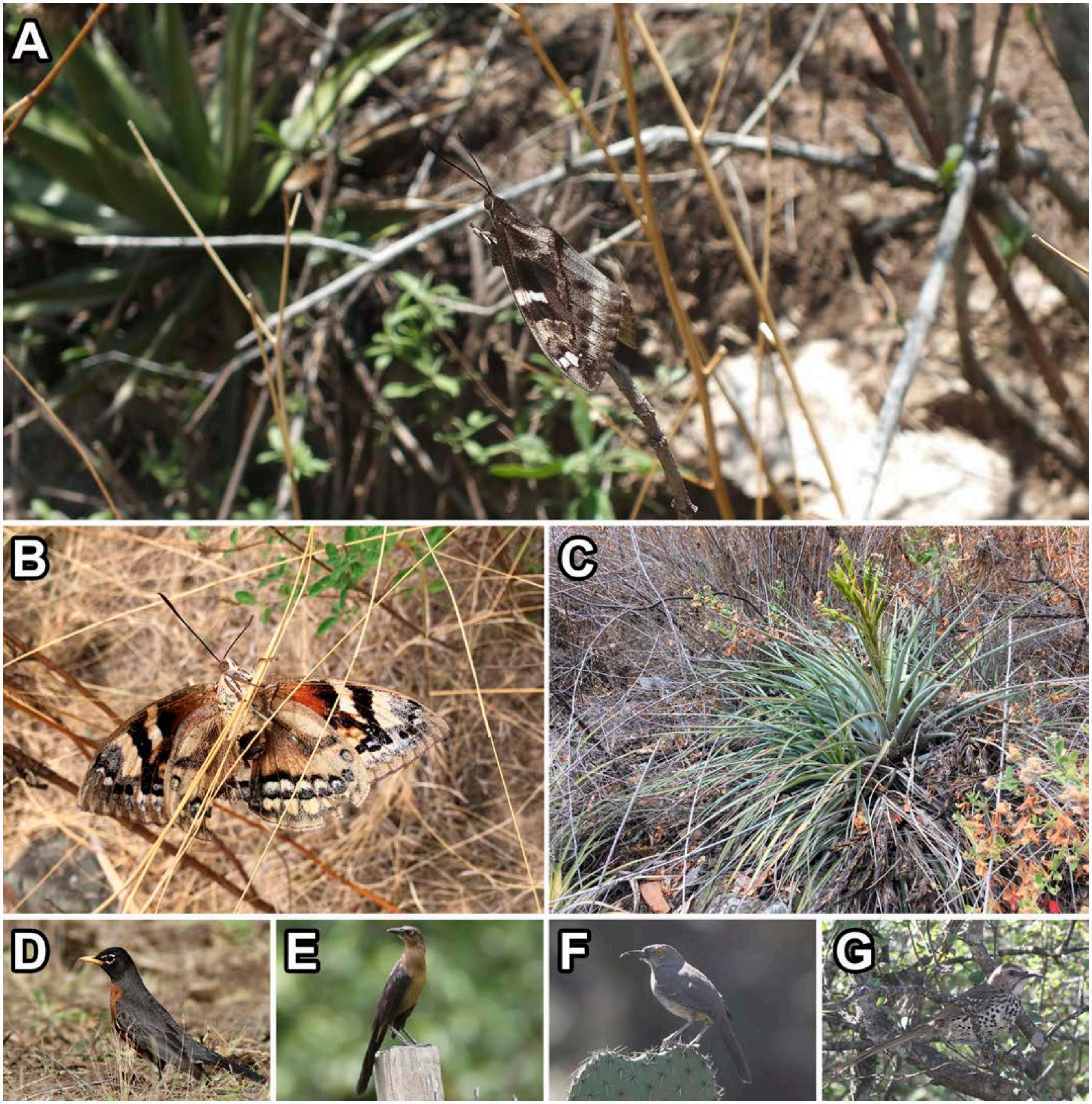

Figure 2. A) Lateral view of a male *Athis thysanete* camouflaged against its surroundings (La Lobera, Tehuacán, Puebla, 23-V-2021); B) male *A. thysanete* without abdomen, after bird attack (La Lobera, Tehuacán, Puebla, 02-VI-2019); C) *Tillandsia inopinata*, host plant of the species (La Lobera, Tehuacán, Puebla, 01-II-2020); D) *Turdus migratorius phillipsi*, predator of *A. thysanete* (Centro Recreativo El Conejo, Perote, Veracruz, 03-IV-2020, photograph: Amy E. McAndrews); E) *Quiscalus mexicanus mexicanus*, predator of *A. thysanete* (El Triunfo, Ángel Albino Corzo, Chiapas, 01-V-2018, photograph: Amy E. McAndrews); F) *Toxostoma curvirostre curvirostre*, predator of *A. thysanete* (Laguna Alchichica, Tepeyahualco, Puebla, 23-XI-2019, photograph: Amy E. McAndrews); G) *Toxostoma ocellatum villai*, predator of *A. thysanete* (Azumbilla, Nicolas Bravo, Puebla, 10-VIII-2014, photograph: Amy E. McAndrews).

Males fly rapidly (though slower than *A. hechtiae*) in an erratic, up-and-down zigzag pattern, down to a height between 1.5 and 3.5 m above ground level. Females exhibit a similar flight pattern, though slower and heavier. They often fly in the middle of a ravine, in search of a male to copulate with. Similarly, they fly up to 5 m high with the purpose of finding a *Tillandsia* on which to oviposit. Males perch like other *Athis* species in Mexico, that is, with forewings covering most the hindwings, in a stegopterous position (Miller, 1986; Ríos & González, 2011; Vinciguerra *et al.*, 2011; García-Díaz *et al.*, 2020; González *et al.*, 2021) (Figs. 2A, 3). They tend to perch on dry twigs or on shrubs with dry flowers; their cryptic

Table 1. Comparison of climatological data between Tehuacán (Station No. 21083) and Tepelmeme Villa de Morelos (Station No. 20157). Information obtained and calculated from CONAGUA (2021). Annual averages, monthly maximums and minimums are in bold.

Month	A) Mean Monthly Temperature (°C)			B) Mean Monthly Precipitation (mm)		
	Tehuacán	Tepelmeme	Difference	Tehuacán	Tepelmeme	Difference
January	**14.4**	12.9	**1.5**	6.2	3.1	3.1
February	16.0	13.9	2.1	5.6	**2.8**	2.8
March	18.5	16.1	2.4	9.3	9.3	**0.0**
April	20.5	17.7	2.8	21.0	27.0	6.0
May	**21.2**	**18.0**	**3.2**	58.9	68.2	9.3
June	20.5	17.6	2.9	**105.0**	**111.0**	6.0
July	19.0	16.0	2.8	65.1	58.9	6.2
August	19.4	16.6	2.8	71.3	55.8	**15.5**
September	19.3	16.5	2.8	87.0	90.0	3.0
October	17.8	14.9	2.9	31.0	34.1	3.1
November	16.0	13.2	2.8	9.0	6.0	3.0
December	15.0	**12.5**	2.5	**3.1**	6.2	3.1
Annual Average	**18.1**	**15.5**	**2.6**	**472.5**	**472.4**	**0.1**

coloration blends in with the environment at that time of the year (Fig. 2A). Usually, males end their flights by landing on the upper half of a dry twig (Fig. 3). Following this, they walk slowly toward the tip, with the middle pair of legs moving in a rapid 'shuffling' manner. After reaching the tip, they remain there until they fly off again. Just after landing, or when they perceive a sudden movement nearby, males adopt an alert position (Fig. 3B); after perching for more than a minute, they change to a resting position (Fig. 3A). Males are territorial and get startled if another male flies close to the twig on which they are perching, or if a predator or small bird is close by. This species, unlike *A. hechtiae*, is not easily startled by small butterflies flying by. During the day, males often fight with other territorial butterfly species such as *Achalarus tehuacana* (Draudt, 1922) and *Codatractus arizonensis* (Skinner, 1905) (Hesperiidae) by chasing them along the length of the ravine in order to expel them from their perching zones. Males are frequently observed fighting for possession of a particular twig or for part of the ravine. When this occurs, they will fly together up to 15-20 m high. Once the fight is over, the winning male remains in its zone while the loser flies away until it disappears. Sometimes, losing males return and resume the fight, attempting to seize the desired perching zone. This can repeat itself several times during the day. On three occasions males were observed attacking people. When this occurs, they whirl intensely around the victim, hitting the person's body with its wings.

Sometimes, while 10-20 American barn swallows (*Hirundo rustica erythrogaster* Boddaert, 1783 (Passeriformes)) are in a flock in a ravine, close to where a male *A. thysanete* is perched, the castniid will often chase them to defend its territory, flying several meters towards the swallows and attempting to scare them away. The castniid then returns to its perch, and thereupon resumes the confrontation. Pursuing flights can last several minutes and can take place up to 20 m from the ground. This has been observed most frequently with large male *A. thysanete* individuals. These small swallows, measuring 13-17 cm in length, were never seen attacking male *A. thysanete* and do not seem to be predators of this moth species.

Their main predators seem to be larger birds reaching 30 cm in length, such as *Quiscalus mexicanus mexicanus* (Gmelin, 1788), *Toxostoma ocellatum villai* Phillips, 1986, *Toxostoma curvirostre curvirostre* (Swainson, 1827) and *Turdus migratorius phillipsi* Bangs, 1915 (Passeriformes) (Figs. 2D, 2E, 2F, 2G). On various occasions, individuals of those bird species have been observed preying on *A. thysanete* males while the latter were flying unguardedly along a ravine or engaged in a fight at great height, where they appear to be more vulnerable. Sometimes, the predatory birds catch male *A. thysanete* by the abdomen and even though some harmed moths managed to escape without their abdomen, they died shortly thereafter (Fig. 2B).

The only female that was observed perching behaved much like the males, however, it did not walk toward the tip of a dry twig with the middle legs moving in a rapid 'shuffling' manner but instead remained totally motionless. Two males flew close to the perching female but did not startle it. Following that, in the same area, one of the males chased the female and both were flying together in irregular trajectories where they suddenly changed height, going from 1 to 10 m up and down; they repeated the pattern several times for about five minutes until they finally perched on the twig where the female was originally and began to copulate. During copulation, the male remained on the lower part of the twig while the female was on the upper part. Their heads pointing in opposite directions, as seen in *A. hechtiae* (García-Díaz *et al.*, 2020). The copulation lasted about 10 minutes, until the male flew off while the female remained perching for a few more minutes. The two females that were observed ovipositing did so on the lower middle part of the host plants, which were 5 m off the ground. Apparently, they deposited only one egg per plant. Neither eggs, nor larvae, nor pupae of the species were observed. As far as I know, *Athis thysanete* adults have never been observed feeding on flowers, mud or decomposing fruits.

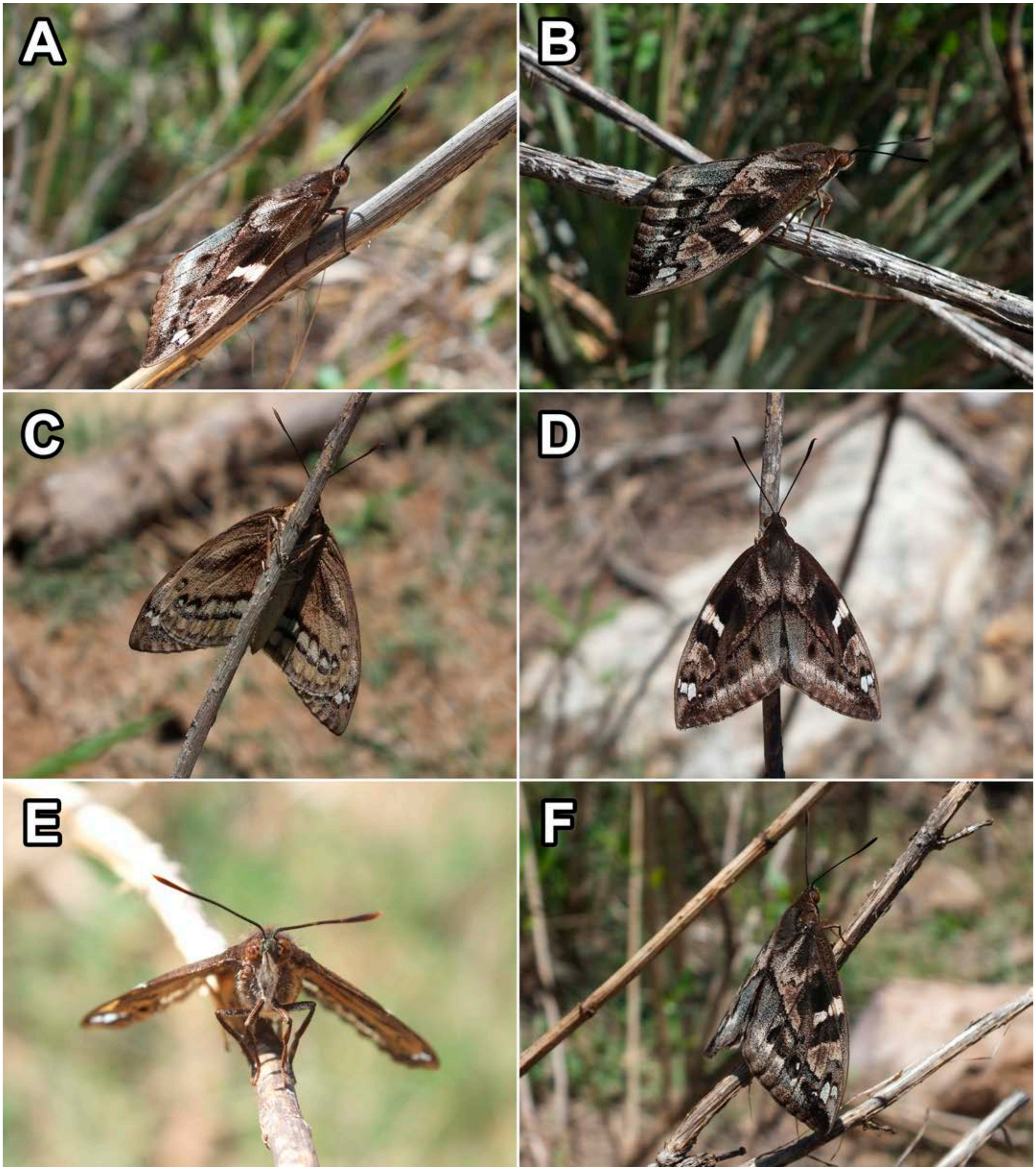

Figure 3. *Athis thysanete* males perching in stegopterous position in La Lobera, Tehuacán, Puebla, 23-V-2021. (A) In resting state, lateral view; (B) in alert state, lateral view; (C) ventral view; (D) dorsal view; (E) frontal view; (F) lateral view.

Material examined. As a result of the examination of various collections, a total of 107 specimens (95♂♂, 12♀♀) were recorded: **Oaxaca:** 2♂♂, 1♀, Tepelmeme Villa de Morelos, Arroyo El Aguacate, 21-VI-1997, *leg.* J. de la Maza E. (CDM); 2♂♂, Tepelmeme Villa de Morelos, Arroyo El Aguacate, 29-VI-1997, *leg.* J. de la Maza E. (CDM); 3♂♂, Tepelmeme Villa de Morelos, Arroyo El Aguacate, 20-VI-1998, *leg.* J. de la Maza E. (CDM); 1♂, Tepelmeme Villa de Morelos, Arroyo El Aguacate, 01-VII-1998, *leg.* J. de la Maza E. (CDM); 2♂♂, 1♀, Tepelmeme Villa de Morelos, Tepelmeme, 24-V-2016, *leg.* J. J. García D. (JJGD); 4♂♂, Tepelmeme Villa de Morelos, Tepelmeme, 24-V-2016, *leg.* J. J. García D. (BLG); 1♂, Tepelmeme Villa de Morelos, Tepelmeme, 05-VIII-2020, *leg.* J. P. Martínez Z. (CFT); 2♂♂, II-1979 (RW) [The date for these specimens does not coincide with typical collecting dates for the species, therefore their validity is doubtful]; **Puebla:** 1♂, Tehuacán, La Lobera, 21-V-2006, *leg.* F. G. Haghenbeck F. (CFH); 1♂, Tehuacán, La

Lobera, 10-VI-2006, *leg.* F. G. Haghenbeck F. (CFH); 4♂♂, Tehuacán, La Lobera, 20-V-2007, *leg.* F. G. Haghenbeck F. (CFH); 3♂♂, Tehuacán, La Lobera, 25-V-2007, *leg.* L. Haghenbeck C. (CFH); 2♂♂, Tehuacán, La Lobera, 25-VI-2007, *leg.* L. Haghenbeck C. (CFH); 1♂, Tehuacán, La Lobera, 30-V-2009, *leg.* F. G. Haghenbeck F. (CFH); 4♂♂, Tehuacán, La Lobera, 08-VI-2010, *leg.* L. Haghenbeck C. (CFH); 2♂♂, Tehuacán, La Lobera, 01-VII-2010, *leg.* F. G. Haghenbeck F. (CFH); 1♂, Tehuacán, La Lobera, 01-VIII-2010, *leg.* F. G. Haghenbeck F. (CFH); 2♂♂, Tehuacán, La Lobera, 05-VII-2011, *leg.* F. G. Haghenbeck F. (CFH); 2♂♂, Tehuacán, La Lobera, 30-V-2012, *leg.* L. Haghenbeck C. (CFH); 1♀, Tehuacán, La Lobera, 15-VI-2012, *leg.* L. Haghenbeck C. (CFH); 1♂, Tehuacán, La Lobera, 01-VI-2011, *leg.* F. G. Haghenbeck F. (BLG); 1♀, Tehuacán, La Lobera, 15-VI-2011, *leg.* J. J. García D. (JJGD); 1Tehuacán, La Lobera, 23-V-2012, *leg.* F. G. Haghenbeck F. (BLG); 1♂, Tehuacán, La Lobera, 26-V-2012, *leg.* F. G. Haghenbeck F. (BLG); 1♂, Tehuacán, La Lobera, 26-V-2013, *leg.* F. G. Haghenbeck F. (BLG); 1♂, Tehuacán, La Lobera, 25-V-2014, *leg.* J. J. García D. (JJGD); 1♀, Tehuacán, La Lobera, 22-V-2015, *leg.* J. J. García D. (JJGD); 3♂, 1♀, Tehuacán, La Lobera, 07-VI-2015, *leg.* J. J. García D. (JJGD); 1♀, Tehuacán, La Lobera, 10-VI-2015, *leg.* J. J. García D. (JJGD); 1♂, Tehuacán, La Lobera, 29-V-2016, *leg.* F. G. Haghenbeck F. (BLG); 1♀, Tehuacán, La Lobera, 01-VI-2016, *leg.* J. J. García D. (JJGD); 1♀, Tehuacán, La Lobera, 09-VI-2016, *leg.* J. J. García D. (JJGD); 1♂, Tehuacán, La Lobera, 15-VI-2016, *leg.* J. J. García D. (JJGD); 1♂, Tehuacán, La Lobera, 27-V-2017, *leg.* J. J. García D. (JJGD); 7♂♂, Tehuacán, La Lobera, 07-VI-2017, *leg.* J. J. García D. (JJGD); 1♂, Tehuacán, La Lobera, 10-VI-2017, *leg.* J. J. García D. (JJGD); 4♂♂, Tehuacán, La Lobera, 14-VI-2017, *leg.* J. J. García D. (JJGD); 2♂♂, Tehuacán, La Lobera, 21-VI-2017, *leg.* J. J. García D. (JJGD); 2♂♂, Tehuacán, 20-V-2010 (DC); 1♂, Tehuacán, 18-V-2010 (DC); 1♀, Tehuacán, VI-2012 (DC); 2♂♂, Tehuacán, La Lobera, 03-VI-2013, *leg.* J. J. García D. (CFV); 2♂♂, Santiago Miahuatlán, Santiago Miahuatlán, 30-V-2021, *leg.* J. J. García D. (JJGD); 1♂, Tehuacán, VI-2013 (RW); 2♂♂, Tehuacán, 29-V-2011, *leg.* P. Rodríguez (RW); 1♂, Tehuacán, 1800 m, 20-V-2010, *leg.* B. López (RW); 1♂, 1♀, Tehuacán, 1800 m, VIII-2010, *leg.* B. López (RW); 1♀, Tehuacán, 1700 m, 20-V-2015 (RW); 3♂♂, Tehuacán, La Lobera, 20-V-2016, *leg.* A. Turrent C. (CFT); 1♂, Tehuacán, La Lobera, 21-V-2016, *leg.* A. Turrent C. (CFT); 1♂, Tehuacán, La Lobera, 17-VII-2016, *leg.* J. J. García D. (CFT); 1♂, Tehuacán, La Lobera, 22-V-2016, *leg.* J. J. García D. (CFT); 1♂, Tehuacán, La Lobera, VI-2015, *leg.* L. Haghenbeck C. (CFT); 1♂, Tehuacán, 30-V-2009, *leg.* Francisco Haghenbeck (IBUNAM); 2♂♂, Tehuacán, La Lobera, VI-2015, *leg.* L. Haghenbeck C. (CDM); 1♂, No. 2712, Tehuacán, VI, *leg.* R. Müller (MHNCM); 1♂, No. 2713, Tehuacán, VI, *leg.* R. Müller (MHNCM); **Veracruz:** 1♂, Orizaba, Río Blanco, VI-2016, *leg.* B. López (DC) [Bernardo López (pers. comm.) points out that this *A. thysanete* specimen was, without doubt, erroneously labeled 'Río Blanco, Orizaba, Veracruz', since it was collected in Tehuacán]; 1♂, Type, No. 478, 20.31, Coatepec, Joicey Bequest. Brit. Mus. 1934-120 (NHMUK) [Vinciguerra *et al.* (2011) indicate that this specimen corresponds to a female; however, after examining the specimen it can be seen that it is in fact a male (Robert Worthy, pers. comm.). Moreover, the specimen's locality is doubtful, since the host plant of *A. thysanete* is not present in that ecosystem, which is completely different to that of the Tehuacán-Cuicatlán Valley; see discussion below].

Variability. *Athis thysanete* is one of the most variable Mexican castniids; this is due to the presence of various colors on its wings, mainly in dorsal view (Fig. 4). Dorsally, the number and size of the black spots on the forewings' postdiscal region is variable. Their white, brown and gray tones, as well as the white subapical spots and the white costal patches vary in most specimens. On the hindwings, the length and width of the red discal band, as well as the size and number of yellow postdiscal spots and the yellow submarginal band are variable. Ventrally, on the forewings, the reddish coloration between the base and the discal region, as well as the gray, brown and cream tones vary in each specimen. The number and size of the white postdiscal and subapical spots is variable. On the hindwings, the base coloration, size and internal coloration of the postdiscal spots vary in each specimen. Vinciguerra *et al.* (2011) illustrate the dorsal variability of the Tehuacán, Puebla population.

This castniid species exhibits little sexual dimorphism. Concerning wing pattern, there are no exclusive characters that differentiate males from females. Nevertheless, females generally have a greater wingspan and a more rounded forewing apex; the abdomen is wider and more voluminous. In males, the base-apex distance varies between 3.0-5.1 cm. In females, the red band tends to be narrower.

Specimens from the known populations from studied localities in the states of Puebla (Tehuacán municipality: El Riego, La Lobera, San Diego Chalma and Santiago Miahuatlán municipality: Santiago Miahuatlán) and Oaxaca (Tepelmeme Villa de Morelos municipality: Arroyo El Aguacate, Puerto Mixteco, Tepelmeme) appear to show interpopulation variability. However, between the populations in both states, some differences can be observed between the population of La Lobera (Puebla) and that of Tepelmeme (Oaxaca), especially among males (Fig. 4), while the population from Arroyo El Aguacate, located between the above-mentioned localities, exhibits characteristics present in both localities. On the forewings (dorsal view), the specimens from Tepelmeme tend to exhibit more extensive and whiter areas than in the Tehuacán populations; while on the hindwings the reddish discal band and the submarginal band are wider; the postdiscal spots are smaller and tend to be white instead of yellow. Ventrally, the forewings of the Oaxaca specimens tend to have more reddish coloration; while on the hindwings, the postdiscal row of spots becomes progressively narrower toward the costa (Fig. 4).

DISCUSSION

Athis thysanete is scarce in collections worldwide (Vinciguerra *et al.*, 2011), and De la Maza-Elvira (2001) notes that until May 1997, fewer than 10 specimens were known. However, observations and collecting records of the species have increased considerably since then.

Vinciguerra *et al.* (2011) mention two records of *Athis thysanete* from outside the Tehuacán-Cuicatlán Valley, from the states of Michoacán (Coahuayana) and Veracruz (Coatepec). They correspond, respectively, to records in the former Tarcisio Escalante Collection (currently incorporated to the McGuire Center for Lepidoptera and Biodiversity, MGCL) and the NHMUK (Vinciguerra *et al.*, 2011). These represent the only known records for the species outside the states of Puebla and Oaxaca, which raises doubts about the veracity of their origins. Coatepec is a town with nearby cloud forests, located about 14 km from Xalapa, the capital of Veracruz, on the Gulf of Mexico slope. Coahuayana de Hidalgo is a city situated on the Pacific slope of Mexico, 6.5 km from the sea and close the Colima state border. These localities present unfavorable ecosystems for *Athis thysanete* in several respects: (1) they are in high humidity areas, lack xerophilous scrub vegetation and are not within the distribution area of *Tillandsia inopinata*, *A. thysanete*'s food plant, which is endemic to the Gulf of Mexico slope and broadly distributed in the states of Guanajuato, Hidalgo, Oaxaca, Puebla, Querétaro, San Luís Potosí and Tamaulipas (Espejo-Serna *et al.*, 2008; López-Ferrari & Espejo-Serna, 2014); (2) Coahuayana de Hidalgo is located at sea level on the Pacific coastal plain, near the Sierra Madre del Sur central subprovince, a region characterized by fauna that is endemic

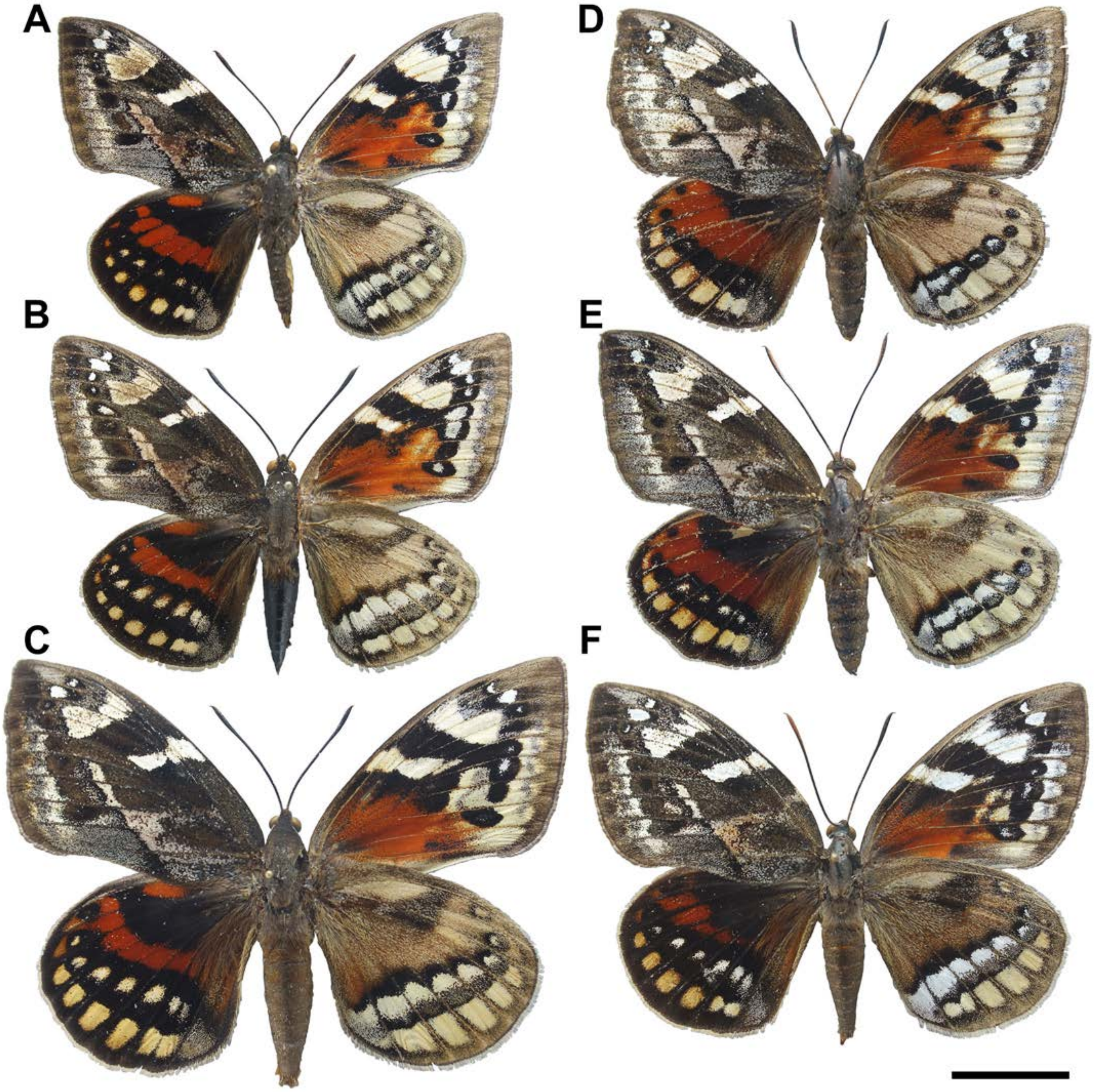

Figure 4. Dorsal and ventral comparison of *Athis thysanete* specimens from the states of Puebla (A-C) and Oaxaca (D-F). A) Male from Puebla, Tehuacán, La Lobera, 07-VI-2017, *leg.* J. J. García D. (JJGD); B) male from Puebla, Tehuacán, La Lobera, 10-VI-2017, *leg.* J. J. García D. (JJGD); C) female from Puebla, Tehuacán, La Lobera, 10-VI-2015, *leg.* J. J. García D. (JJGD); D) male from Oaxaca, Tepelmeme Villa de Morelos, Tepelmeme, 24-V-2016, *leg.* J. J. García D. (JJGD); E) male from Oaxaca, Tepelmeme Villa de Morelos, Tepelmeme, 24-V-2016, *leg.* J. J. García D. (JJGD); F) female from Oaxaca, Tepelmeme Villa de Morelos, Tepelmeme, 24-V-2016, *leg.* J. J. García D. (JJGD). Scale bar = 2cm.

to that slope (Morrone, 2017; Rocha-Méndez *et al.*, 2019); (3) in the Coatepec area, the temperatures are low for much of the year and the region is located between the boundaries of the Trans-Mexican Volcanic Belt and the Sierra Madre Oriental (Llorente-Bousquets *et al.*, 1986; Hernández-Baz, 1993); both regions support well defined fauna and flora (Luna-Vega *et al.*, 2016). These aspects might indicate that the locality records for those specimens are possibly erroneous. Additionally, it is difficult to formulate the hypothesis that those specimens were found at the aforementioned localities because high elevation mountain barriers stand between the two putative populations and the Tehuacán-Cuicatlán Valley. There is the possibility that those two specimens were collected in Oaxaca or Puebla and were erroneously placed with material from Michoacán and Veracruz, respectively. De la Maza-Elvira *et al.* (2017) point out that Tarcisio Escalante relied on collectors who often mixed material from several localities, a practice which has complicated various studies on the distribution of Mexican

Lepidoptera. Based on the above-mentioned statements, we should consider *A. thysanete* endemic to the Tehuacán-Cuicatlán Valley (Fig. 1).

Athis thysanete, *A. flavimaculata* and *A. inca* belong to the same complex of species (Miller 1972, 2000) and are allopatrically distributed in Mexico: *flavimaculata* on the Pacific slope, *inca* in the rainforests and cloud forests along the Gulf slope, and *thysanete* in the Tehuacán-Cuicatlán Valley. The isolation of *thysanete* in the xerophilous Tehuacán-Cuicatlán Valley was possibly caused by the formation of the Trans-Mexican Volcanic Belt, an event that partitioned the Oaxaquia microcontinent in two, thus separating the Tehuacán-Cuicatlán valley from Metztitlán (Centeno-García *et al.*, 2008; De la Maza-Elvira & De la Maza Elvira, 2019; González *et al.*, 2021; García-Díaz & Turrent-Carriles, 2022). I concur with Roberto de la Maza (pers. comm.) who hypothesizes that its isolation process possibly began in the late Miocene.

Vinciguerra *et al.* (2011) point out that *Yucca periculosa* Baker could be the host plant of *A. thysanete*, which seems to be doubtful because after ten years of field work, neither males nor females have been observed perching on the leaves of those plants. Luis Haghenbeck (pers. comm.) also indicates that in 30 years of expeditions in the Tehuacán-Cuicatlán Valley, he has never observed this castniid species perching on leaves of any *Yucca* species. Additionally, it is well known that Mexican *Athis* species are closely associated with Bromeliaceae (García-Díaz *et al.*, 2019; García-Díaz *et al.*, 2020; González *et al.*, 2021). According to López-Ferrari & Espejo-Serna (2014), *T. inopinata* is a Mexican endemic bromeliad with wide distribution north of the Trans-Mexican Volcanic Belt; nevertheless, south of the Trans-Mexican Volcanic Belt it has only been recorded within the Tehuacán-Cuicatlán Valley, in the states of Oaxaca and Puebla. The distribution of the host plant of *A. thysanete* supports the isolation of the castniid species in the xerophilous region south of the Trans-Mexican Volcanic Belt. Likewise, it is possible that *A. inca* has *T. inopinata* as a host plant in certain localities in Hidalgo, Querétaro, San Luis Potosí, or Tamaulipas.

The recent discovery of *A. thysanete* in Santiago-Miahuatlán could indicate that the species has more than one host plant, because *T. inopinata* has not been observed in that locality and was not recorded by López-Ferrari & Espejo-Serna (2014). However, more field work is required to confirm this hypothesis.

Athis thysanete has been observed at 1650 masl in the Tehuacán municipality and at 2000 masl in the Tepelmeme Villa de Morelos municipality. During every month of the year, the monthly mean temperature is higher in Tehuacán; the average annual temperature is 2.6 °C higher than in Tepelmeme (Table 1). On the other hand, the annual average precipitation is similar in both localities, though in Oaxaca precipitation peaks during April, May and June (Table 1). This explains the delay in the last eclosions of the species in Tepelmeme, which can be observed up until the first days of August.

In the eastern part of the Tepelmeme region there is oak forest; consequently, it is inhabited by some Lepidoptera species that have not been observed in other parts of the valley. These ecosystem differences between this place and other localities in the valley, to a large extent, might explain part of the phenotypic variation seen between *Athis thysanete* specimens from the two regions within the Tehuacán-Cuicatlán Valley (Fig. 4).

Athis hechtiae as well as *A. thysanete* are Tehuacán-Cuicatlán Valley endemic species, with highly local and restricted distributions. For this reason, they are more vulnerable than other lepidoptera within the region. Their ecosystems in the Tehuacán-Cuicatlán Biosphere Reserve (RBTC) and the Cerro Colorado Protected Natural Area (ANPCC) must continue to be protected.

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On the Pterophoridae (Lepidoptera) of Colombia

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Abstract: Twelve species of Pterophoridae were collected in the Department of Cundinamarca, Colombia during three days in July 2018. From this sample, the new species *Postplatyptilia chicaquensis* Landry & Gielis, **sp. n.** and *Hellinsia danielae* Landry & Gielis, **sp. n.** are described and five other species are reported as new for Colombia. Adults of all 12 species are illustrated, as well as the genitalia of the sex(es) collected. Additionally, a list of all of the 53 species reported from Colombia is presented.

Key words: *Adaina*, *Exelastis*, *Lioptilodes*, *Oidaematophorus*, plume-moths, Pterophoroidea.

Resumen: En el departamento de Cundinamarca, Colombia, se hicieron recolectas de la familia Pterophoridae durante tres días en julio del 2018. Se recolectaron 12 especies de las cuáles cinco son reportadas por primera vez para el país. Así mismo se describen las nuevas especies *Postplatyptilia chicaquensis* Landry & Gielis, **sp. n.** y *Hellinsia danielae* Landry & Gielis, **sp. n.** Los adultos son ilustrados, así como las genitalias de los sexos recolectados. Adicionalmente, se presenta una lista de todas las 53 especies reportadas para Colombia.

Palabras claves: *Adaina*, *Exelastis*, *Lioptilodes*, *Oidaematophorus*, polillas plumas, Pterophoroidea.

INTRODUCTION

Pterophoridae, or plume-moths, are small to medium-sized gracile moths found on all continents except Antarctica. The world fauna of Pterophoridae comprises 1554 species, that of the Neotropical region 467 species, and that of Colombia 46 species (Hobern, 2022 and pers. comm.). The Pterophoridae fauna of Colombia has never been treated specifically in a taxonomic or faunistic publication. Publications with species records and descriptions of Pterophoridae of Colombia had a broader geographical scope, from either a few countries (Gielis, 2014) to a continental scale (Gielis, 2006, 2011) to an even larger scale (Zeller, 1877). The Andean mountains provide a unique continuum of great ecological variation in temperature, humidity, altitude, and precipitation, resulting in numerous ecological niches that support the development of local species. However, small moths are poorly sampled in the Neotropical region and, consequently, the true diversity and range of the species are mostly unknown.

Thanks to Helber Adrian Arévalo Maldonado and Prof. Francisco Javier Serna Cardona of the University of Colombia, the first author had the opportunity to collect moth specimens in Colombia in 2018. Twenty-six specimens of Pterophoridae were collected at light in a private nature park a few kilometers away from Bogotá, the capital of the country. Here we illustrate with photos the adults and genitalia of the 12 species collected, including a new species in the genus *Postplatyptilia* Gielis and another in the genus *Hellinsia* Tutt.

MATERIAL AND METHODS

The specimens of Pterophoridae discussed here were collected at light with the use of a LepiLED (Brehm, 2017) placed inside a 2-meter-high tower of white gauze. The collecting locality, chosen for convenience and quality of its variety of habitats, is Parque Natural Chicaque (www.chicaque.com), San Antonio de Tequendama, department of Cundinamarca. Most specimens were collected around the accommodation structure of the park known as the ‘Refugio’, located at 2150 m and 04°36'53"N, 74°18'40"W. In addition, one specimen came to light at 2250 m in the park’s oak (*Quercus humboldtii* Bonpland) forest (04°36’22”N, 74°18’17”W). Also collecting with B. Landry were H. Arévalo and Jurate De Prins.

The specimens collected are mostly deposited in the insect collection of the Universidad Nacional Agronomía Bogotá, Museo Entomológico de la Facultad de Ciencias Agrarias de la Universidad Nacional de Colombia (UNAB), except for a few deposited in the Muséum d’histoire naturelle, Geneva, Switzerland (MHNG).

The online catalogue maintained by Hobern (2022) was used to obtain lists of species known for each of the genera found at Chicaque and to find out which species were already known from Colombia. Based on the world catalogue of Gielis (2003), the Holbern catalogue continues to be fed by the identification database and distribution data of C. Gielis. The generic classification adopted here and order of species presented below reflect those of Gielis (2006, 2011).

The data on the labels of the holotypes are recorded verbatim, with missing information in square brackets and vertical bars representing changes of lines. The term wingspan is abbreviated ‘ws’ in the figure legends. Morphological terms follow Gielis (2006, 2011).

RESULTS

Postplatyptilia parana Gielis, 1996

Postplatyptilia parana Gielis, 1996: 92.
Figs. 1A, 3a, b

Type locality. Brazil, Paraná, Castro.

Distribution. Argentina (Jujuy), Brazil (Paraná, Rio de Janeiro; Santa Catarina) and Costa Rica (Cartago) (Gielis, 2006). This species is reported from Colombia for the first time.

Remarks. One male specimen was collected at 2250 m in Chicaque’s oak forest. The female genitalia are illustrated by Gielis (1996, 2006).

Postplatyptilia chicaquensis Landry & Gielis, **sp. nov.**

Figs. 1B, 1C, 3c, d, 5a

Description. MALE (n=3) (Figs. 1B, 1C). Head blackish brown on vertex and above slightly produced fronto-clypeus medially; paler brown laterally above on fronto-clypeus; paler, grayish white between antennae and below fronto-clypeus. Antennae with alternating blackish brown and grayish white rows of scales. Labial palpus porrect, with second palpomere reaching tip of fronto-clypeus, without scale tuft, with palpomere I dark blackish brown laterally, white dorsally and ventrally, palpomere II blackish brown laterally with white at apex, palpomere III blackish brown at base, pale chestnut brown on distal half. Thorax coloration dorsally (Fig. 1B, 1C) mostly brown of various shades, ochraceous on tegulae and black on metathorax lined with white apically along lateral margins. Forewing 7.0-8.0 mm in length, wingspan 15.0-17.5 mm (holotype: 17.5 mm); coloration and markings similar to congeners with blackish-brown costal triangle, subterminal thin cream lines across lobes, and two dark brown scale teeth along anal margin. Hindwing uniformly blackish brown except for small medial white patch on third lobe; third lobe fringes interspersed with dark spatulate scales including apical scale tooth on anal margin, white at apex. Foreleg coxa and femur blackish brown with few dispersed white scales; tibia blackish brown with longitudinal white stripes and spots of variable sizes; tarsomere I pale golden-white with long longitudinal blackish brown stripes dorsally and shorter one laterally on distal half; tarsomere II and III pale golden-white with longitudinal blackish brown stripe dorsally, that on tarsomere III shorter; tarsomeres IV and V pale golden-white. Midleg coxa white with blackish brown mostly at base and apex; femur mostly blackish brown with few white scales mostly at apex; tibia blackish brown with pair of white stripes interrupted at submedian and apical scale tufts, tibial spurs blackish brown and white, reaching just beyond middle of tarsomere I; tarsomere I and II striped blackish brown and pale golden-white; tarsomeres III and IV mostly pale golden-white with few blackish brown scales dorsally, more so on tarsomere III; tarsomere V uniformly pale golden-white. Hindleg coxa not visible; femur blackish brown with small white spots; tibia with four alternating pale golden-white and blackish brown areas, darker blackish brown at base of spurs, with few white scales apically, spurs blackish brown at their base and apex, pale golden-white medially, with median tibial spurs slightly longer, about as long as second tarsomere; tarsomere I blackish brown at base and beyond 1/3, pale golden-white in between; tarsomere II mostly pale golden-white, blackish brown at tip; tarsomeres III-V missing on holotype, III and IV as 2nd, V entirely pale golden-white. Abdomen dorsally (Fig. 1B, 1C) with mixed blackish brown, paler brown and white scales, also with blackish brown spots near middle and on other segments; ventrally on basal half mostly dark blackish brown, with few white scales, on distal half paler, grayish brown, with lateral white spots on apical margins.

Variation. One of the males collected is much darker than the others, especially on the forewing, with markings therefore less contrasted (Fig. 1C).

Male genitalia (Figs. 3c, d, n=2). Uncus straight, positioned ventrally on tegumen slightly beyond middle of tegumen along mid length, barely reaching apical margin of tegumen, of medium girth, slightly narrowing from base to apex, with few setae of medium length. Tegumen moderate in size, apically truncate. Valva rather wide, distinctly enlarged at 2/3, with broadly rounded margin dorsally; sacculus simple, extended to mid length of valva, with thick setae on basal half along dorsal margin; cucullus with ventral margin incorporating strong longitudinal sclerotized bar; apex shortly pointed. Saccus triangular, apically bifid with narrow cleft almost reaching mid length, not clearly visible on image because of overlap with juxta/anellus complex, with pointed arms of medium width. Juxta about as long as wide, with converging sclerotized bars laterally, more thickly sclerotized at rounded base of anellus arms; anellus arms of medium length, narrow along whole length, with few short setae. Phallus of medium girth; shaft slightly enlarged dorsally at base and at 2/3; coecum penis short, straight; vesica spiculose.

FEMALE (n=1). As male except for slightly longer labial palpus. Wingspan 18.0 mm; forewing length: 9.0 mm.

Female genitalia (Fig. 5a, n=1). Papillae anales short, weakly sclerotized, with few short to medium long setae. Apophyses posteriores thin, long, reaching anterior margin of tergum VIII. Tergum VIII with lateral oval windows medially at lateral margins. Tergum VII not modified. Sternite VII about one third longer than tergum VII, medially shortly concave. Lamella postvaginalis about half as wide as tergum VIII, laterally joining thin, pointed apophyses anteriores slightly shorter than papillae anales, apically reaching about ¾ length of tergum VIII and forming pair of rounded bumps separated by short, narrow median cleft. Antrum wide and long, funnel-shaped, wrinkled, slanted to left. Ductus seminalis about twice as long as antrum, thin, sclerotized towards antrum. Corpus bursae oval, large, slightly longer than ductus seminalis plus antrum, with pair of rather short, slightly curved signa with large, rounded area around their bases with lightly sclerotized pentagons.

Etymology. Named for the collecting locality, Chicaque Natural Park.

Specimens examined. Holotype ♂: 1- “COL[OMBIA]., Cundinamarca | S[an]. Antonio de Tequendama | P[arque]N[atural] Chicaque, n[ea]r Refugio, at | lights, 4°36’53”N 74°18’40”W | 2150 m, 19-20.vii.2018, *leg[it]*. B. | Landry, H. Arévalo, J. De Prins”; 2- “if selected as holotype | return to Museo | Entomológico, UNAB | Bogotá, Colombia”; 3- “Export permit | ANLA, Colombia | n° 01292, 2018”; 4- “HOLOTYPE | Postplatyptilia | chicaquensis Landry & Gielis”. First three labels white, printed in black, fourth red, handwritten in black. Deposited in UNAB.
Paratypes: 2 ♂♂, same data as holotype, with dissected parts on slides BL 1895 and 1902, 1 ♀ with same data as holotype and dissected parts on slide BL 1898. Deposited in UNAB and MHNG.

Diagnosis. In external characters this species is similar to many others of the genus, but the white patch medially on the third lobe of the hind wing is possibly diagnostic. In any case, the genitalia need to be studied for a reliable determination. In male genitalia the small uncus barely projecting beyond the distal margin of the tegumen will separate this species from all others, the most similar in this respect being: *Postplatyptilia oxapampa* Gielis, 2014 described from Peru, for which the uncus is very short and knob-like and the anellus arms much shorter; *P. transversus* Gielis, 2006, described from Colombia, Cundinamarca, for which the small, thin uncus does not reach the elongate tegumen’s apical margin, the anellus arms are longer and apically spatulate, and the saccus is simple, not bifid as in *P. chicaquensis*; and *P. parana* Gielis, mentioned above (Fig. 3a), in which the uncus is thin from base to apex, longer, and not reaching the apical margin of the pointed tegumen, the saccus is not so deeply cleft (the cleft is more rounded and the arms are narrower), and the valva is thinner. In female genitalia, the position and shape of the lamella postvaginalis along with the long funnel-shaped ‘antrum’ and the short ductus bursae collectively serve to identify this species. The most similar species is *P. zongoensis* Gielis, 2006 (fig. 352), described from Bolivia, for which the lamella postvaginalis is similar in shape

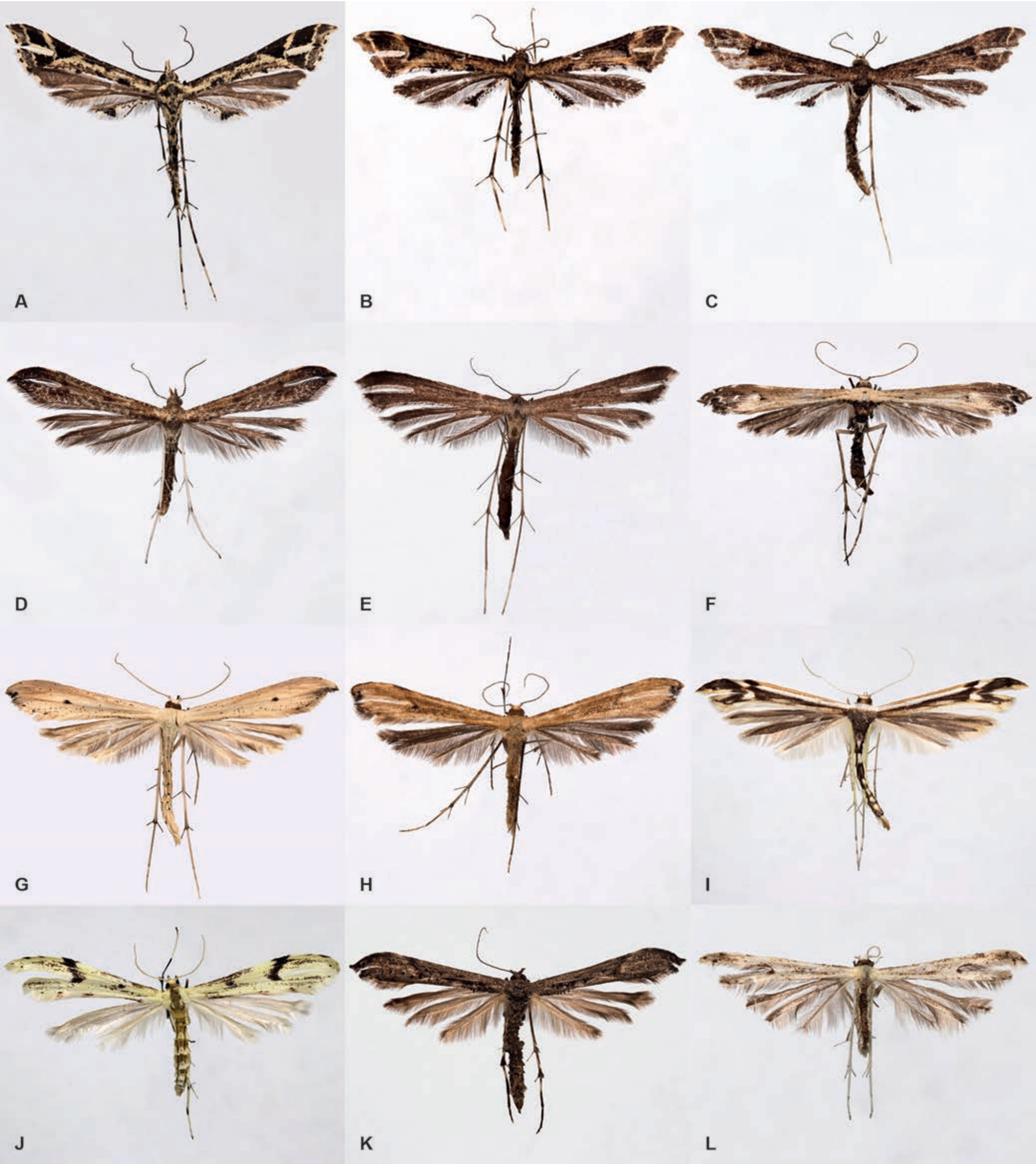

Figure 1. Pterophoridae species collected at Parque Natural Chicaque in 2018. **A.** *Postplatyptilia parana* Gielis, male, ws: 19.5 mm; **B.** *Postplatyptilia chicaquensis* **sp. n.**, holotype male, ws: 17.5 mm; **C.** *Postplatyptilia chicaquensis* **sp. n.**, paratype male, ws: 17.0 mm; **D.** *Lioptilodes cocodrilo* Gielis, male, ws: 17.0 mm; **E.** *Exelastis* sp., female, ws: 17.0 mm; **F.** *Hellinsia barbatus* (Gielis), male, ws: 23.0 mm; **G.** *Hellinsia danielae* **sp. n.**, holotype male, ws: 23.5 mm; **H.** *Hellinsia obscuricilia* Arenberger & Wojtusiak, male, ws: 19.0 mm; **I.** *Hellinsia pelospilus* (Zeller), male, ws: 26.5 mm; **J.** *Hellinsia* sp., female, ws: 26.5 mm; **K.** *Oidaematophorus pseudotrachyphloeus* Gielis, male, ws: 30.0 mm; **L.** *Adaina atahualpa* Gielis, female, ws: 17.0 mm. ws = wingspan.

but smaller and extending only to about 1/3 of the length of segment VIII and the antrum is also funnel-shaped and medially situated, but it is straight, narrower, and shorter. *Platyptilia palmeri* Gielis, 1996 (see also Gielis, 2006, fig. 355), described from Mexico, is also similar in female genitalia, but the papillae anales are long, there is no lamella postvaginalis but a lamella antevaginalis forming a pair of bumps apically and extending slightly beyond the basal margin of segment VIII, and the antrum is narrower, short, and not slanted to the left.

Figure 2. Pterophoridae species collected at Parque Natural Chicaque in 2018; *Adaina* sp., female, ws: 21.0 mm.

Distribution. This species presently is known from the type locality only.

Remarks. *Postplatyptilia* Gielis, 1991 includes 40 species distributed in the Neotropical region (Hobern, 2022). Only one of these, *P. pusillus* (Philippi, 1860), cannot be recognized as its description is not sufficiently diagnostic and the type specimen is lost (Gielis, 2006). Another one, *P. paraglyptis* (Meyrick, 1908) described from Argentina, is represented by a unique type specimen without abdomen, but its habitus (see Gielis, 2006) allows us to recognize it as different from the species described here based on the forewing markings on the first lobe. The fact that one of the sexes is unknown for many species of *Postplatyptilia* means that the new species diagnosis is *de facto* incomplete.

Lioptilodes cocodrilo Gielis, 2006

Lioptilodes cocodrilo Gielis, 2006: 152.
Figs. 1D, 3e, f

Type locality. Ecuador, Napo Province, 15 km SE Cosanga, Cocodrilo.
Distribution. Previously known from Ecuador and Peru (Gielis, 2006), the species is reported from Colombia for the first time.
Remarks. Two male specimens were collected around the Refugio of Parque Natural Chicaque. The female genitalia are illustrated by Gielis (2006, fig. 396).

Exelastis sp**.**

Figs. 1E, 5b

Remarks. The unique specimen collected around the Refugio of Parque Natural Chicaque is a female. In female genitalia this specimen is similar to *Exelastis pumilio* (Zeller, 1873) in the absence of a signum on the corpus bursae. However, the central position of the ostium bursae on abdominal segment VII in this specimen does not agree with that shown for *E. pumilio* by Gielis (2006, fig. 408), Landry (1993, fig. 7), and Matthews *et al.* (2019, fig. 46) in which the ostium bursae is positioned at the terminal margin of abdominal segment VII. Also, in the Chicaque specimen the shape of the antrum, with distinctly parallel sides and being not much wider than the ductus bursae, and the posterior part of the ostium subtended by an elongate sclerite, differ from the shorter antrum with divergent sides and the absence of a posterior sclerite in *E. pumilio*. The wingspan indicated by Gielis (2006: 195) for *E. pumilio* is 12-15 mm while the Chicaque specimen reaches 17 mm; this female also possesses spatulate scales in the fringe of the third hindwing lobe, which are absent in *E. pumilio* based on Gielis (2006), Landry (1993), and Matthews *et al.* (2019). We conclude that this species is probably new, but male specimens would need to be available for study to conclude with certainty and provide a description.

Oidaematophorus pseudotrachyphloeus Gielis, 2011

Oidaematophorus pseudotrachyphloeus Gielis, 2011: 697.
Figs. 1K, 4h, i, 5d

Type locality. Peru, Lima, 'Reserva Nacional de Lachay'.
Distribution. Argentina, Ecuador, Peru (Gielis, 2011) and Chile (Vargas, 2021). It is reported for Colombia for the first time.
Remarks. Six specimens, three males and three females, were collected around the Refugio of Parque Natural Chicaque. The rather large tufts of raised scales on the forewing and abdomen are remarkable.

***Hellinsia barbatus* (Gielis, 1996)**

Oidaematophorus barbatus Gielis, 1996: 97.
Figs. 1F, 3g-i

Type locality. Colombia, Sierra del Libano.
Distribution. Brazil (new record from: Santa Catarina, São Joaquim, 1400 m, 2.ii.1993, *leg*. V.O. Becker, genitalia preparation CG7103, Coll. V.O. Becker), Colombia, Costa Rica, Venezuela (Gielis, 2011, 2014).
Remarks. This species is represented in the Parque Natural Chicaque sample of 2018 by one male collected near the Refugio. The female genitalia are illustrated by Gielis (2011, fig. 345).

Hellinsia danielae Landry & Gielis, **sp. n.**

Figs. 1G, 4a-c

Description. MALE (Fig. 1G). Head wheat-colored between antennae, chocolate-brown on vertex and on flat fronto-clypeus. Antennae wheat-colored on scape except for two chocolate-brown spots at apex; pedicel and basal 8 flagellomeres wheat-colored with small chocolate-brown spots, grayish white on subsequent flagellomeres. Labial palpus porrect, with ventrally projecting scales on first palpomere and short appressed scales on distal two palpomeres; palpomere I white to pale grayish white; palpomere II mostly pale grayish brown, paler ventrally; palpomere III slightly darker grayish brown. Thorax mostly wheat-colored, light ochraceous at base of tegulae. Forewing length: 11 mm; wingspan: 23.5 mm; coloration and markings wheat-colored with dark brown spot at cleft base and scattered dark brown scales along costa and anal margin; first lobe with R_5 terminus marked by black spot and gray and black fringes; second lobe M_3, Cu_1, and Cu_2 terminals also marked with gray scales. Hindwing uniformly wheat-colored, fringes pale drab. Foreleg coxa wheat-colored with thin chocolate-brown stripe, femur and tibia longitudinally striped pale wheat-colored and chocolate brown; tarsomere I wheat-colored with thin chocolate-brown stripe not reaching apex; tarsomeres II-V wheat-colored. Midleg as in foreleg, with tibial tufts blackish brown, with few white scales at apex of apical tuft, tibial spurs dark brown dorsally, paler grayish brown ventrally. Hindleg mostly wheat-colored, with blackish brown at base of tibial spurs, dorsally on spurs, and at very apex of tarsomeres I-IV. Abdomen dorsally as shown; ventrally not recorded.

Male genitalia (Figs. 4a-c, n=1). Uncus thin, thinning toward apex, pointed, with sparse short setae. Tegumen rather long and narrow, more than twice as long as uncus, with broad triangular anterior projection dorsomedially. Valvae asymmetrical, both with hair pencils of moderate size and density, with apices somewhat pointed; left valva broader, with long, thin saccular spine first directed medially for short distance, then straight anteriorly, then curved back

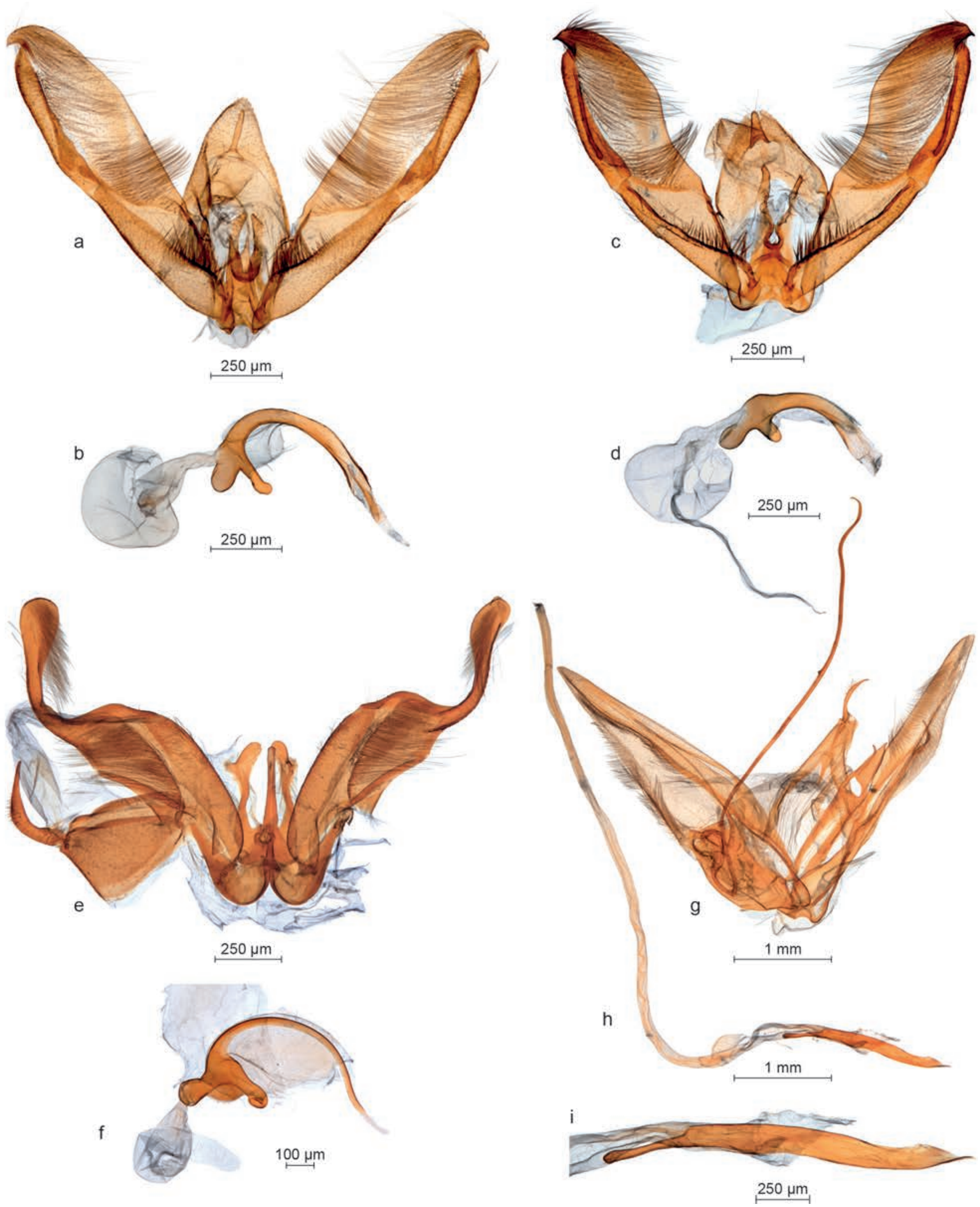

Figure 3. Male genitalia of Pterophoridae species collected at Parque Natural Chicaque in 2018; genital capsule above phallus. **a-b**. *Postplatyptilia parana* Gielis; **c-d**. *Postplatyptilia chicaquensis* **sp. n.**; **e-f.** *Lioptilodes cocodrilo* Gielis; **g-i.** *Hellinsia barbatus* (Gielis).

posteriorly, and reaching tip of valva; saccus of right valva with short, broad triangular process associated with subventral sclerotized bar reaching slightly beyond mid-length. Juxta narrow, elongate, about half as long as valvae, with short asymmetrical anellus arms with sparse short setae, the right arm wider. Phallus thin, slightly down-curved, about half as long as valvae, apically pointed; vesica adorned with thin short plate with basal triangular projection.

FEMALE. Unknown.

Etymology. This species is dedicated to Daniela Cubillos Cañizares, Colombian engineer in agronomy, myrmecologist, and friend, for her most kind and efficient help to BL with fieldwork in the Colombian Amazon.

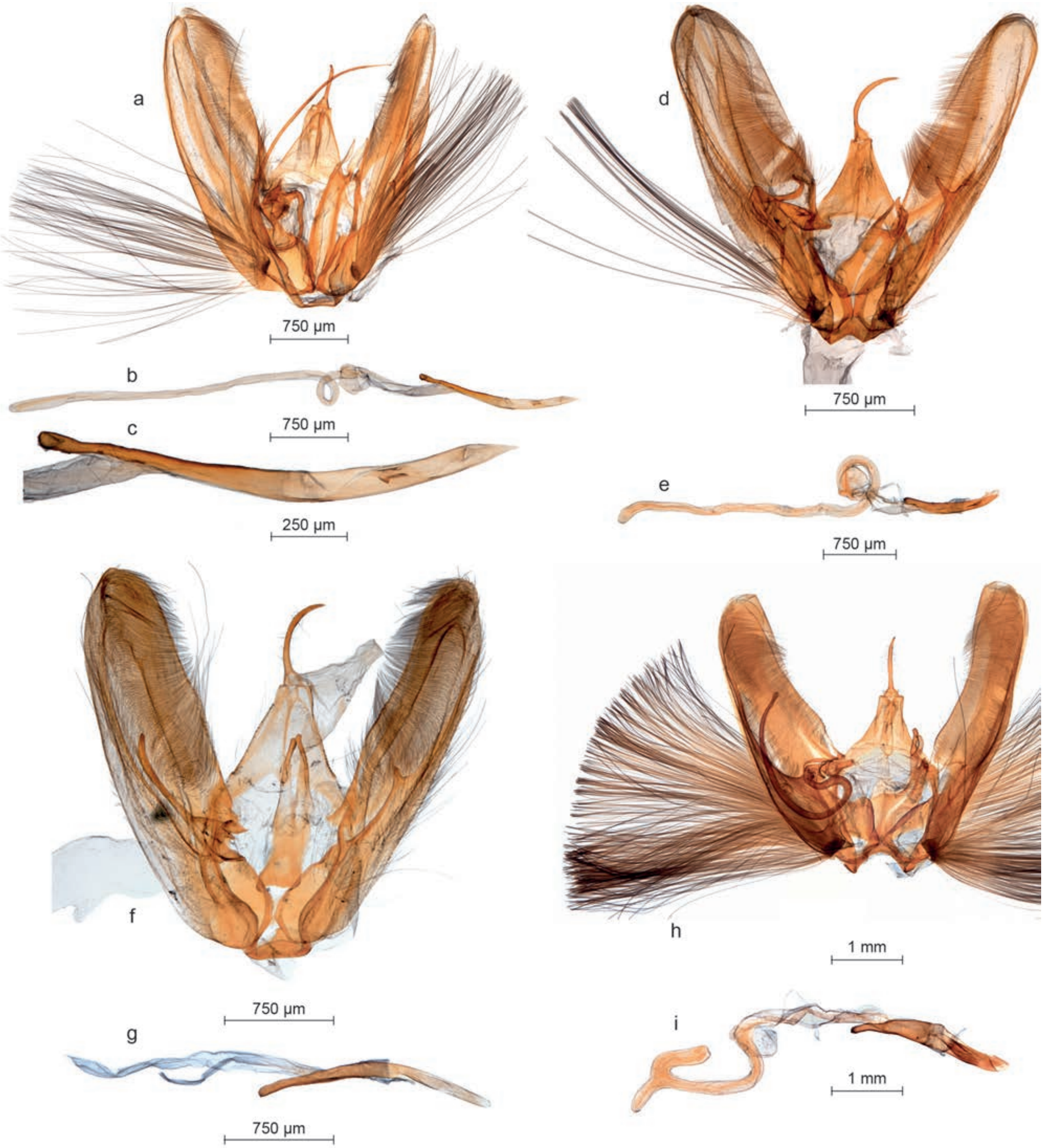

Figure 4. Male genitalia of Pterophoridae species collected at Parque Natural Chicaque in 2018; genital capsule above phallus. **a-c.** *Hellinsia danielae* **sp. n.**; **d-e**. *Hellinsia obscuricilia* Arenberger & Wojtusiak; **f-g.** *Hellinsia pelospilus* (Zeller); **h-i.** *Oidaematophorus pseudotrachyphloeus* Gielis.

Specimen examined. Holotype ♂: 1- "COL[OMBIA]., Cundinamarca | S[an]. Antonio de Teguendama | P[arque]N[atural] Chicaque, n[ea]r Refugio, at | lights, 4°36'53"N 74°18'40"W | 2150 m, 19-20.vii.2018, *leg[it]*. B. | Landry, H. Arévalo, J. De Prins"; 2- "if selected as holotype | return to Museo | Entomológico, UNAB | Bogotá, Colombia"; 3- "Export permit | ANLA, Colombia | n° 01292, 2018"; 4- "Slide | BL 1905♂"; 5- "HOLOTYPE | Hellinsia | danielae | Landry & Gielis". First three labels white, printed in black, fourth green, handwritten in black, fifth red, handwritten in black. Deposited in UNAB.

Diagnosis. The species has pale forewings with very limited markings, as shown (Fig. 1G). A similar pattern is present also in *Hellinsia capucayae* Gielis, 2012, *H. cosangae* Gielis, 2012 and *H. lenis* (Zeller, 1877). All these species differ in the shape of the male genitalia. The present species has a long saccular spine, which is basally curved back at the base of the valve, consistent with "type E" of Gielis (2011), whereas the other species have a different shape of their saccular processes (*H. capucayae* (type B); *H. cosangae* (type B), and *H. lenis* (type C)).

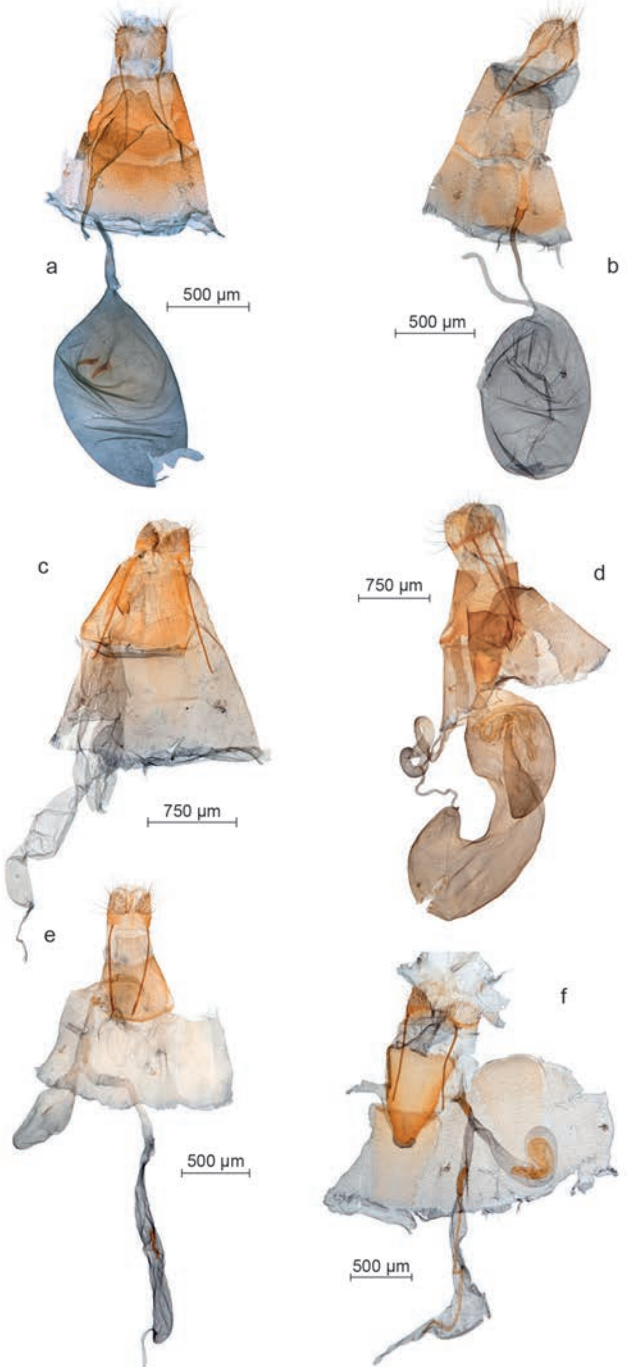

Figure 5. Female genitalia of Pterophoridae species collected at Parque Natural Chicaque in 2018. **a.** *Postplatyptilia chicaquensis* sp. n.; **b.** *Exelastis* sp.; **c.** *Hellinsia* sp.; **d.** *Oidaematophorus pseudotrachyphloeus* Gielis; **e.** *Adaina atahualpa* Gielis; **f.** *Adaina* sp.

Distribution. Presently this species is known only from the type locality, in Colombia.

Remarks. The holotype and unique specimen known is missing the left midleg. The genitalia had been mounted on slide before they were described.

Hellinsia obscuricilia Arenberger & Wojtusiak, 2001

Hellinsia obscuricilia Arenberger & Wojtusiak, 2001: 70.

Figs. 1H, 4d, e

Type locality. Venezuela, Paramo El Batallon, Quebrada de los Pios, 2950 m.

Distribution. Bolivia (Gielis, 2013), Costa Rica (Gielis, 2011), Honduras (Kovtunovich *et al.*, 2018), Panama (Kovtunovich *et al.*, 2019), Venezuela. Reported here from Colombia for the first time.

Remarks. Only one male of this species was collected at Chicaque near the Refugio in 2018. The female is yet unknown.

Hellinsia pelospilus (Zeller, 1877)

Leioptilus pelospilus Zeller, 1877: 481.

Figs. 1I, 4f, g

Type locality. Peru, Junín, Chanchamayo.

Distribution. Previously known from Ecuador and Peru (Gielis, 2011), the species is reported from Colombia for the first time.

Remarks. Five males were collected in the vicinity of the Refugio of Parque Natural Chicaque. The female is still unknown.

Hellinsia sp.

Figs. 1J, 5c

Remarks. Based on our knowledge of the described species of *Hellinsia*, this one appears to be undescribed. However, we refrain from describing it until more specimens, or at least one male can be collected as only the one female specimen figured here was collected in the vicinity of the Refugio of Parque Natural Chicaque. It is similar in color and forewing markings to *H. pallens* Gielis, 2011 and *H. scripta* Gielis, 1999, respectively described from Ecuador, Pichincha and Costa Rica, Puntarenas. However, both of these species are smaller with documented wingspans of 17 mm for *H. pallens* and 19-22 mm for *H. scripta* compared to the 26.5 mm of the Colombian species. On the forewing the blackish-brown markings of this species appear to be unique in the continuous blackish-brown oblique band from the base of the cleft to the costa. In the female genitalia, all three species have the ostium bursae positioned on the left and a funnel-shaped antrum, but differ in details of the length of the enlarged section of the ductus seminalis compared to the length of the corpus bursae.

Adaina atahualpa Gielis, 2011

Adaina atahualpa Gielis, 2011: 707.

Figs. 1L, 5e

Type locality. Ecuador, Napo Province, 15 km SE Cosanga, Cocodrilo.

Distribution. Colombia, Ecuador (Gielis, 2011).

Remarks. Two females were collected at Chicaque in the vicinity of the Refugio.

Adaina sp.

Figs. 2, 5f

Remarks. This species is slightly similar in habitus to *Adaina ambrosiae* (Murtfeldt, 1880) although the paler and darker stripes and spots, especially on the forewing lobes differ significantly. Also, the female genitalia of the unique specimen collected in the vicinity of Chicaque's Refugio differ strongly in the large, elongate, triangular, and thickly sclerotized tergite VIII, and other features of the genitalia as such (see Landry *et al.*, 2004). Although we suspect that it is new, we refrain from describing it pending the availability of male specimens.

DISCUSSION

Far from having been a true inventory of the Pterophoridae at Parque Natural Chicaque, the collecting efforts involved during three days and nights nevertheless allowed us to record a sample of 12 species, including two that could be identified as new, and three that may be new, but for which material is lacking to ascertain their taxonomic status.

Based on Holbern (2022) and the database of the second author, below we provide a complete checklist of the Pterophoridae of Colombia in phylogenetic order. Species marked with * are recorded here for the first time for Colombia.

Quadriptilia obscurodactyla Gielis, 1994
Platyptilia thyellopa Meyrick, 1926
Stenoptilia suprema Meyrick, 1926
Stenoptilia tenuis (Felder & Rogenhofer, 1875)
Amblyptilia scutellaris (Felder & Rogenhofer, 1875)
Anstenoptilia hugoiella Gielis, 1996
Stenoptilodes gilvicolor (Zeller, 1877)
Stenoptilodes posticus (Felder & Rogenhofer, 1875)
Stenoptilodes sordipennis (Zeller, 1877)
Stenoptilodes stigmatica (Felder & Rogenhofer, 1875)
Stenoptilodes thrasydoxa (Meyrick, 1926)
Stenoptilodes umbrigeralis (Walker, 1864)
*___Postplatyptilia chicaquensis___ Landry & Gielis, **sp. n.**
Postplatyptilia fuscicornis (Zeller, 1877)
*___Postplatyptilia parana___ Gielis, 1996
Postplatyptilia transversus Gielis, 2006
Lioptilodes albistriolatus (Zeller, 1877)
*___Lioptilodes cocodrilo___ Gielis, 2006
Cnaemidophorus smithi Gielis, 1992
Exelastis pumilio (Zeller, 1873)
Michaelophorus nubilus (Felder & Rogenhofer, 1875)
Sphenarches languidus (Felder & Rogenhofer, 1875)
Megalorhipida leucodactylus (Fabricius, 1794)
Hellinsia argutus (Meyrick, 1926)
Hellinsia barbatus (Gielis, 1996)
Hellinsia bogotanus (Felder & Rogenhofer, 1875)
Hellinsia conjunctus (Zeller, 1877)
Hellinsia crescens (Meyrick, 1926)
*___Hellinsia danielae___ Landry & Gielis, **sp. n.**
Hellinsia estrellae Gielis, 2014
Hellinsia fumiventris (Zeller, 1877)
Hellinsia fusciciliatus (Zeller, 1877)
Hellinsia lenis (Zeller, 1877)
Hellinsia monserrate Arenberger & Bond, 1995
Hellinsia nigricalcarius (Gielis, 1996)
Hellinsia nodipes (Zeller, 1877)
*___Hellinsia obscuricilia___ Arenberger & Wojtusiak, 2001
Hellinsia ochracealis (Walker, 1864)
Hellinsia ochricostatus (Zeller, 1877)
*___Hellinsia pelospilus___ (Zeller, 1877)
Hellinsia praenigratus (Meyrick, 1921)
Hellinsia schneblei Gielis, 2014
Hellinsia scribarius (Meyrick, 1926)
Hellinsia surinamensis (Sepp, 1855)
Oidaematophorus espeletiae Hernandez, Fuentes, Fajardo & Matthews, 2014
*___Oidaematophorus pseudotrachyphloeus___ Gielis, 2011
Adaina atahualpa Gielis, 2011
Adaina desolata Arenberger & Bond, 1995
Emmelina buscki (Barnes & Lindsey, 1921)
Singularia brechlini Kovtunovich & Ustjuzhanin, 2016
Singularia guajiro Kovtunovich & Ustjuzhanin, 2016
Singularia lesya Kovtunovich & Ustjuzhanin, 2016
Singularia tolima Kovtunovich & Ustjuzhanin, 2016

In sum, with 53 species (56 if the three undetermined species treated here from Chicaque are included), the Pterophoridae fauna of Colombia is undoubtedly poorly known, given the 130 species recorded from neighboring Ecuador (Ustjuzhanin *et al.*, 2021). Of the 46 species previously mentioned in the literature from Colombia, 41 were described as new species with a type locality in Colombia. This high proportion suggests an equally high proportion of endemic species, a situation also observed in neighboring countries such as Ecuador and Peru. Much more field work is needed to provide a clearer picture of the diversity of the Colombian Pterophoridae, a situation that is undoubtedly similar in many other groups of micro-moths.

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Scientific Note: Records of *Pseudocoladenia dan fabia* and *P. fatua* (Lepidoptera: Hesperiidae: Pyrginae) from Nepal

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Abstract: Several individuals of *Pseudocoladenia dan fabia* (Evans, 1949) and *Pseudocoladenia fatua* (Evans, 1949) are reported from Sunsari and Dhankuta districts of East Nepal. Identifications were based on external characters and genital structures of examined specimens. This is the first record of *P. fatua* from Nepal, while a previous report of *P. dan fabia* from Nepal was doubtful and we here confirm for the first time its occurrence in Nepal.

Key words: Fulvous Piet Flat, new record, Ruddy Pied Flat, Sikkim Pied Flat.

INTRODUCTION

The species of *Pseudocoladenia* Shirôzu & Saigusa, 1962 were previously placed under *Coladenia* Moore, 1881. Shirôzu & Saigusa (1962) erected *Pseudocoladenia* based on differences in the male genital structures in comparison with other species of *Coladenia*. All the species in these two genera are Oriental in distribution (Evans, 1949). Only one species of *Pseudocoladenia* has so far been reported from Nepal, namely *P. fatih* (Kollar, [1844]) (Smith, 1989, 2010, 2011; Huang, 2021). While that taxon in the past has been regarded as a subspecies of *Pseudocoladenia dan* (Fabricius, 1787), recently it was elevated to species level by Huang (2021) based on its male genital morphology. The species is common across the country from as low as 640 m to 2,070 m (Smith, 1989, 2010, 2011). On the Indian subcontinent, *P. fatih* is recorded from northwest to central Himalayas, from Hazara in Pakistan to central Nepal (Evans, 1949; Gasse, 2018). In the present study, *Pseudocoladenia fatua* (Evans, 1949) is reported for the first time from Nepal, while the previous report of *Pseudocoladenia dan fabia* (Evans, 1949) from Nepal was doubtful and we thus confirm here for the first time its occurrence in Nepal.

MATERIALS AND METHODS

This paper is based on information collected during opportunistic surveys made by the first author in Sunsari and Dhankuta districts in East Nepal in the months of March, August and November, 2021. A Canon 7D Mark II camera with 100 mm f/2.8L Macro IS USM lens was used to photograph butterflies. A GPS built into the camera recorded location and the elevation details within image metadata. Butterflies were hand-collected and stored in a vial containing ethyl acetate. The specimens were taken to the National Entomology Research Center, Khumaltar, Lalitpur, for dissection. Abdomens of the collected specimens were stored in 80% ethyl alcohol with data labels for subsequent study of genitalia to help confirm identifications. The specimens were immersed in 10% KOH solution and dissected under an Olympus Stereo-microscope Model SZ2-ILST, and photographs of genital parts were taken with an iPhone 6s smartphone. Contrast of the genitalia images was enhanced using MS Word 2019.

In the field, identification was done using Evans (1949). Identifications were subsequently verified by examination of male genitalia (Fig. 2) and comparison with illustrations/photographs in Evans (1949), Huang & Xue (2004) and Huang (2021). Additional information on the species was obtained from Kehimkar (2016) and Smetacek (2016), and identifications were further confirmed through personal communication with Hao Huang (China). We follow Evans (1949) for morphological terms such as those used for wing venation and male genitalia.

RESULTS

Hesperiidae Latreille, 1809
Pyrginae Burmeister, 1878
Celaenorrhini Swinhoe, 1912
Pseudocoladenia Shirôzu & Saigusa, 1962

Pseudocoladenia dan fabia (Evans, 1949)

Material examined: 4♂♂; Itahari, Sunsari District, Province No. 1, 26°43’08”N, 87°17’09”E, 120-150 m; 14-21.VIII.2021 and 9-11.XI.2021; Coll. Sajan K.C.

Diagnosis: According to Huang & Xue (2004) and Huang (2021), *P. dan fabia* has the forewing spots smaller and more

Figure 1. *Pseudocoladenia* in Nepal. **A**: *Pseudocoladenia dan fabia* (male from Sunsari, 130 m). **B**: *P. dan fabia* (female from Sunsari, 130 m). **C**: *P. dan fabia* (male from Sunsari, 623 m). **D**: *P. fatua* (male from Dhankuta, 723 m). **E**: *P. fatua* (male from Dhankuta, 650 m). **F**. *P. fatua* (male from Dhankuta, 1,416 m). **G**: *P. fatua* (male from Dhankuta, 1,566 m). **H**: *P. fatua* (male from Dhankuta, 1,356 m). **I**: *P. fatua* (male from Dhankuta, 1,487 m). **J**: *P. fatua* (female from Dhankuta, 1,358 m). **K**: *P. fatih fatih* (male from Kaski, central Nepal, around 850 m). **L**: *P. fatih fatih* (female from Kaski, central Nepal, around 850 m).

separated (spot 2 not extending beyond v3 origin), with the cell spot more excavated inward and its lower half longer than the upper half, while *P. fatua* and *P. fatih* both have their forewing spots more compact with the cell spot less excavated. The male genitalia of *P. dan fabia* are distinguished by the short apical process of the valva (Figs. 2A, 2C).

Taxonomic notes: *Pseudocoladenia dan* (Fabricius, 1787), commonly called the Fulvous Pied Flat, has two subspecies on the Indian subcontinent, with *P. dan dan* recorded from SE Gujarat to Kerala in the Western Ghats, and SE Andhra Pradesh in the Eastern Ghats (Gasse, 2018; Varshney & Smetacek, 2015) and *P. dan fabia* (Evans, 1949) from Sikkim to NE India, including Bhutan, and NE Bangladesh (Gasse, 2018; Singh & Chib, 2015). Although Smith's (1989) illustrated list of butterflies of Nepal included a picture of *P. dan fabia* in its natural habitat, from Jhapa District at around 365 m in June, he listed this image under *P. fatih*. Kehimkar (2016) included Nepal as part of the distribution of *P. dan fabia*.

We observed several individuals of *P. dan fabia* flying inside a forest and sitting on or under leaves, between 14 to 21 August, 2021 in Itahari, Sunsari District at 120-150

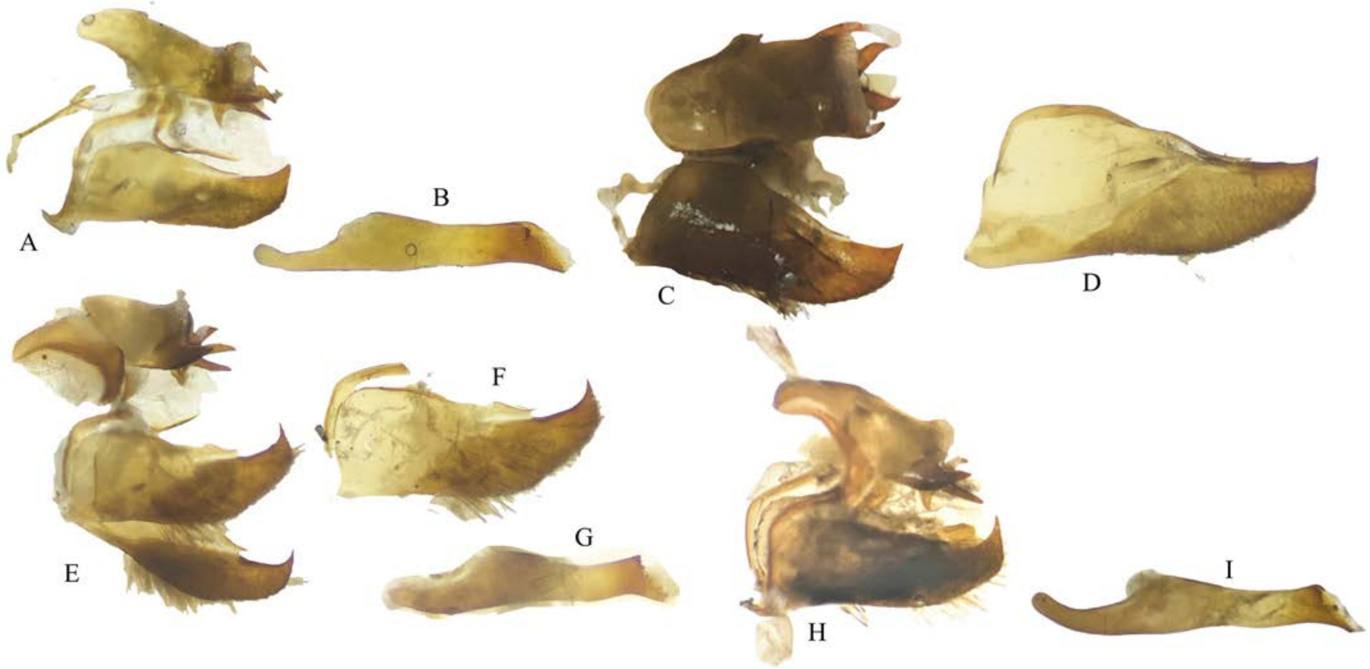

Figure 2. **A**: *Pseudocoladenia dan fabia* male genitalia (Fig. 1A specimen). **B**: Ditto, aedeagus **C**: *Pseudocoladenia dan fabia* male genitalia. **D**: Ditto, valva. **E**: *P. fatua* male genitalia (Fig. 1F specimen). **F**: Ditto, valva. **G**: Ditto, aedeagus. **H**: *P. fatua* male genitalia (Fig. 1H specimen). **I**: Ditto, aedeagus.

m (Fig. 1A,1B). The species was equally abundant during the first author's next visit in early/mid-November. A few individuals were also found in Dharan, Sunsari District at 620 m (Fig. 1C). Prominent vegetation included *Shorea robusta* (Dipterocarpaceae), *Tectona grandis* (Lamiaceae), *Lantana camara* (Verbenaceae), and *Mikania micrantha* (Asteraceae) in Itahari, and *Shorea robusta* in Dharan.

Pseudocoladenia fatua (Evans, 1949)

Materials examined: 1♂; Pakhribas, Dhankuta District, Province No. 1, 27°02'42"N 87°17'32"E, 1,566 m; 23.VIII.2021; Coll. Sajan K.C. 1♂ Paripatle, Dhankuta District, Province No. 1, 27°0'27"N 87°18'43"E, 1,416 m; 29.VIII.2021; Coll. Sajan K.C.

Diagnosis: Males of *P. fatua* lack any spot in forewing space 1b and have yellow forewing spots, while the female has white spots with the spots in space 1b sometimes present. The closely related *P. fatih* has a single or twin spot in forewing space 1b and has white hyaline forewing spots in both sexes. Both taxa have more compact forewing spots than those in *P. dan fabia* (Huang & Xue, 2004; Huang, 2021). The male genitalia of *P. fatua* are distinguished by the much longer and curved apical process of the valva than in *P. dan fabia* (Fig. 2F, 2H).

Taxonomic notes: *Pseudocoladenia fatua* (Evans, 1949), commonly called the Sikkim Pied Flat or (sometimes) Ruddy Pied Flat, was originally considered to be a subspecies of *P. dan*, until Huang & Xue (2004) raised it to species level. On the Indian subcontinent, the taxon has been reported from Sikkim to NE India, including Bhutan (Gasse, 2018; Kehimkar, 2016; Singh & Chib, 2015). Another similar taxon found in Sikkim, which may fly in Nepal, is *P. fatih festa* (Evans, 1949); that taxon can be identified from the sympatric *P. fatua* based on the following characters: 1. Forewing spots very compact, more so than in *P. fatua* (completely conjoined). 2. White spot(s) in forewing space 1b present, as in *P. fatih fatih*. 3. Both sexes have forewing spots yellowish, unlike in *P. fatua* where only the males have yellowish spots (Huang, 2021).

Individuals of *Pseudocoladenia fatua* were found in Bhedetar, Dhankuta District at around 700 m in March (Fig. 1E), August (Fig. 1D) and November; in Paripatle, Dhankuta District they were found at around 1400 m (Figs. 1F, 1G) in August, and in Pakhribas, Dhankuta District they were found at around 1500 m, also in August (Figs. 1H, 1I, 1J). Worn individuals were dull (Figs. 1F, 1G) while fresh ones were bright with sharp upper-hindwing spots (Figs. 1H, 1I, 1J). While specimens with traits typical of *P. fatua* as given in Huang (2021) were observed (Fig. 1D, 1E, 1G), especially at around 700 m, both examined specimens of male *P. fatua* had white spots in forewing space 1b (Figs. 1F, 1H), which seems to represent variation, and the most reliable characters are in male genitalia (Huang, 2021, personal communication). The prominent vegetation in both localities included pine trees (Pinaceae), *Castanopsis indica* (Fagaceae), citrus species (Rutaceae), *Pyrus* species (Rosaceae), and herbs such as *Lantana camara* and *Ageratina adenophora* (Asteraceae).

DISCUSSION

Intraspecific variation in wing pattern is often present in the species of *Pseudocoladenia*. As a result, species are most reliably identified by examination of their male genitalia,

Figure 3. Study area in Nepal.

especially the shape of the valva. In the absence of a specimen, however, identification can be made using a combination of external morphological traits and distribution, but such identifications may not always be correct.

Pseudocoladenia fatih is abundant from west to central Nepal (Figs. 1K, 1L). Its easternmost range limit, however, is not clearly known and requires more research. The transitional zone of this west Himalayan species and other east Himalayan species of *Pseudocoladenia* probably lies somewhere in Bagmati Province or west of Province Number 1 in Nepal.

Eastward, in the Terai region at lower altitudes (below around 650 m), *P. dan fabia* is abundant and adults are likely present in all seasons. *Pseudocoladenia fatua* likewise occurs from around 700 m to at least 1,600 m. Adults may or may not have a richer red wing color depending on how recently they emerged, not all are small in size as mentioned by Evans (1949), and sometimes males may also have spots in forewing space 1b.

At present, all three *Pseudocoladenia* species recorded from Nepal, namely *P. fatih fatih*, *P. dan fabia* and *P. fatua*, appear to be quite common within their Nepalese distribution. Both *P. dan fabia* and *P. fatua* have also been reported from Sikkim, and thus were indeed expected to be present in eastern Nepal.

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Scientific Note: Clarification of the nomenclature and distribution of *Mania aegisthus* (Fabricius, 1781) (Lepidoptera: Geometroidea: Sematuridae)

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Abstract: Until recently there has been considerable confusion over the correct nomenclature of the sexually dimorphic moth species in the genus *Mania* (Sematuridae). In addition, some websites still indicate that *Mania aegisthus* (Fabricius) occurs in Suriname, whereas this species is confined to the Greater Antillean islands of Cuba, Hispaniola, and Jamaica. This note clarifies the taxonomy and distribution of this species.

Key words: Cuba, Hispaniola, identification, Jamaica, nomenclature, Suriname.

INTRODUCTION

The genus *Mania* Hübner was previously regarded as a member of the Uraniidae within the superfamily Uranioidea. However, following phylogenetic and molecular studies (Minet & Scoble, 1999; Regier, 2008; Sihvonen *et al.*, 2011; Heikkila *et al.*, 2015), these moths are now recognized as members of the family Sematuridae within the Geometroidea, with six genera containing forty species (van Nieukerken *et al.*, 2011). Despite the genus containing only a few species, until now there has been confusion over the identification and distribution of species. This note provides a summary of the misapplication of names along with the correct nomenclature, description, and distribution of *Mania aegisthus* (Fabricius, 1781).

MATERIALS AND METHODS

The present study was conducted under Permit 18/27 issued by the National Environment Planning Agency, Kingston, but no new specimens of *Mania* were collected. Adults were photographed while at rest using a Nikon D800 camera with a Nikkor AF-S 18-200 mm lens or Nikon D850 camera with a Micro Nikkor AF-S 105 mm lens. Several existing pinned specimens were examined and photographed using a Canon EOS 5DsR camera with Tamron 90 mm F/2.8 lens or Sony Cyber-shot 20.4 megapixels with 30X optical zoom.

Adult wingspans were measured in millimeters from forewing tip to forewing tip, but this measurement provides only an approximate measurement of size that depends on how the wings were arranged at time of pinning, so we also provide average wing length measured from mid-thorax behind the head to wing tip. A brief description of wing markings and color patterns together with photographs highlight features to aid identification.

Superfamily GEOMETROIDEA Leach, 1815
Family Sematuridae Guenée, 1858
Subfamily Sematurinae Guenée, 1858, Corkscrew moths
Genus *Mania* Hübner, 1821
Mania aegisthus (Fabricius, 1781)
Type locality: Jamaica

Nomenclature

Fabricius (1781) described *Papilio aegisthus*. Billberg (1820) proposed *Nothus* as a name for the genus, but this name is preoccupied by *Nothus* Olivier, 1811 (Coleoptera: Tenebrionidae; Olivier, 1811) and is therefore unavailable. However, *Nothus* has been in common usage, with Gaede (1930) referring to Jamaican specimens as *Nothus aegisthus*, a nomenclature Gowdey (1928) followed in his list of Jamaican Lepidoptera. More recently, the Barnes' (2002) website Moths of Jamaica, West Indies, refers to *Nothus aegisthus* and *Nothus excavata* [sic] from Jamaica.

The Moth Photographers Group's (2013) online checklist of Lepidoptera of the Antilles currently lists *Mania aegisthus* (Fabricius, 1793) from Cuba, but also lists the same species as *Nothus aegisthus* (Fabricius, 1781) from Jamaica and Hispaniola. Walker (1854) referred to the species as *Nyctalemon aegisthus* for specimens from Jamaica and *Nyctalemon excavatus* for the same species from Hispaniola.

The generic name *Sematura* has also been in use for this species (Dalman, 1825), such as *Sematura aegithus* for specimens from Jamaica, and a female specimen of *M. aegisthus* from Haiti described as *Sematura phoebe* by Guenée in 1857.

Figure 1. *Mania aegisthus* in Jamaica: ♂ dorsal (top left); ♂ ventral (top right); ♀ dorsal (bottom left), ♀ ventral (bottom right). ♀ photos courtesy of IJ, NMHJ.

Figure 2. *Mania lunus*: ♂ dorsal (left). Photo courtesy of National Museums of Scotland; ♀ dorsal (center), ♀ventral (right). Photos courtesy of Matthew J. W. Cock.

An application made by Cock & Lamas (2011) to stabilize the name *Sematura* Dalman, submitted to the International Commission on Zoological Nomenclature, ICZN, was rejected, giving precedence to the older genus name *Mania* Hübner, 1821 (ICZN, 2015), as noted by Cock (2016). Both *Nothus* Bilberg, 1820, and *Sematura* Dalman, 1825 are now recognized as being synonymous with *Mania*.

Mania is a small genus with four recognized Neotropical to subtropical species. The sexes are dimorphic; the male of *M. aegisthus* was originally described by Fabricius in 1781 as *Papilio aegisthus*, and the female was described as *Nyctalemon excavatus* by Westwood (1879). It also appears that Gaede (1930) confused the male and female in his brief descriptions of each sex of *Mania aegisthus* (as *Sematura*). The female of

Figure 3. *Mania empedocles*: ♂ dorsal (left); ♂ ventral (right). Photos courtesy of Matthew J. W. Cock.

M. aegisthus was misidentified by Stoll (1782) as the female of *Mania lunus* (Linnaeus, 1758), being illustrated with male specimens of *M. lunus* from Suriname. While the brown ground color and lighter banding of *M. lunus* (Fig. 2) and *M. empedocles* (Cramer, 1779) (Fig. 3) are superficially similar to those of *M. aegisthus*, the post-discal lines on both forewing and hindwing in *M. lunus* and *M. empedocles* are virtually straight, while those on the wings of *M. aegisthus* are undulating in both sexes, being first extended outwards at the end of the cell, then strongly indented below the cell on the forewing, this sequence repeated again near the tornus on the hindwing.

The type locality for *M. aegisthus* was given by Fabricius (1781) as “in Indiis”, and later ascribed to Jamaica by Butler (1870) from a specimen collected by Philip Gosse identified then as *Papilio aegisthus* and deposited in the Banksian Collection (Walker, 1854). *Mania aegisthus* is confined to the Greater Antillean islands of Cuba, Jamaica, and Hispaniola and is not present in Suriname (Cock & Lamas, 2011; Cock, 2016).

Material examined

The following description is based on nine specimens examined; three males and three females in the Thomas Turner collection; two females from the Natural History Museum of the Institute of Jamaica collection, Kingston; together with photographs of eight additional specimens taken by Vaughan Turland, John Fletcher, and from photographs by Leonard Wright from the Natural History Museum of the Institute of Jamaica, along with information from Barnes’s ‘Moths of Jamaica’ website (Barnes, 2002).

The common name for *Mania*, Corkscrew Moths, is derived from the tails on the hindwings, which in life are twisted. The species of this genus are also known as Eye-tailed Moths, in reference to the eyespots located at the base of the hindwings and on the tails. Specimens of both sexes vary greatly in size. Although the immature stages in Jamaica have not been found, such wide variation in adult size can occur when eggs are laid in large batches with some larvae experiencing a shortage of larval food plant toward the end of the final larval instar while still developed enough to pupate and produce smaller adults (Turner, pers. obs.). Regardless of size, the wing markings and patterns remain constant.

Male: (Fig. 1). Male wingspan ranges from 56 mm to 80 mm with forewing length of between 35 mm and 45 mm (n=3). Ground color dark brown with a mix of a mix of pale chestnut, and lighter straw-colored lines with darker cells in series of chevron-like markings.

Dorsal forewing divided into three concentric series: a basal series edged distally by a series of larger cells; a median series edged distally by undulating postdiscal band, which extends outwards at end of cell between veins Cu_1-Cu_2, and a marginal series between post-discal band and outer margin.The latter is defined by more heavily patterned cells distad of a darker brown postdiscal line. Outer sub-margin is marked with a series of undulating lighter and darker brown lines, and with a very thin almost continuous dark brown marginal line. This wing pattern continues on upper hindwing, outer margin of which is edged with three pronounced indentations, third extending into a tail which terminally becomes broadly spatulate. At base of tail toward tornus is largest of three eyespots, each black with a thin white distal crescent, and almost completely ringed with a thin light brown margin; second eyespot is positioned along basal edge of tail at point where tail becomes spatulate and is half size of basal eyespot; third eyespot is slightly smaller than second and is positioned medially, just before end of tail, which can be 22 mm in length in largest specimens; undulating postdiscal line extends outwards between veins Cu2-A2. A light brown submarginal marking tapers from basal eyespot to tornus and is also marked with a thin dark brown submarginal line. Antennae light brown, filamentous, slightly thickened toward end before tapering to a point, extending almost to postdiscal band along forewing; labial palpi pale chestnut, each edged frontally with a fine brush of long brown scales and with a pair of short, forward-extending projections approximately 1.5 mm in length, distally knobbed; dorsal head, thorax and abdomen dark brown; three chestnut brown ‘v’-shaped markings on thorax; abdomen with a pale dashed mid-dorsal line; first three abdominal segments also display pale yellowish-brown intersegmental bands; laterally pale gray.

Ventral head, thorax, and abdomen, light brown with slightly darker legs; thorax with longer light brown scales.

Ventral forewings and hindwings light brown; costa to subcosta crossed by darker bands between middle of cell and submargin; postdiscal band prominent, undulating, dark brown enclosing faint darker basal striae; a submarginal band of speckled brown ellipses tapering toward tornus; continuing as a dark brown speckled band to anal margin above tornus; eyespots absent, tail speckled

Figure 4. Distribution map for *Mania aegisthus*.

brown basally, more uniform brown distally; anal wing margin with long buff scales. Tornal area between basal eyespot and hind margin often flushed with reddish-brown, more so than in female.

Female: (Fig. 1). Female wingspan ranges from 42 mm to 73 mm with forewing length of between 30 mm and 45 mm (n=6).

Dorsal forewing ground color darker brown than that of male, with greater differentiation of dark brown cells edged with contrasting lighter brown to yellowish-brown lines; postdiscal lines undulating like that of male, pale yellowish-brown, bifid, anterior lines most prominently marked; submargin with better defined dark and lighter brown banding than in male; post discal band fading somewhat toward anal margin on upper hindwing; three marginal indentations better defined than those of male marked with golden brown marginal lines; eyespots and tail as in male. Antennae are slightly shorter and darker than those of male. Labial palpi with short brush hairs, not as well developed as those of male; projections of palpi longer than those of the male, approximately 3 mm in length, terminally knobbed. Dorsal and ventral markings of head, thorax, and abdomen similar to those of male; legs brown.

Ventral forewing defined by a narrow, undulating, dark brown postdiscal band similar to that of male; ground color basad of this light brown, and distad of this by a broad creamy-brown band followed by a dark brown wedge-shaped band extending from costa, tapering to hind margin. A broad marginal band of yellowish-brown dusted with dark brown scales. These patterns extend to lower hindwing. Tail brown without eyespots.

Distribution, habitats and behavior

In Jamaica, *M. aegisthus* is found in primary and secondary moist broadleaf forest and areas adjacent to these forests primarily at elevations between 450 m and 600 m, but there are also coastal records in secondary forest from elevations as low as 25 m. Specimens are also present at elevations up to at least 1,736 m in the Dominican Republic (Turner, pers. obs.). In Cuba, Núñez (2021, pers. comm.) describes *Mania* as ‘widespread but very rare’, found at altitudes from a few hundred meters up to 1800 m. Usually only a single specimen is seen at any time. It occurs in well preserved forest in the western, central, and eastern mountains. There is an old record from the Zapata Swamp in south western Cuba, which is very humid with dense forest (Núñez, 2021, pers. comm.).

In Jamaica, adults hide in shaded rock crevices within the forest during the day from where they are easily disturbed during daylight hours. Adults are also flushed from their daytime resting places by smoke during slash and burn cultivation events in the Dominican Republic (Turner, pers. obs.). In Jamaica, adults appear toward dusk, with solitary males patrolling back and forth with an undulating flight inside territories defined by small clearings within the forest or by steep-walled limestone ‘cockpits’. Mating has not been observed and there has been no description of the immature stages from the Greater Antilles. Both sexes are attracted to artificial lights, but in low numbers, and mostly with only a single specimen seen on any given night, and moths often continue to fly by rather than settle (Turland, pers. obs.). In Jamaica, this species has been seen in January, between May and August, and in October but is most frequently seen between July and August.

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Figure 5. *Mania aegisthus* in Jamaica: ♂ Marshall’s Pen, Manchester Parish (left); ♂ Marshall’s Pen, Manchester Parish (center); ♀ Stony Hill, St. Andrew Parish (right). ♀ photo courtesy of John Fletcher.

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On the Picture-winged Leaf Moths (Lepidoptera: Thyrididae) from Chittagong University Campus, Bangladesh, with a report of a pouch-like structure on the caterpillar metathoracic legs of *Aglaopus decussata* Moore and notes on its life history

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Abstract: We studied nine morpho-species belonging to six genera of thyridid moths from the Chittagong University campus, Bangladesh. Four of them are identified to species, of which three are new records for Bangladesh. *Striglina* Guenée, 1877 was the most diverse genus, with *Striglina scitaria* (Walker, 1862) observed more than ten times, while other species were observed only once. The life history and immature stages of *Aglaopus decussata* (Moore, 1883) are described for the first time. A modification on the caterpillar metathoracic legs is reported, which makes these legs resemble boxers' hands with boxing gloves. Images of the adults of all the studied species, along with images of the female genitalia of *Aglaopus decussata* (Moore, 1883) and *Collinsa* cf. *acutalis* (Walker, [1866]), are provided. In addition, a taxonomic note on the misidentification of *Picrostomastis subrosealis* (Leech, 1889) from Bangladesh is provided.

Keywords: genitalia, leg modification, *Picrostomastis subrosealis*, pyraliform, *Striglina*.

INTRODUCTION

Thyrididae comprises 940 species in 93 genera worldwide (van Nieukerken *et al.*, 2011). The moths are small to large in size, with 9-90 mm wingspan (Heppner, 2008), and are widely distributed in tropical and subtropical regions in woodland habitat (Li, 1996). The species of this family are rare in comparison with many other lepidopterans and are usually represented by very few specimens in field collections (Whalley, 1976). The taxonomy of Thyrididae is largely unresolved and the family has often been considered as a polyphyletic group (Whalley, 1976) closely related to pyralid moths (Hampson, 1892; Whalley, 1976; but see Kawahara *et al.*, 2019). The caterpillars of this family are pyraloid or pyraliform with five pairs of prolegs (Hampson, 1892; Whalley, 1976).

Diagnostic characteristics of Thyrididae include the presence of a reticulated pattern on the upper and underside of both pairs of wings and, in a few species, the presence of fenestra or a clear window on the hind wing (Li, 1996). Hampson (1892) listed 55 species of thyridid moths belonging to 10 genera from India, Sri Lanka, and Myanmar, along with adjacent countries. Of them, three species were reported to occur in Bangladesh: *Dysodia ignita* Walker, 1865, *Herdonia osacesalis* Walker, 1859, and *Glanycus insolitus* Walker, 1855; while the following three species, *Banisia myrsusalis* (Walker, 1859), *Banisia myrtaea* (Drury, 1773), and *Striglina scitaria* (Walker, 1862), were reported to be distributed throughout [erstwhile] India (Hampson, 1892). More recently, Mazumdar *et al.* (2021) reported *Picrostomastis subrosealis* (Leech, 1889) from the Chittagong University campus, Bangladesh.

The caterpillars of Thyrididae show various morphological modifications. In the caterpillar of *Calindoea trifascialis* (Moore, 1877), Darling *et al.* (2001) reported an arm-like eversible paired protuberance situated dorsoventrally on the first abdominal segment at the opening of sac-like glands producing cyanogenic compounds. The behavior of the caterpillars, along with the description of the abdominal protuberance, was discussed by Darling *et al.* (2001) and Darling (2003). The protuberance, with cyanogenic compounds secreted from the sac-like glands, is part of a defense mechanism and is considered as an adaptation for the dry, dipterocarp forest habitats of southeast Asia (Darling, 2003). Possibly, this protuberance is widely distributed in Thyrididae, but so far it has been reported only in *C. trifascialis* (Darling, 2003).

In the present paper, we studied nine morpho-species belonging to six genera of thyridid moths from the Chittagong University campus, Bangladesh. Four of them are identified to species, of which three are new records for Bangladesh. *Striglina* Guenée, 1877 was the most diverse genus, with *Striglina scitaria* (Walker, 1862) observed more than ten times, while other species were observed only once. The life history and immature stages of *Aglaopus decussata* (Moore, 1883) are described for the first time. A modification on the caterpillar metathoracic legs is reported, which makes these legs resemble boxers' hands with boxing gloves. Images of the adults of all the studied species, along with images of the female genitalia of *Aglaopus decussata* (Moore, 1883) and *Collinsa* cf. *acutalis* (Walker, [1866]), are provided. In addition, a taxonomic note on the misidentification of *Picrostomastis subrosealis* (Leech, 1889) from Bangladesh is provided.

MATERIALS AND METHODS

Chittagong University is situated at Zobra Village of Hathazari Upazila in Chittagong District, Bangladesh (22°27'30"-22°29'0"N & 91°46'30"- 91°47'45"E), about 6 km east of the Bay of Bengal (Haidar *et al.*, 2017). The campus comprises 1754 acres of land and is the largest university in Bangladesh. About 60% of the land area of the campus is covered by steep or very steep hills (Hossain *et al.*, 2013), and overall 72% of the land comprises hills, lakes, ponds, plains and valleys as low as 16 m above sea level (Islam *et al.*, 1979). The vegetation is semi-evergreen (Ahsan & Khanom, 2005), and a total of 665 plant species in 126 families and 404 genera have been recorded from the campus, of which 550 are dicotyledons and 115 are monocotyledons (Alam & Pasha, 1999).

Moths were observed at various locations of the Chittagong University campus from 2018 to 2021. During the day moths were observed directly within their natural habitat, while at night moths were observed at porch lights in residential areas. Specimens of only two species, *Collinsa* cf. *acutalis* (Walker, [1866]) and *Aglaopus decussata* (Moore, 1883), were collected using plastic boxes containing cotton soaked with acetone as a killing agent. Remaining species were photographed using a cell-phone camera.

Identification was done mainly on the basis of original descriptions, as well as descriptions given by Hampson (1892), Whalley (1976), and Whitaker *et al.* (2014). Type materials, where accessible, were examined, including images of types at the NHMUK (The Natural History Museum, London, U.K.). Caterpillars were collected and reared inside square plastic boxes with suitable ventilation and moisture. Genitalia dissection of voucher specimens was done following the procedures given by Robinson (1976).

RESULTS

Family **Thyrididae**
Subfamily **Siculodinae**

Genus ***Calindoea* Walker, 1863**
Calindoea Walker, 1863, *List Spec. Lepid. Insects Colln. Br. Mus.* 27: 87.
Type-species: Calindoea cumulalis Walker, 1863.
Distribution: China and India to Solomon Islands (Robinson *et al.*, 1994).

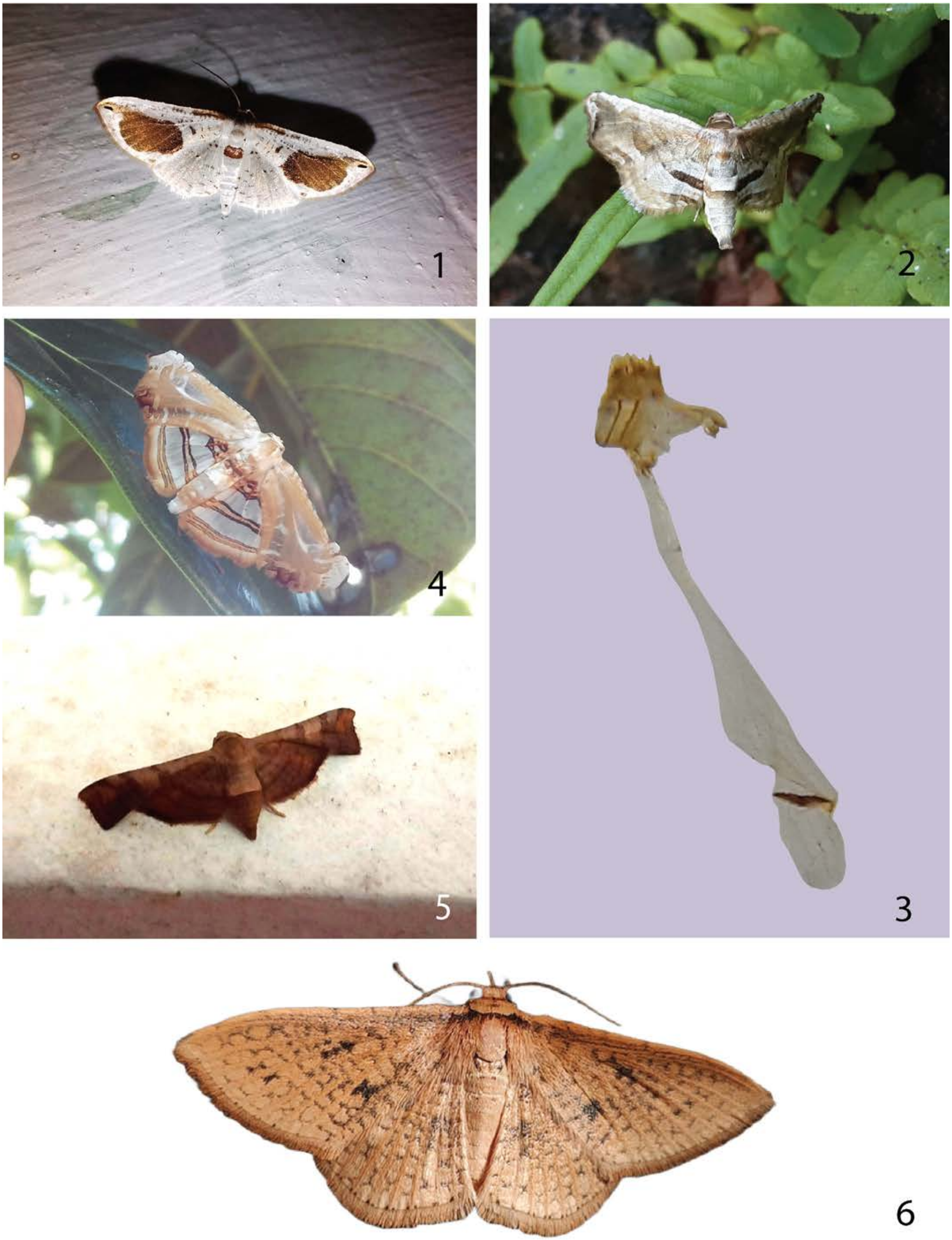
Calindoea argentalis (Walker, [1866])
Figure 1
Pyralis argentalis Walker, 1866, *List Spec. Lepid. Insects Colln. Br. Mus.* 34: 1522.
Type-locality: Java (Images of type material examined from NHMUK).
Material examined: Only one individual photographed from Shaheed Abdur Rab Hall, Chittagong University Campus (22°28'27.70"N, 91°47'07.26"E) on 4.V.2018.
Diagnosis: A white moth with bronze head and collar. Easily recognizable from the congeners by the following characteristics: wings are slightly striated with bronze, forewings with a prominent oval-shaped large bronze postmedial patch, a prominent elongated black ocellus in subapical region, and abdomen having bronze band proximally.
Distribution: Java, Borneo, Bhutan, Sri Lanka, India (Hampson, 1896; Whitaker *et al*., 2014), Bangladesh (present study).
Remarks: New record for Bangladesh.

Genus ***Collinsa* Whalley, 1964**
Collinsa Whalley, 1964, *Ann. Mag. Nat. Hist.* (13)7: 118.
Type-species: Dohertya roseopuncta Warren, 1902
Distribution: Africa, Indo-Australian region, America (Whalley, 1971).

Collinsa* cf. *acutalis (Walker, [1866])
Figures 2-3
Pyralis acutalis Walker, 1866, *List Spec. Lepid. Insects Colln. Br. Mus.* 34: 1523.
Type-locality: Indonesia (Misool) (Images of type material studied from NHMUK)
Material examined: BANGLADESH, Chittagong University, Fateyabad road (22°27'33.56"N, 91°48'53.54"E), 30.XI.2021, 1♀, *leg.* Jahir Rayhan, Sayema Jahan.
Diagnosis: This species is differentiated from other closely related species of *Collinsa* by the following characteristics: a whitish brown moth, forewings with distinct darker brown lines with whitish 'c'-shaped apical spot, and the hind wings with antemedial line darker and very prominent.
Remarks: The female genitalia is somewhat similar to that of *Collinsa acutalis* and *C. hamifera* (Moore). However, it is distinct due to the sclerotized signum and its dentition, for which the species has been provisionally identified as a member of *C. acutalis* group, pending further investigation.

Genus ***Herdonia* Walker, 1859**
Herdonia Walker, 1859, *List Spec. lepid. Insects Colln Br. Mus.* 19: 963.
Type-species: Herdonia osacesalis Walker, 1859
Distribution: India, Nepal, Myanmar, Thailand, China, Japan, Sundaland, Philippines, New Guinea, Bangladesh (Hampson, 1892; Inoue, 1993).

***Herdonia* sp. 1**
Figure 4
Material examined: Single individual photographed from Shaheed Abdur Rab Hall, Chittagong University Campus (22°28'27.70"N, 91°47'07.26"E) in 2019.
Diagnosis: The observed species differs from *Herdonia osacesalis* Walker, the most closely similar species occurring in Bangladesh, in the basal band of the hind wings forming an angle at the outer side, and the marginal band being wider.
Remarks: The moth was observed during daytime resting on the leaf of a mango tree.



Figures 1-6. Adult moths. **1.** *Calindoea argentalis* (Walker, [1866]); **2-3.** *Collinsa* cf. *acutalis* (Walker, [1866]); **4.** *Herdonia* sp. 1; **5.** *Kanshizeia* cf. *obscuralis* (Hampson, 1893); **6.** *Aglaopus decussata* (Moore, 1883).

Genus ***Kanshizeia*** **Strand, 1920**
Kanshizeia Strand, 1920, *Arch. Naturgesch.* 84(A)12: 188.
Type-species: Kanshizeia camadenalis Strand, 1920
Distribution: Madagascar, Aldabra, Mauritius, Africa and north India (Whalley, 1971 [as *Hapana*]).
Remarks: The genus is newly recorded for Bangladesh.

Kanshizeia* cf. *obscuralis (Hampson, 1892)
Figure 5
Hypolamprus obscuralis Hampson, 1892, *Fauna Br. In.* 1: 365.
Type-locality: India (Sikkim) (Images of type material examined from NHMUK).
Material examined: Only one individual photographed from Faculty of Science Building, Chittagong University Campus (22°28'12.95"N 91°46'58.36"E) on 23.IV.2019.
Diagnosis: The observed species resembles the only Indian species of this genus, *Kanshizeia obscuralis* Hampson, in having an overall pale chestnut coloration with elongated forewings with straighter outer margin, and broad hind wings with rounded outer margin. Both wings are striated with darker lines forming broader bands on the forewings. There is an oblique line extending from the costa towards the inner angle of the forewings.
Remarks: The moth was observed only once, resting up above a wall during day time. Further study is needed to confirm the identification, including collecting and examining specimens.

Picrostomastis subrosealis (Leech, 1889) (presence in Bangladesh requiring confirmation)
Microsca subrosealis Leech, 1889, *Entomologist* 22: 66.
Type-locality: China (Yunnan: Ningpo) (Images of type material studied from NHMUK)
Taxonomic note: P. subrosealis is distributed in China, Hong Kong, Sri Lanka, Myanmar, Thailand, Sumatra, West Malaysia, Singapore, Brunei, Sabah, Sarawak, Java, Bali, Philippines, Australia, and India (Whitaker *et al*., 2014). Mazumder *et al*. (2021) reported this species from Chittagong University campus, Bangladesh. The image of the species provided by Mazumder *et al*. (2021; plate VI, figure 83) is not from Bangladesh but originated in Australia, Northern Territory, according to BOLD (2022). In BOLD, there are 4 public records of *P. subrosealis*, forming 1 BIN (DNA sequence cluster potentially representing a species), with specimens from two countries, Australia and Bangladesh, deposited in two institutions (Australian National Insect Collection, Canberra, ACT, Australia and Centre for Biodiversity Genomics, University of Guelph, Ontario, Canada), but the adult photographs are only available for Australian specimens. The DNA barcode data suggest that the specimens from Australia and Bangladesh belong to the same species, but after studying the type material and the BOLD photographs of Australian specimens, we suggest these specimens are misidentified. Instead, we suggest that they possibly belong to the genus *Microbelia* Warren, 1906, because they have wing maculation similar to *Microbelia*, namely the presence of a single black punctum in the central area of both wings and a triangular or V-shaped marking extending back from the forewing costa (Whitaker *et al.*, 2014). If this suggestion is correct, then it follows that the putative *P. subrosealis* BOLD specimens from Bangladesh noted by Mazumder *et al.* (2021) are also misidentified. We were unable to determine the identity of the specimens collected by Mazumder *et al*. (2021) from the Chittagong University campus, but re-examination of the Australian specimens, for which the data is present in BOLD, and the specimens from Bangladesh which were studied by Mazumder *et al.* (2021), is required.

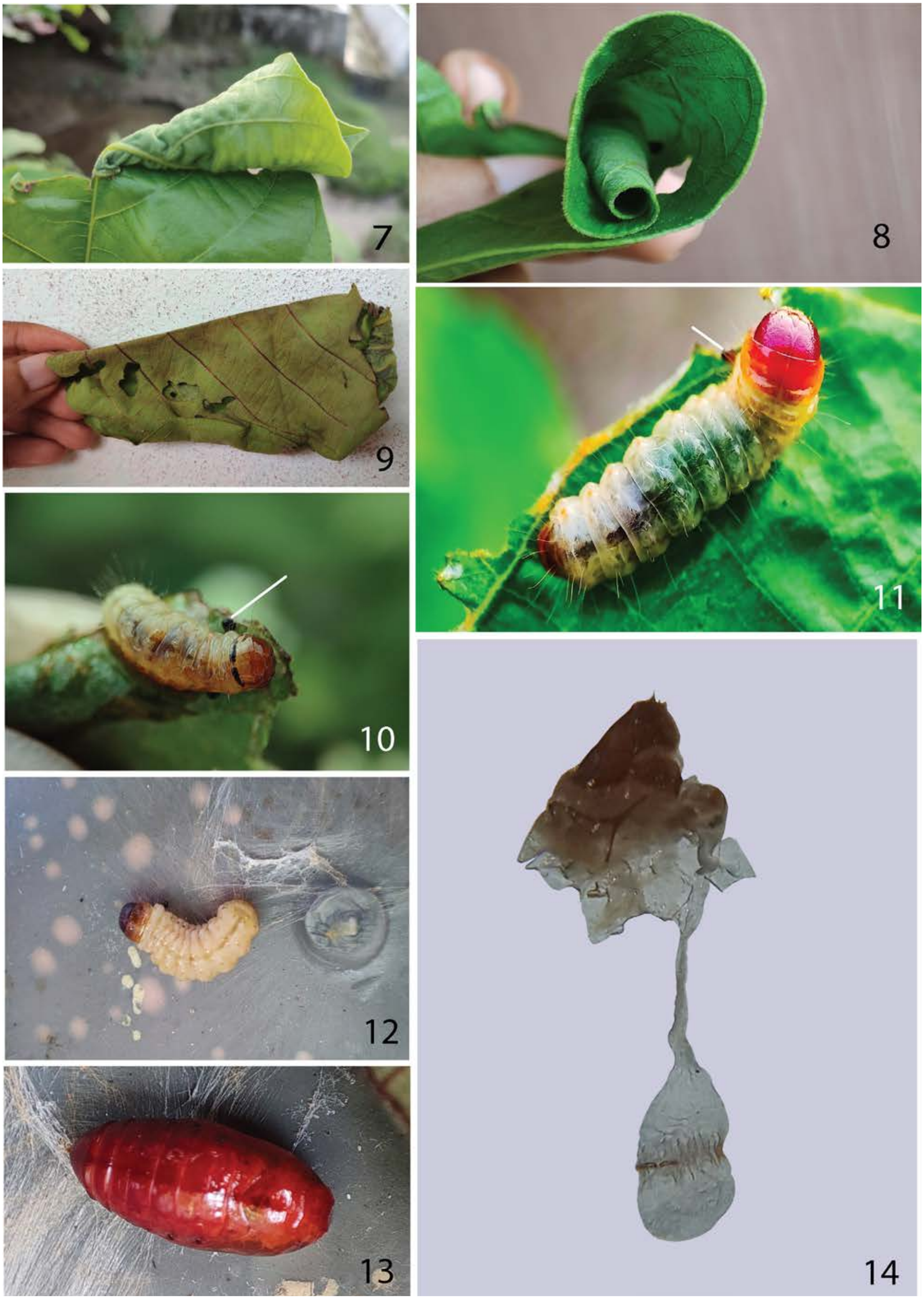
Subfamily **Striglininae**

Genus ***Aglaopus*** **Turner, 1911**
Aglaopus Turner, 1911, *Ann. Qd Mus.* 10: 97 [key], 98.
Type-species: Aglaopus niphocosma Turner, 1911
Distribution: India, Indonesia, New Guinea, Australia, China, Ethiopia (Whalley, 1976 [as *Misalina*]; Whitaker *et al.*, 2014).
Remarks: The genus is newly recorded for Bangladesh.

Aglaopus decussata (Moore, 1883)
Figures 6-21
Sonagara decussata Moore, 1883, *Proc. Zool. Soc. Lon*. Pg. 27, pl. 6, fig. 8.
Type-locality: India (Type materials not examined).
Material examined: BANGLADESH, Chittagong University, Faculty of Biological Science, 22°27'58.33"N, 91°46'52.14"E, 10.X.2021, 5.XII.2021, 8 caterpillars, 23.X.2021, 1♀, *leg*. Jahir Rayhan, Sayema Jahan.
Diagnosis: Externally, *A. decussata* is closely similar to the other members of *Aglaopus glareola* (Felder & Rogenhofer, 1875) species group, which includes *A. glareola*, *A. ferocia* (Whalley, 1976), *A. decussata*, *A. industa* (Whalley, 1976), *A. sordida* (Pagenstecher, 1892), and *A. gemmulosa* (Whalley, 1976), but it is quite distinct in genitalia characteristics. The female genitalia (Fig. 14) have the papillae analis shorter, and the bursa copulatrix with paired spiny signa and a sclerotized patch of spines.
Notes on life history: The life history of *Aglaopus decussata* (Moore, 1883) has not been previously described, and it is documented here for the first time.

Caterpillar (Figs. 7-12, 15-21): A final instar caterpillar (Figs. 11, 15) was collected on 10 October 2021 feeding on a leaf of *Litsea monopetala* (Roxb.) Pers. (Lauraceae) inside a conical leaf shelter (Figs. 7-9) made by rolling the leaf near the tip. The conical shelter had several holes made by the caterpillar while feeding. The final instar caterpillar (Fig. 11) is stout, cream-colored and somewhat translucent (internal organs are visible from the outside), and has numerous setae on the body. The thoracic legs are black with modified hind legs, and the prolegs are cream-colored. The chaetotaxy was not studied. The head, frontal part of the prothorax, and tip of the abdomen are reddish-brown. There is a trace of a dark dorsal line on the body.

During another field visit on 5 December 2021 in the same location, the same plant was found to be covered with numerous larval conical shelters. Seven caterpillars among them were collected in the early instar stages, but the attempt to rear them was unsuccessful as they died after a week. The conical shelter was opened up intentionally, and we observed that the caterpillars again rolled up the leaves, but not in a



Figures 7-14. *Aglaopus decussata* (Moore, 1883); **7-9.** conical leaf shelter; **10.** early instar caterpillar (collected on 5th December, 2021); **11.** final instar caterpillar; **12.** pre-pupating stage; **13.** pupa; **14.** genitalia. (White line indicates modified metathoracic legs).

conical fashion, rather in a simple rolling fashion similar to that of tortricid leaf rollers. The prothoracic shield of these early instar caterpillars (Fig. 10) has a dark black line broken in the middle which was observed as faded in the final instar caterpillar (collected on 10 October, 2021).

A peculiar modification (Figs. 10-11 & 15-21) of the metathoracic legs was observed in all the caterpillars studied herein. Each caterpillar has a dark black pouch-like modification on the distal part of the metathoracic legs which is easily recognizable and very prominent. The pouch is variable in size (0.5-1.5 mm) and contains yellowish liquid of unknown type. Because of the modified pouch-like structure, the metathoracic legs resemble the hands of boxers wearing boxing gloves.

Pupa (Fig. 13): The final instar caterpillar collected on 10 October 2021 started to pupate on 13 October 2021 outside the leaf shelter with the pre-pupating stage (Fig. 12, 16) darker with a dark brown head and thorax. The dorsal dark line is prominent. Secretion of silk was observed but no cocoon was made. The pupa is stout and dark red, formed on a bed of silken threads instead of a cocoon.

Adult (Fig. 6): A female moth emerged from the pupa on 23 October 2021. The wings are brownish with small dark spots, and the forewing has a dark spot at the end of the discal cell and one below it near the inner margin. At the end of almost all wing veins there are paired dark small spots on the outer margin at the base of the fringe. The base of the forewing and collar are dark. There is a notable depression at the base of the abdomen dorsally.

Distribution: India, Thailand, West Malaysia, Sabah, Sarawak, Sumatra, Java, West Papua, Philippines, Taiwan (Whitaker *et. al.*, 2014), Bangladesh (present study).
Remarks: New record for Bangladesh.

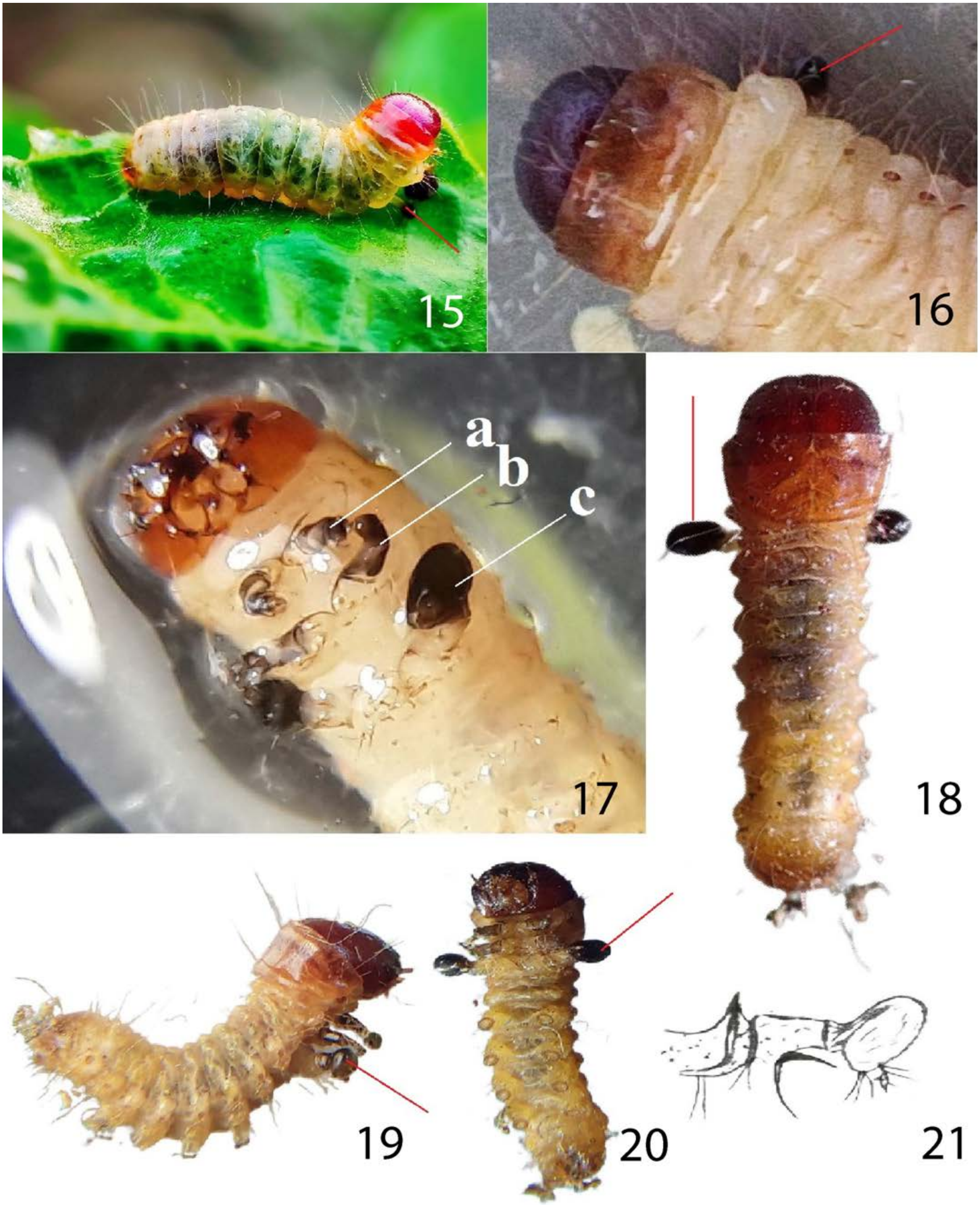
Genus ***Striglina* Guenée, 1877**
Striglina Guenée, 1877, *Ann. Soc. ent. Fr.* (5) **7**: 283.
Type-species: Striglina lineola Guenée, 1877
Distribution: Old World tropics and subtropics to Australia, temperate Asia to Japan (Whalley, 1976).
Remarks: Among all the recorded genera, this genus was found to be the most diverse.

Striglina castaneata Hampson, 1914
Figure 22
Striglina castaneata Hampson, 1914, *Ann. Mag. Nat. Hist.* (series 8) 14: 109.
Type-locality: Singapore (Images of type material studied from NHMUK).
Material examined: Only one individual was photographed from Shaheed Abdur Rab Hall, Chittagong University Campus (22°28'27.70"N, 91°47'07.26"E) on 24.XI.2019.
Diagnosis: Striglina castaneata differs from other congeners in the absence of the prominent median fascia or patches on the forewing and hind wing. The median fascia in this species is inconspicuous, thin, discontinuous, and runs from the forewing stigma to the hind wing dorsum. It is a red-brown moth with dark reticulations, more prominent on the distal half of the forewing and hind wing.
Distribution: Singapore, China, India, West Malaysia, Brunei, Philippines (Whalley, 1976; Whitaker *et al.*, 2014), Bangladesh (present study).
Remarks: New record for Bangladesh.

Striglina scitaria (Walker, 1862)
Figure 23
Drepanodes scitaria Walker, 1862, In *List Spec. Lepid. Insects Colln. Br. Mus.* 26: 1488.
Type-locality: Sri Lanka (Images of type material studied from NHMUK)
Material examined: More than 10 individuals from various locations of the Chittagong University Campus including Shaheed Abdur Rab Hall (22°28'27.70"N 91°47'07.26"E) and Faculty of Biological Science (22°27'58.33"N 91°46'52.14"E). Figure 23 was taken from the Shaheed Abdur Rab Hall on 28.III.2018.
Diagnosis: Externally, the species is allied to several other species together forming the *S. scitaria* species group. The species of this group are best identified by the male genitalia. *Striglina scitaria* has a variable wing pattern, but externally it can be distinguished from the other species of the group by the hind wing, in which the subsidiary transverse line is strongly curved at the middle and continues towards the tornus.
Distribution: India, Sri Lanka, China, Taiwan, Korea, Japan, Maldives, Nepal, Myanmar, Vietnam, Thailand, Laos, Malaysia, Brunei, Indonesia, Philippines, Australia, Fiji, Bangladesh (Hampson, 1892; Whitaker *et al.*, 2014).
Remarks: A very common moth in comparison to other species, being observed more than ten times during the study period, especially in the cold season. The hostplants of this species, *Acacia*, *Cassia* (Fabaceae), *Terminalia* (Combretaceae), and *Mangifera indica* L. (Anacardiaceae), are abundant in the study area. In addition, during the winter season, another hostplant of this species, beans (*Phaseolus*, Fabaceae), is cultivated almost everywhere by the local people (for hostplant data see Robinson *et al.*, 2010).

***Striglina* sp. 1**
Figure 24
Material examined: Only one individual photographed from Shaheed Abdur Rab Hall, Chittagong University Campus (22°28'27.70"N 91°47'07.26"E) on 04. V. 2018.
Diagnosis: The suffusions on the diagonal line are thin and the moth is considerably larger in comparison with *S. scitaria*.
Remarks: Because of its considerably larger size and thin suffusion on the diagonal line, the moth appears to be allied to *Striglina irresecta* Whalley, 1976.

***Striglina* sp. 2**
Figure 25
Material examined: Only one individual photographed from Faculty of Science, Chittagong University Campus (22°28'12.95"N, 91°46'58.36"E) on 10. X. 2021.
Diagnosis: This moth differs from *S. scitaria* in the origination of the diagonal line from the forewing costal margin, and in the curvature of the post-median line on the hind wing.
Remarks: The wing maculation suggests that this moth may be related to *Striglina propatula* Whalley, 1974.



Figures 15-21. *Aglaopus decussata* (Moore, 1883), Caterpillars with modified metathoracic leg. **15.** final instar caterpillar; **16.** pre-pupating stage; **17.** frontal part in ventral view (a. foreleg; b. mid leg; c. hind leg); **18.** dorsal view; **19.** lateral view; **20.** ventral view; **21.** sketch of hind (metathoracic) leg. (Red lines indicate pouch on the metathoracic leg).

Figures 22-25. Adult moths. **22.** *Striglina castaneata* Hampson, 1914; **23.** *Striglina scitaria* (Walker, 1862); **24.** *Striglina* sp. 1; **25.** *Striglina* sp. 2.

DISCUSSION

Thyridid moths have assumed pest status on many occasions. *Striglina scitaria* has been reported as a leaf roller in cultivated plants such as *Sesbania bispinosa* (Jacq.) W. Wight, *Erythrina* sp. (Fabaceae), *Mangifera indica*, *Populus* sp. (Salicaceae), and *Terminalia bellirica* (Gaertn.) Roxb. (Robinson *et al.*, 2010). Sapota Midrib Borer *Banisia myrsusalis elaralis* (Walker, 1859) caused more than 10% damage to Sapota *Manilkara zapota* (L.) P. Royen (Myrtaceae) in the hill region of Karnataka state in India (Satish *et al.*, 2013). The present study documents *Litsea monopetala* (Lauraceae) as the first host plant record of *Aglaopus decussata* (Moore, 1883). *Aglaopus glareola* (Felder & Rogenhofer, 1875), a closely related species of *A. decussata*, is known to feed on *Camelia sinensis* (L.) Kuntze (Theaceae) and *Cinnamomum zeylanicum* J. Presl (Lauraceae) (Robinson *et al.*, 2010).

Protecting biodiversity needs a good understanding of the floral and faunal diversity of our surrounding environment. Bangladesh, being one of the most human-dominated parts of the world, is under threat of biodiversity loss due to different anthropogenic pressures (Mukul *et al.*, 2018). The current study on the diversity of thyridid moths along with the life history data on *Aglaopus decussata* will help in building up knowledge of biodiversity for further conservation efforts. Comprehensive taxon sampling may reveal more species in this family as well as give further important knowledge on the life history of this little-known group of moths.

The metathoracic leg modification of the caterpillars of *Aglaopus decussata* is an important finding of this study. After reviewing published data and works on the immature stages of different species of Thyrididae, no report of such modification could be found. Published data on the caterpillars of the other species of *Aglaopus* do not mention anything about this kind of modification. This type of organ modification is possibly a new report for Thyrididae and may be an adaptation for the caterpillars to live inside leaf shelters, or for defense against predators, or to withstand certain environmental conditions. Further study will be conducted to understand the function of this structure and its role in the survival of the caterpillars.

Information on the life history of not only the Thyrididae but also other moth groups is still lacking or scarce. The modified abdominal protuberance as mentioned in Darling (2001) and the modifications to the leg reported in the present study exemplify the numerous mysterious and yet to be discovered aspects of Lepidoptera biology. From the evolutionary perspective, the origin and adaptive benefit of such modifications could be an important topic for future study.

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Transformations of Atala: Effects of heparin on wing pattern development of the Atala Butterfly, *Eumaeus atala* (Lepidoptera: Lycaenidae: Eumaeinae)

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Abstract: *Eumaeus atala*'s normal coloration, both of its brightly colored caterpillars and adult butterflies, is famous among lepidopterists and butterfly enthusiasts. The ventral hindwing pattern is characterized by iridescent markings arranged in imperfect concentric circles on a black background. In this study, injections of heparin at the early pupal stage caused a radical transformation of the wing pattern, in the first demonstration of heparin-induced phenotype alteration in Lycaenidae. Changes in wing pattern ranged from slight to dramatic, depending on the dose of this sulfated polysaccharide that was administered. The predominant effect was on the iridescent blue pattern elements of the hindwings. These experiments allowed us to propose that the markings of Atala belong to one or another symmetry system, which shed light on the homologies of pattern elements present on the wings of this beautiful iconic Florida butterfly, within the framework of the Nymphalid Groundplan and of other works on lycaenid wing patterns. Additionally, an unusual Atala specimen from our laboratory culture is illustrated, perhaps representing a mutation in which dorsal patterning is transferred, in part, to the ventral wing surface in a mosaic manner.

Key words: nymphalid ground plan (NGP), pharmacology, sulfated polysaccharide, *wingless*, *Wnt*

INTRODUCTION

There are several recent developments that make the study of the beautiful lycaenid, the Atala Butterfly, very exciting. For instance, its life history and seasonal polyphenism have recently been examined in detail by Koi & Daniels (2017), an investigation into Atala's opsins was recently published by Liénard *et al.* (2021), and sequencing this species' genome helped determine some of the underlying evolutionary trends in Eumaeini (Robbins *et al.*, 2021). The evolutionary development of the beautiful color pattern of this butterfly has not yet been studied however, and the present study is the first attempt in this direction, through the use of heparin injections.

Most experiments using heparin injections conducted to date have involved Nymphalidae, a family that has also been at the forefront of other types of Lepidoptera wing pattern research projects (e.g., Gallant *et al.* 2014; Martin & Reed, 2014; Martin *et al.*, 2012; Mazo-Vargas *et al.*, 2017; Monteiro, 2015; Zhang *et al.*, 2017). However, several other families have also recently been the subjects of experiments. A study by Fenner *et al.* (2020) examined *Colias* Fabricius, 1807 (Pieridae); Sourakov (2020) and Reed & Mazo-Vargas (2021, pers. comm.) experimented on several genera of Papilionidae; Sourakov & Shirai (2020) compared heparin influence on eyespots of the Io and Polyphemus moths (Saturniidae); and Sourakov (2020) looked at the effect of this compound on the wing pattern development of a crambid moth and of several erebids.

The activity of regulatory genes that have been implicated in mapping out wing pattern elements (*Wnt* ligand genes) is likely to be affected by heparin, as demonstrated by experiments combining heparin injection with gene expression determination (e.g., Martin & Reed, 2014). One hypothesis is that heparin is easing the flow of the morphogen that determines the color and shape of scales from the wing pattern organizers, such as wing margins or nymphalid marginal eyespot centers. It is likely that the morphogen travels further through intracellular spaces under the influence of heparin injections than under normal conditions. This, in turn, seems to affect *Wnt*-positive pattern elements by causing them to increase in size, frequently in the direction of the morphogen's spread. Only pattern elements belonging to certain symmetry systems within the wing, such as the Central Symmetry System (CSS) or the Marginal Band System (MBS), tend to be affected by heparin. As concentrations of heparin increase, many pattern elements tend to break down and disappear altogether (see, for example, Sourakov, 2020). Thus, for the heparin tests to be useful for understanding homologies, they need to be applied to a large enough sample size and at variable quantities and times before (BP) and after (AP) pupation, so that a gradient of transformations can be obtained. Though undoubtedly somewhat crude, heparin injections are a useful tool for probing homology among wing pattern elements within and across species, as demonstrated by Sourakov & Shirai (2020), and, perhaps, for determining the time frame during which pattern elements are formed during metamorphosis.

Among abovementioned studies, Martin & Reed (2014) examined a highly patterned species of nymphalid, known as the Variable or Chalcedon Checkerspot, *Euphydrias chalcedona* (Doubleday, 1847). By attributing its various pattern elements to symmetry systems (e.g., basal, discal central and external, in their terminology), their experiments demonstrated very clearly how the Central Symmetry System (CSS) and the External one (or the Marginal Band (MBS) following Otaki's (2012) terminology) are "*Wnt*-positive," meaning that they expand under the influence of heparin. The same symmetry systems contract under the influence of dextran sulfate, a substance that was first shown by Serfas & Carrol (2005) to have the opposite effect to heparin when applied to the developing pattern of the Buckeye butterfly *Junonia coenia* Hübner, 1822. Martin & Reed (2014) also convincingly demonstrated that the wing pattern elements belonging to the Border Symmetry System (BoSS in Otaki (2012)) do not expand under the influence of heparin. This symmetry system in nymphalids, on which the Nymphalid Groundplan (NGP) was developed by Schwanwitsch (1924) and then modified by many others, is associated with border serial eyespots as well as the adjacent parafocal elements. In general, instead of bands exhibited in a "standard" NGP, many butterflies have concentrically organized (though sometimes displaced) spots. This is because the original bands are "broken up" by veins which influence pattern formation by providing barriers that guide morphogen flow. If veins disappear, as happens on occasion in veinless mutants (e.g., *Papilio xuthus* Linnaeus, 1767 (Koch & Nijhout, 2002) or Monarch *Danaus plexippus* (Linnaeus, 1758) (Sourakov, 2020)), the normally disjunct spots become continuous bands.

Among Lycaenidae, the patterns of polyommatine blues can superficially resemble miniature NGP. Many patterns can be imagined as a series of concentric circles with the center at the attachment points of the wings. Since the time of the great novelist and lepidopterist, Vladimir Nabokov, who attempted to schematize these wing patterns in his descriptive work on Polyommatini (see, for example, Nabokov's drawings in Blackwell & Johnson, 2016), these patterns have undergone some scrutiny and attempts at generalization. Much more recently, Iwata *et al.* (2013) fed mutagen (ethyl methane sulfonate) to the Pale Grass Blue butterfly, *Zizeeria maha* (Kollar, 1844), and obtained mutations distorting spots in a fashion that supported the existence of pattern elements homologous with the central symmetry system of NGP. In a follow-up paper, using the same polyommatine model species, Iwata *et al.* (2015) analyzed not only mutations, but also cold-induced aberrations (both natural and artificial). The authors also analyzed two species belonging to the tribe Lycaenini, concluding that their model may also be applied to other subfamilies and tribes of the Lycaenidae. In addition, the recent article by Gardiner & Terblanche (2010) reviewed the wing patterns of two Aphnaeinae lycaenid genera (*Erikssonia* Trimen, 1891 and *Aloeides* Hübner, [1819]) within the context of the NGP.

The present study is an attempt to interpret the wing pattern of the beautiful, aposematic and toxic butterfly, *Eumaeus atala* (Poey, 1832), belonging to yet another lycaenid subfamily, the Eumaeinae, which shares some common features with the aforementioned subfamilies, but stands out from the other Lycaenidae due to the disappearance of some of its wing pattern elements (Fig. 1). Here, we used heparin injections to obtain a gradient of aberrations, and thus offer a glimpse into the similarities and differences in the effects that heparin has on this in comparison with other butterfly families.

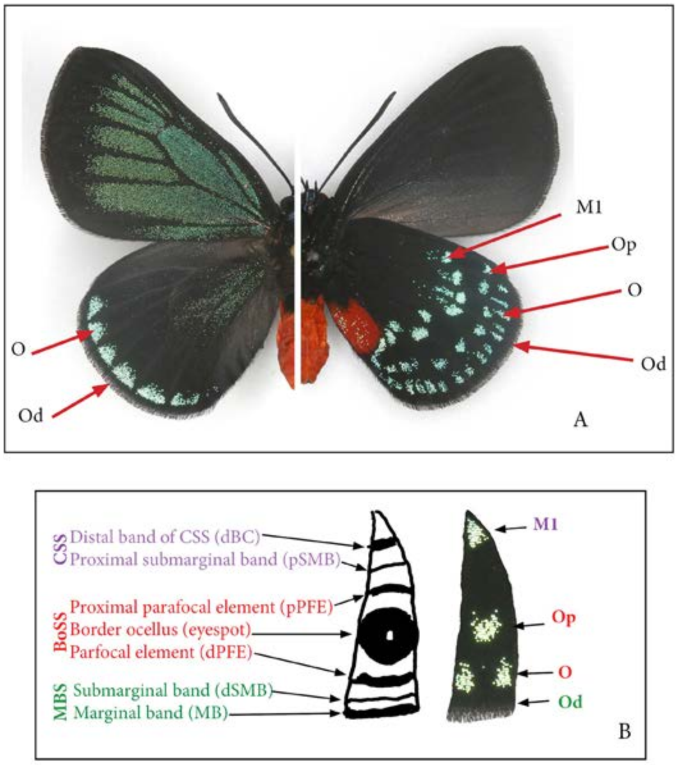

Figure 1. (A) A schematic showing concentric organization of *Eumaeus atala* wing pattern. Gardiner & Terblanche (2010) terminology: Od - part of distal symmetry system, O - border oceli, Op - proximal border, M1 - Medial CSS. (B) Pattern from the single cell (M3) of the ventral hindwing surface shows revised nymphalid groundplan (after Otaki (2012)) and same for the Atala: BSS - basal symmetry system. CSS - central symmetry system; BoSS - border symmetry system; MBS - marginal band system.

MATERIALS AND METHODS

The Atala laboratory colony was composed of two subpopulations (marked as "D" or "M" in Suppl. Table 1, for their origins from either the Disney captive colony or from a wild population in Montgomery, Florida, respectively). The unmanipulated individuals exhibited a certain amount of natural variation (Fig. 2). Caterpillars were maintained at the Florida Museum of Natural History, University of Florida, Gainesville, FL, USA, on foliage of *Zamia integrifolia* (Zamiaceae). Larvae were kept in the laboratory at 22°C, but the prepupae and pupae were chilled to 17°C prior to injections with heparin solution droplets that varied in quantity and concentration. Heparin sodium salt from porcine, manufactured by MP Biomedicals, Inc., was first dissolved at 1 part salt : 4 parts water (by weight) to 21% (the maximum concentration used for injections) and then diluted to achieve the desired concentrations, going as low as 1%. Droplets were measured out with a micropipette and injected using a hypodermic syringe: subcutaneously in prepupae

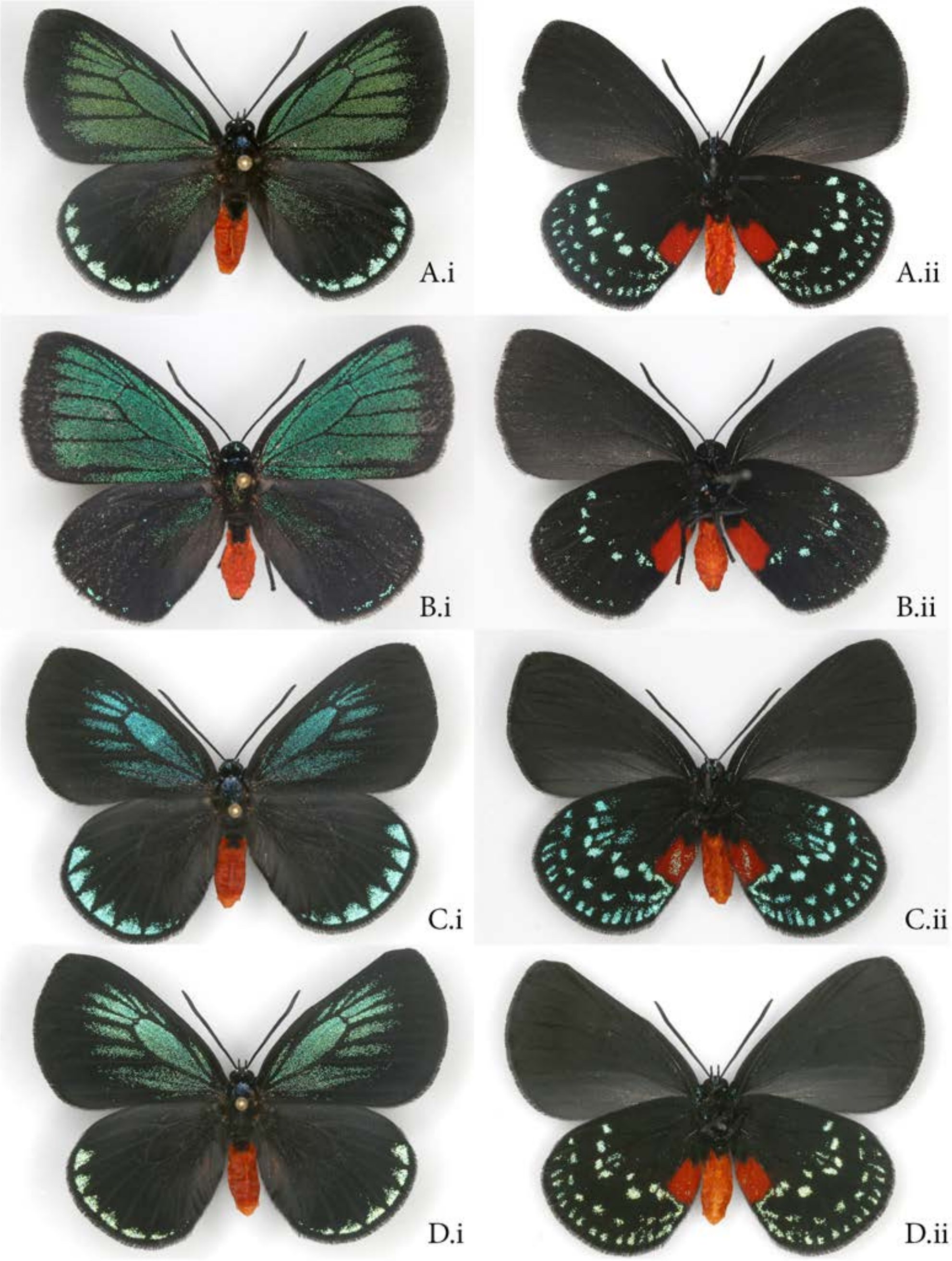

Figure 2. Examples of variation found among wild-type *Eumaeus atala* in our captive colony during the experiments: (A,B) males, (C,D) females, (i) dorsal, (ii) ventral. Males and females share ventral color pattern, but dorsally in the female the iridescent markings, although more pronounced on the hindwing along the margin, do not extend distally on the forewing as far as in males. The tint of males' iridescence is grass-green or emerald-green (A,B), while that of females is greenish or bluish, depending on the season/pupation temperature (C,D) as was previously determined by Koi & Daniels (2017).

(Fig. 3A), or deep and into the middle of the abdomen dorsally in pupae (Fig. 3B). Atala caterpillars both feed and pupate in clusters and were therefore reared in large plastic bags hanging on ropes. As they entered the prepupal stage (spined silk pads on which they tend to pupate gregariously and became immobile), the bags were cut into sheets and the prepupae were monitored for pupation. The pupae were separated into individual 2-oz cups until adult butterflies eclosed.

A total of 150 individuals were injected with heparin at different concentrations and an additional 16 were injected with distilled water. Among individuals that survived the injections with heparin and spread their wings (N=88 or 59%), the injection timing ranged from 60 hours before pupation (hBP) to 43 hours after pupation (hAP). A similar span of stages was treated with water injections as controls. The prepupae were monitored and pupation time range was noted as accurately as possible,

Figure 3. (A) Prepupae and (B) a pupa of *Eumaeus atala*. Red arrows show the angle and approximate site of heparin/distilled water injections. (C) Wild-type (left) vs. heparin-induced transformations (middle, right).

with variable precision. The heparin solution quantity ranged from 0.5 ul to 1 ul, and concentrations ranged from 1% to 21%. A total of 53 individuals received heparin at concentrations of 2.5-3%, which early on proved to be an effective dose for inducing wing pattern transformation; 23 individuals received solutions of 1-1.5% (ca. 0.005 mg),10 individuals received 5% solution (ca. 0.025 mg), and two received 21% solution (ca. 0.1 mg). The data concerning injections and photographs of the resulting specimens can be found in Supplementary Files (low resolution) as well as in high resolution in the OSF data depository (Sourakov, 2022). Numerous additional unmanipulated specimens from the colony numbering over 100 individuals were preserved at the same time as the experimental specimens were emerging to assess the pattern variability within our laboratory culture at the time. All voucher specimens are labeled as such, in addition to their MGCL number, and are deposited in the collection of the McGuire Center at the Florida Museum of Natural History (MGCL).

RESULTS AND DISCUSSION

Wing pattern change

As the Atala butterflies are sexually dimorphic, we illustrate the outcomes of heparin injections in males (Fig. 4) separately from those in females (Fig. 5). While the dorsal iridescent patch does not appear to be heparin-sensitive, heparin can reduce its size in males, likely by expanding the size of the black heparin-sensitive patterns of more distal origins. Neither of the sexes is heparin-sensitive in the ventral HW red region, suggesting it is a remnant of the basal symmetry system, but that, as well as all other symmetry systems attributions, would need to be confirmed by gene expression determination work.

In males, when the supposed marginal band of the dorsal FW expanded under the influence of heparin (Figs. 4 (B.i-E.i)), it displaced the iridescent color basally, thus widening the wing's black margin. Since in females the iridescent scales of dorsal FW do not extend as far to the wing margin as in males, the marginal band expansion under heparin's influence is not readily observable (Fig. 5A.i-G.i).

The supposed CSS (M-1 (see Fig. 1)) expands at lower heparin doses, while the more proximal heparin-sensitive spots (Op and O), possibly corresponding to the border symmetry system, begin to disappear and are displaced distally (Fig 5C.ii). As the effect of heparin becomes more pronounced, M-1, O and Op merge into short longitudinal stripes on the ventral HW (e.g., Figs. 4B.ii, 5D.ii). This effect is reminiscent of the gradient of transformation that has been achieved in Buckeyes by Serfas & Carroll (2005) (and recently replicated by Sourakov (2020)). As we increased the amount of injected heparin, the affected pattern elements began to break down and disappear (Figs. 4E, 5G). The result was a stunning butterfly of a very different appearance from the wild-type phenotype, illustrating how one butterfly pattern can rapidly transform into another via regulatory mechanisms. In Fig. 6, we provide schematic repre-

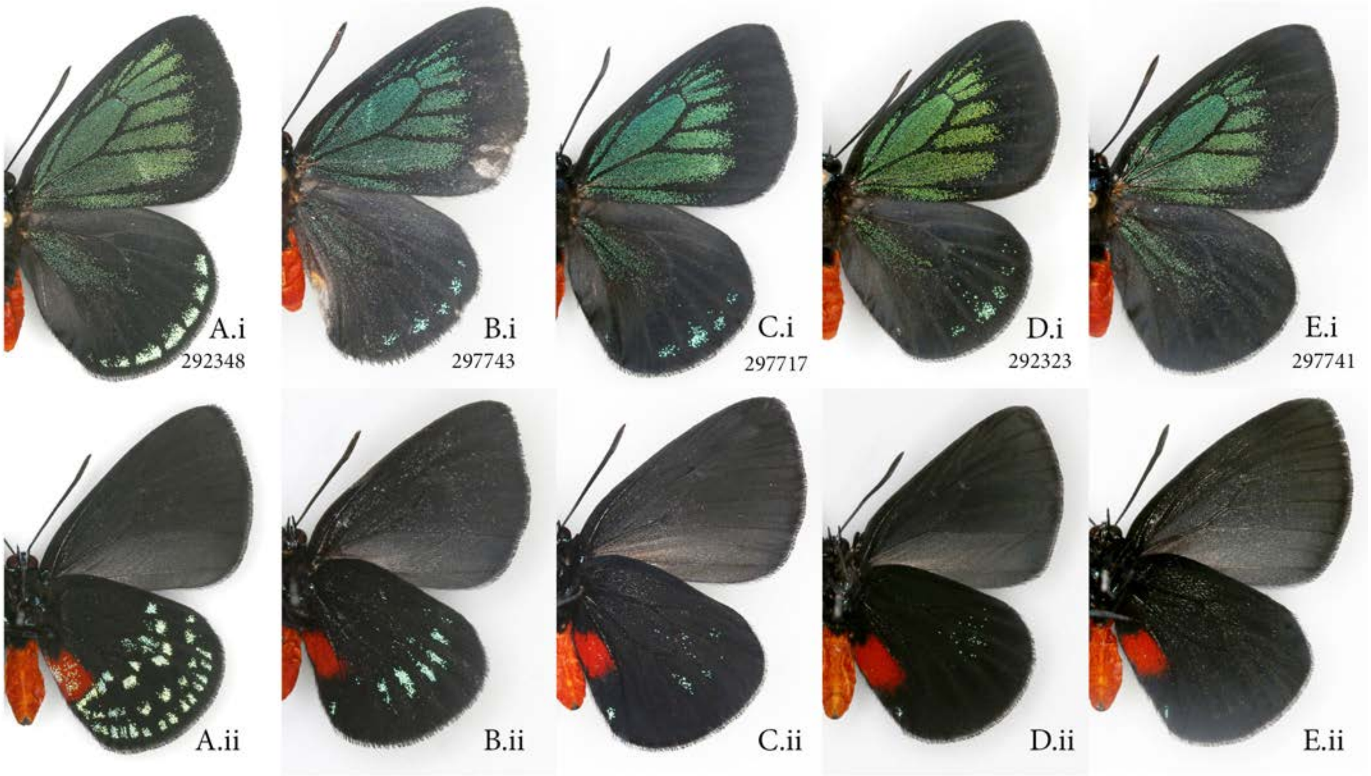

Figure 4. Heparin-induced changes in the wing pattern of *Eumaeus atala* males: (i) - dorsal, (ii) ventral. (A) Normal pattern resulting from H$_2$O-injected control; (B-F) Injected heparin as pupae at (B) 6 hAP, 0.018 mg (0.6 ul, 3%); (C) 10-15 hAP, 0.018 mg (0.6 ul, 3%); (D) 2-5 hAP, 0.0175 mg (0.7 ul, 2.5%); (E) 10-15 hAP, 0.018 mg (0.6 ul, 3%).

Figure 5. Heparin-induced changes in the wing pattern of *Eumaeus atala* females: (i) - dorsal, (ii) ventral. (A) H2O-injected control; (B-G) Injected heparin as pupae at (B) 5-7 hAP, 0.0075 mg (0.5 ul, 1.5%); (C) 5-7 hAP, 0.01 mg (1 ul, 1%); (D) 4-5 hAP, 0.03 mg (1 ul, 3%); (E) 5-10 hAP, 0.018 mg (0.6 ul, 3%); (F) 25 hAP, 0.0125 mg (0.5 ul, 2.5%); (G) 5-10 hAP, 0.015 mg (0.5 ul, 3%).

sentation of how individual pattern elements, corresponding to lycaenid-specific elements of Gardiner & Terblanche (2010), were affected by heparin.

Timing of injections and heparin amount

The role of heparin was further emphasized by the correlation between its quantity (concentration) and the degree of transformation (Fig. 7). Substantial wing pattern changes occurred in the 55 individuals injected from late prepupae (ca. 5 hBP or less) and until 43 hAP, with heparin doses between 0.0125-0.025 mg (0.5-1 ul of 2.5-5% solution). The younger prepupae were not affected regardless of heparin amount: for example, the two individuals that survived the injection of 21% heparin solution (ca. 0.1 mg) at 12 and 24 hBP had a wild-type wing pattern. However, the four individuals that were injected at a late prepupal stage, after the separation of the cuticle from

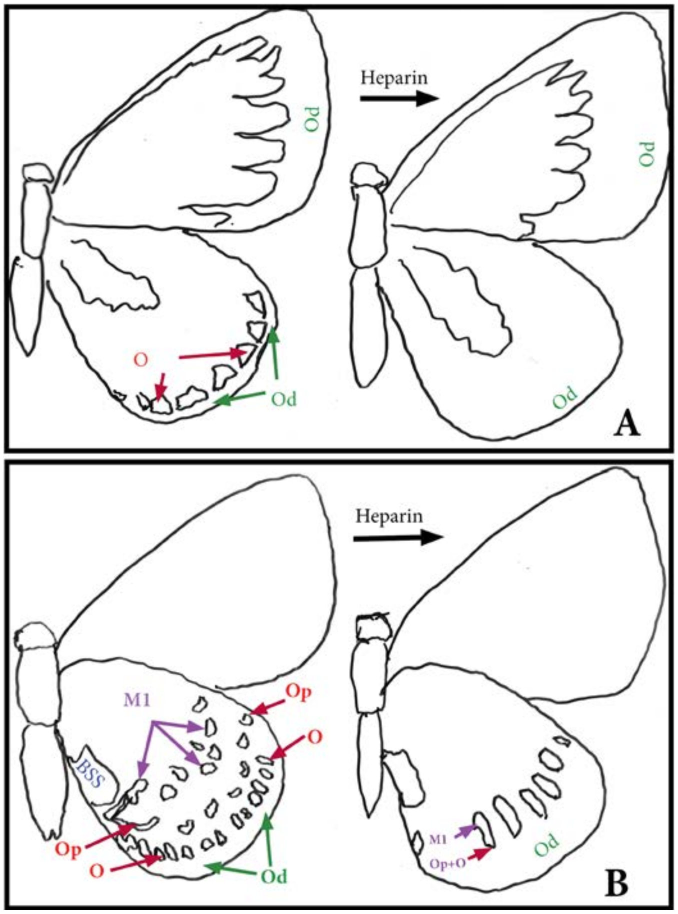

Figure 6. Visualizing wing pattern transformation of *Eumaeus atala*. **A**. dorsal wings; **B**. ventral wings. Od - part of distal symmetry system, O - border ocelli, Op - proximal border, M1 - Medial CSS (terminology after Gardiner & Terblanche (2010)).

the underlying pupae, were transformed. Such individuals have very thin skin, easily pierced with a needle. This stage can *de facto* be considered a pharate pupa, but for the sake of convenience we refer to all animals that have not shed their integument during pupation as "prepupae."

It remains unclear whether the wings are simply insensitive to heparin influence during most of the prepupal stage until the pharate pupa is formed under the larval skin, or whether prepupae, which in this species have an unusually thick defensive integument, are able to prevent foreign substances injected under their skin from entering their circulation. If the former is true, this would contrast with several species from other families such as Nymphalidae, Erebidae, and Saturniidae, where heparin can affect wing pattern development when injected both in the prepupal and pupal stages (Sourakov, 2020). Yet it would not be entirely surprising, as the forming wings of Atala remained sensitive to heparin significantly later than in the families mentioned above. In fact, while many individuals injected after 24 hAP did not survive, pattern transformation was achieved as late as 43 hAP, in contrast with Nymphalidae and Erebidae, where wing transformations could rarely be achieved after the 20 hAP mark (Serfas & Carroll, 2005; Sourakov, 2020). Perhaps the period during which the wing pattern mapping processes occurs is simply shifted forward relative to pupation time compared to other families.

Mortality

The increase in mortality during our experiments can be linked to larger quantities of injected solution, larger heparin concentrations and to using older pupae. It was found that injecting small droplets of 0.5 ul or less with concentrations of 2.5-3% (ca. 0.02-0.03 mg) at 5-15 hAP may represent optimal conditions for achieving results.

The mortality in the present experiment of 42% was higher than observed in toxin-sequestering Polydamas Swallowtails *Battus polydamas* (Linnaeus, 1758), Zebra Longwings *Heliconius charithonia* (Linnaeus, 1767), Monarchs or Tiger Moths (Erebidae), where it can be as low as 10-20%. It is still quite low, however, compared to non-sequestering species, such as Giant Swallowtails *Heraclides cresphontes* (Cramer, [1777]) or Tawny Emperors *Asterocampa clyton* (Boisdval & Leconte, [1835]), where 70-80% of organisms died (Sourakov, 2020). Mortality in the Atala noticeably increased once heparin concentrations exceeded 5%, with all pupae injected with 21% heparin solution dying (even though sometimes as fully-formed individuals failing to emerge from the pupal case). Pupae that had already hardened (20 hAP or more) had lower survival rate under injections (see Supplementary Fig. 4). Mortality of the water-injected control individuals was low, at only 1 among the 16 individuals (or 6%), which also supports the notion that higher heparin dosage rather than an injection itself was the cause of increased mortality.

As a caterpillar, the Atala feeds on highly toxic cycad plants in the genus *Zamia*, but, unlike the heroine of Chateaubriand's novella for which this butterfly was named (who poisoned herself), it is well adapted to poisons. Not only can it detoxify cycasin (the neurotoxic glucoside) in the plant, but it can also sequester the compounds for defense (hence the aposematic coloration). Based on previous experiments with a variety of Lepidoptera species, heparin-caused mortality seems to be higher in species that do not sequester toxic compounds; species like the Monarch or Polydamas Swallowtail that feed on toxic milkweeds and pipevines, respectively, show a very high degree of tolerance to heparin (Sourakov, 2020). We suspect that the small size of pupae may have also contributed to the higher mortality as compared to other toxin-sequestering butterfly species tested with heparin injections previously.

Natural heparin-induced-like aberrations

After examining ca. 1,500 citizen scientist observations of *E. atala* (with over 80% of photographs showing the ventral wing pattern of adults) on the iNaturalist website, a single specimen was found that was observed in Miami, Florida by Noah Frade (Frade, 2018) with an aberrant pattern similar to some of those obtained with heparin injections. No similar aberrations were found among specimens in our laboratory population nor among the 550 specimens examined in the MGCL collection, consistent with these phenotypes being very rare in nature. This is not too surprising; in previous heparin studies, searching photographs and specimens in the collection of *Dione vanillae* (Linnaeus, 1758) and *Automeris* spp. for aberrations similar to those obtained with heparin yielded only five wild-caught specimens for the former and one for the latter. However, in some other species, such as *Battus polydamas* or

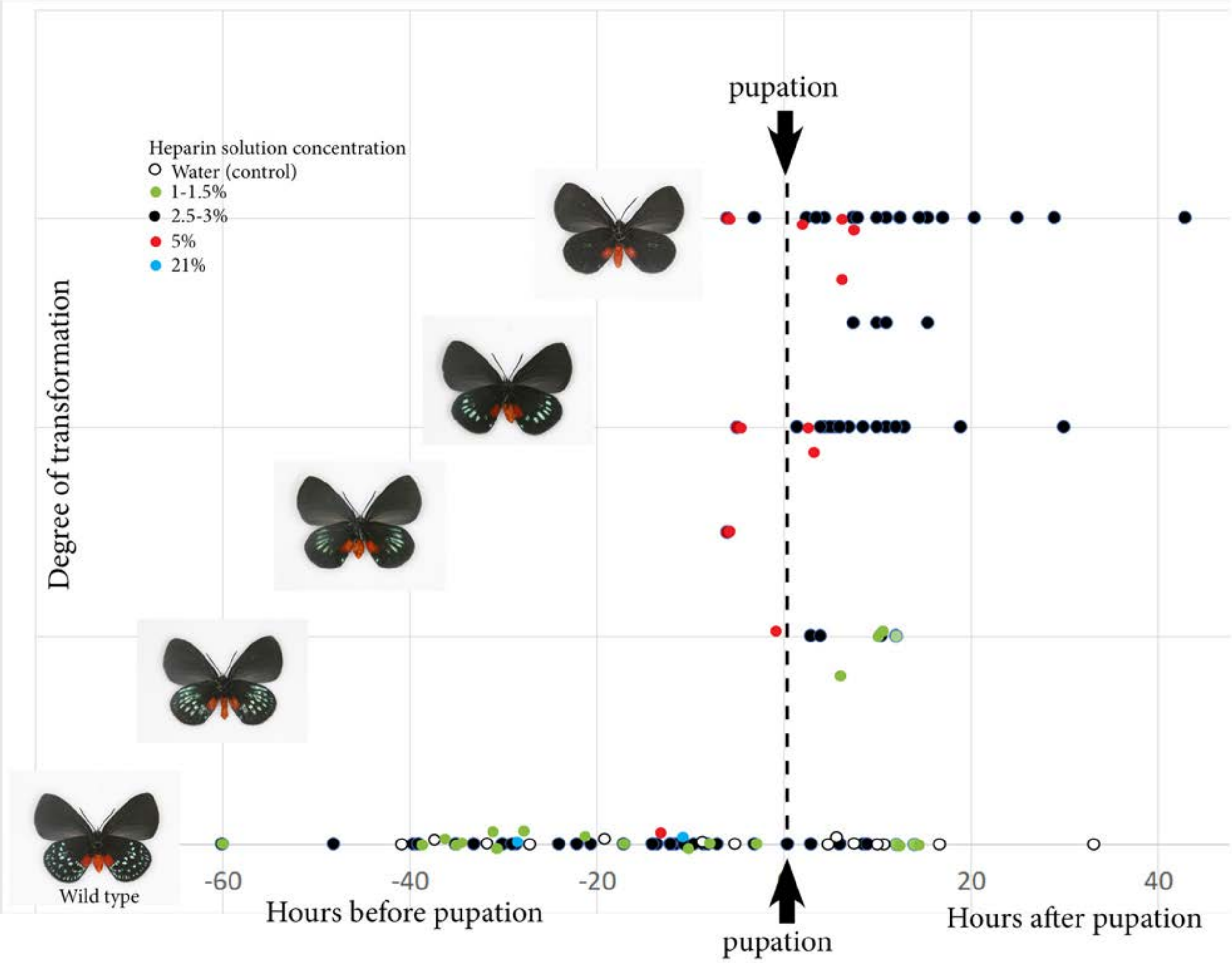

Figure 7. Transformation of *Eumaeus atala* wing pattern under the influence of heparin as a function of developmental stage and heparin amount. Transformation was most likely when injection of 0.5 ul was made after pupation at 2.5-3% concentration (black dots), or when higher doses of heparin (red dots = 5%) were injected before pupation. Injection of water (white dots), lower doses of heparin (green dots = 1-1.5%) or injections of high doses (including 21% - blue dots) into prepupae caused little or no transformation. See supplementary table and figures for details.

Junonia coenia, heparin-induced forms may closely resemble populations of another, geographically isolated, subspecies or species (Sourakov, 2020).

Concluding remarks

Interpreting the Atala butterfly's individual pattern elements as belonging to one or another symmetry system based on their color or location may have led us to erroneous conclusions about their homology, as the pattern elements seem to be able to migrate around the wing and change in color rapidly in the course of evolution. For instance, the border symmetry system elements of the ventral hindwing found along the wing margin of many swallowtails (e.g., *Papilio xuthus*) has relocated to the middle of the wing in *Heraclides cresphontes*, as is obvious from the heparin injection experiments of Sourakov (2020); the metallic markings on the ventral surface of *Dione vanillae* belong to different symmetry systems as shown by Martin & Reed (2014). Building on previous works, among others, by Schwanwitsch (1949), Nijhout (1991), Itawa *et al.* (2013, 2015) and Gardiner & Terblanche (2010), who discussed wing patterns of lycaenids relative to the NGP, we have obtained additional evidence of lycaenid pattern elements, as represented in *E. atala*, belonging to one or another symmetry system.

By conducting heparin injections we were able to confirm that the inner band of iridescent markings on the ventral HW are heparin-sensitive, so are likely to be homologous to the central symmetry system, while the two identically colored outer bands may correspond to the border symmetry system of Nymphalidae. The marginal band system, while likely to be present and heparin-sensitive, is obscured by the black background color of the wings and is thus “invisible” until its existence is revealed by the effect of heparin, when it begins to displace the visible pattern elements both dorsally and ventrally. Judging by the proximal position of the ventral red HW spot, and the fact that it is not heparin sensitive, it may be a remnant of the basal stripe of BSS, but this, as well as all of the above conclusions, remain to be confirmed by gene expression work.

Figure 8. An aberrant specimen of *Eumaeus atala* from the lab colony exhibits bilateral asymmetry of wing pattern, perhaps due to somatic mutation. (i, iii) dorsal, (ii, iv) ventral.

Addendum: Reporting another aberrant pattern of Atala

As mentioned above, over 100 non-manipulated specimens from our laboratory culture were spread and added to the study group as additional controls to assess the presence of background variation. There was one aberrant specimen in that group lacking normal symmetry (Fig. 8). While the right side of the specimen is normal, most brightly colored scales (both iridescent and red) on the hindwing on the left side are displaced with background black scales. Unlike a local melanization that sometimes results from an injury to the developing pupa or from a non-lethal infection during wing formation, in this specimen the iridescent scales also disappeared sharply below F-P boundary of the left dorsal forewing surface (see Abbasi & Marcus, 2017 for the wing compartment terminology), but the rest of the iridescent pattern was not affected. Also, the normally plain black ventral surface of the same forewing acquired many iridescent scales above the F-P boundary, suggesting that the aberration is caused by developmental abnormality, perhaps due to a somatic mutation at the onset of the aberrant wing's development, with patterning from the dorsal wing surface being transferred to the ventral side in a mosaic way. Dissection of the abdomen of this female individual, as well as examining its appendages, head, and thorax, suggest that the aberration is restricted to the wings.

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Author Contribution: AS: Designed and performed experiments; wrote the article; **MJS, KR, JCD**: provided experimental animals.

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Supplementary Materials:

Suppl. Table 1. Specimen and image data, including (A) supplementary file containing the image, (B) stage at which injection was made (or unmanipulated specimen), (C) reference to an individual high resolution image (located in folders within Sourakov 2022), (E) hours before or after pupation when injection was made, (F) heparin concentration, (G) heparin volume, (H) heparin amount (mg), (I) brood.
https://osf.io/wx4ts

Suppl. Figure 1. Transformation of *Eumaeus atala* wing pattern under the influence of heparin, Part 1 of 3: Controls consisting of unmanipulated specimens chosen at random from the experimental brood as well as specimens injected distilled water. See Supplementary Table 1 for additional injection details.
https://osf.io/2s9hq

Suppl. Figure 2. Transformation of *Eumaeus atala* wing pattern under the influence of heparin, Part 2 of 3: Specimens injected heparin before pupation (as prepupae). See Supplementary Table 1 for additional injection details.
https://osf.io/tg8ba

Suppl. Figure 3. Transformation of *Eumaeus atala* wing pattern under the influence of heparin, Part 3 of 3: Specimens injected heparin after pupation (as pupae). See Supplementary Table 1 for additional injection details.
https://osf.io/vzpks

Suppl. Figure 4. Mortality of the *Eumaeus atala* pupae injected with heparin as a function of the injection time after pupation and heparin concentration. Mortality increased with the increase of heparin dosage and after pupae began to harden. The 4 additional pupae injected 21% heparin and another 4 injected 2.5% heparin after 72 hAP (not shown on the graph) here also died. (A) Alive, (D) Dead.
https://osf.io/gtb46

An annotated list of Jamaican butterflies of potential conservation concern

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Abstract: Conservation measures needed to prevent extinction of Jamaica's National Butterfly, the Homerus Swallowtail (*Pterourus homerus*), and, to a lesser extent, measures needed to protect the endemic Blue Swallowtail (*Protographium marcellinus*), have been documented from time to time, but there has been no recent or overall assessment of the conservation status of all the island's butterflies. To correct this omission, we provide a brief summary of all the species of Jamaican butterflies in potential need of conservation measures, pending further studies.

Key Words: deforestation, endemic species, field surveys, forest fragmentation, subpopulations.

INTRODUCTION

There are 138 species of butterflies recorded from Jamaica. One butterfly, an unidentified species of *Caligo* Hübner, [1819] described but not illustrated by Sir Hans Sloane, who visited Jamaica between December 1687 and March 1689, is apparently extinct, with no known Jamaican specimens in collections. There are also no specimens yet collected of what appears to be a species resembling the Cuban *Anetia cubana* Salvin, 1869 that has been observed in the Blue Mountains of eastern Jamaica, and an *Archaeoprepona*-like insect, possibly a stray from Hispaniola, observed on the north coast of the island. *Heraclides cresphontes* (Cramer, 1777), whose larvae develop on citrus, was a probable introduction and is no longer present. As discussed in Discovering Jamaican Butterflies (Turner & Turland, 2017), of the remaining 134 species, five species are vagrants from Hispaniola, and five are known as repeat migrants or temporary visitors, sometimes also breeding but apparently not becoming permanent island residents. Seventy-two of the remaining species are found commonly across the island and a further thirty species are uncommon, largely because they are restricted to particular habitats and not encountered as often as other species. These do not require any special conservation measures at this time. An additional twenty-five species are categorized as rare, often found in restricted habitats that are frequently under severe threat from habitat destruction. Because some of these species are rarely seen, several have not been adequately studied. Their true status therefore is in need of further investigation (Turner & Turland, 2017).

Species such as *Cyanophrys hartii* Turner & Miller, 1992, are very uncommon and have not been seen in recent years. However, Jamaica is a mountainous country with numerous unexplored microhabitats where species can be suddenly found after long absences. This was the case for *Grais juncta* Evans, 1953 Jamaican Hermit Skipper, where a male was collected in the Cockpit Country in 2008 after an absence of 68 years. The female, which was unknown, was photographed for the first time in October 2014 (Turner & Turland, 2017). Also, because

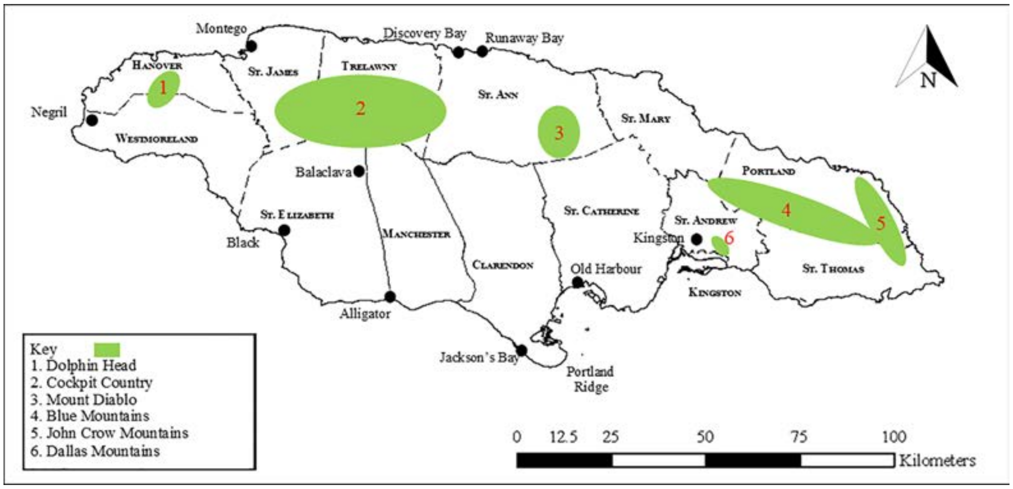


Figure 1. Map of Jamaica showing diagrammatic indication of key areas of conservation concern.

Jamaica, biologically speaking, is still not fully explored and because there are so few professional insect collectors in the island at any given time, much more systematic fieldwork needs to be done. There are still good reasons why, for example, *D. cleophile yameyensis* Turner & Turland, 2018, may yet be rediscovered in the central mountains of the island, even though this insect has not been reported since 1941.

Only *Pterourus homerus* (Fabricius, 1793), and *Protographium marcellinus* (Doubleday, 1845) are currently recognized by the International Union for Conservation of Nature and Natural Resources (IUCN) as being in need of conservation (Wells *et al*., 1983; Collins & Morris, 1985). However, a number of other Jamaican endemic species and subspecies are now confined to small habitats. These are often in isolated patches of primary forest subject to human incursions, which appear to be in need of conservation. They are listed here for the first time (Table 1).

Permit restrictions do not allow the publication of precise geographic coordinates of Jamaican butterflies in need of protection. Sites of occurrence between 1898 and 1972 are determined mostly from Brown & Heineman (1972). Sites of occurrence between 1973 and 2017 are determined from Turner & Turland (2017). The locations of species in need of protection between 2018 and the present time have been documented in continuing field surveys by Turner and Turland. Specimens have been photographed but not collected.

Table 1. List of Jamaican species of special conservation concern.

SPECIES	REASONS FOR CONCERN
Family **HESPERIIDAE**	
Subfamily Eudaminae	
Phocides perkinsi	Isolated population in the Cockpit Country.
Subfamily Pyrginae	
Grais juncta	Isolated population in the Cockpit Country.
Subfamily Hesperiinae	
Rinthon cubana	Insufficiently known.
Troyus turneri	Endemic genus and species. Insufficiently known.
Panoquina panoquinoides	Beach colonies. Threatened by development.
Panoquina ocola ocola	Rarely seen. Tiny, restricted habitats.
Lerodea eufala eufala	Rarely seen. Tiny, restricted habitats.
Family **PAPILIONIDAE**	
Subfamily Papilioninae	
Protographium marcellinus	Small, threatened, breeding sites. Currently IUCN Red List category **Vulnerable**.
Pterourus homerus	Two fragmented sub-populations. Currently IUCN Red List category **Endangered**.
Family **LYCAENIDAE**	
Subfamily Theclinae	
Cyanophrys hartii	Endemic. Known only from type.
Chlorostrymon orbis	Endemic. Known only from type.
Subfamily Polyommatinae	
Cyclargus shuturn	Endemic. Two small breeding sites.
Family **NYMPHALIDAE**	
Subfamily Danainae	
Greta diaphanus	Restricted forest habitats.
Danaus cleophile yameyensis	Endemic subspecies. Not reported since 1941.
Subfamily Nymphalinae	
Atlantea pantoni	Small fragmented sub-populations.
Antillea pelops pygmaea	Uncommon. Tiny shifting colonies.

Key to species distribution maps.

- ● Documented collection sites of specimens 1895-1995.
- ● Occasional sightings. Strays far from known breeding sites.
- ● Presence confirmed from surveys 1995-2020.
- ● Evidence of possible breeding sites, confirmation needed.

STATUS OF SPECIES IN TAXONOMIC ORDER

Phocides perkinsi (Kaye, 1931) (Hesperiidae: Eudaminae)

This endemic species is not commonly seen. It is a strong flying canopy dweller sometimes observed nectaring at *Gliricidia sepium* (Jacq.) Kunth ex Griseb or *Bauhinia divaricata* L. (both Fabaceae) flowers in and around the Cockpit Country. The larval foodplant is *Eugenia sachetae* Proctor (Myrtaceae), an endemic plant known only from southern Trelawny Parish in the Cockpit Country. Observations and collection records suggest this large powerfully flighted insect disperses from this small breeding area to both the north and south coasts, providing the false impression that the species permanently occupies a large territory and is a not uncommon species. The present breeding site is being subjected to gradual forest degradation.

Recommendations: Monitoring required. Both the butterfly and its known breeding area need to be periodically surveyed. Urgent surveys are required immediately followed by biannual surveys.

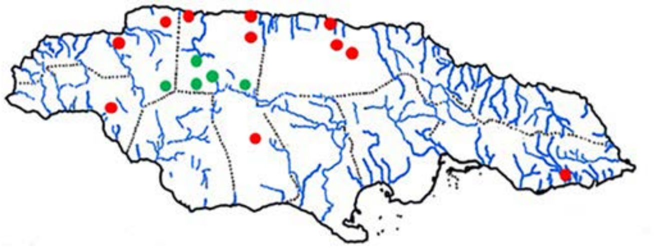


Figure 2. Distribution map, *Phocides perkinsi*.

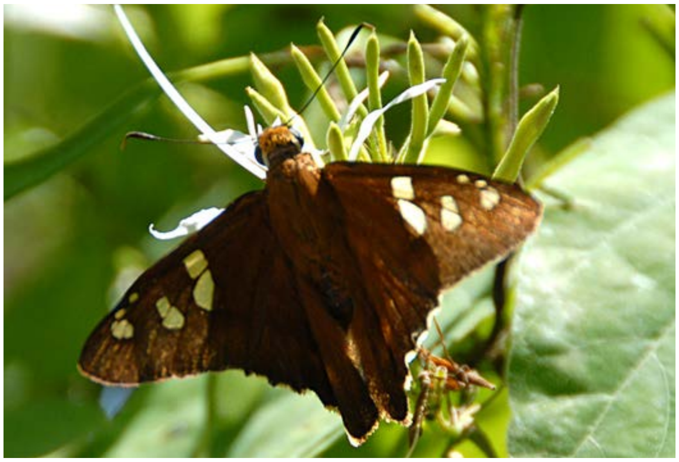


Figure 3. ♂ *Phocides perkinsi*, Cockpit Country, Apr., 2010.

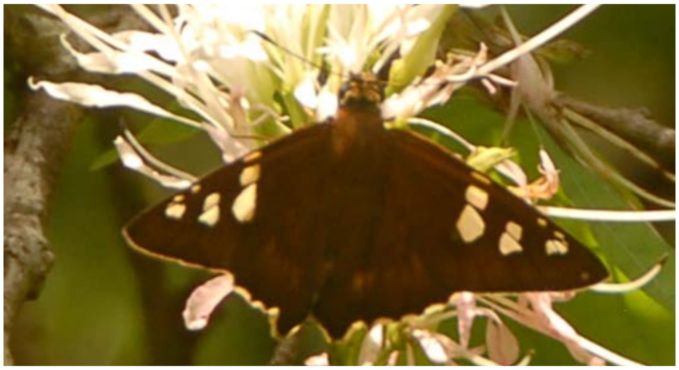


Figure 4. ♀ *Phocides perkinsi*, Cockpit Country, Apr., 2012

Grais juncta Evans, 1953 (Hesperiidae: Pyrginae)

This endemic species is rarely seen and the female has not yet been formally described. It is found only in the forests of the Cockpit Country. The larval foodplant has not yet been identified and the immature stages are undescribed.

Recommendations: Additional fieldwork is required to learn more about this insect's distribution, life history and behaviors. Relationships to mainland populations of *Grais* Godman & Salvin, [1894] are still unresolved.

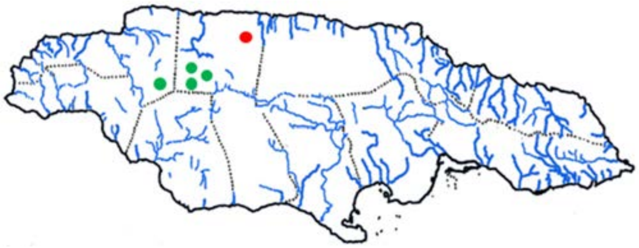


Figure 5. Distribution map, *Grais juncta*.

Figure 6. ♂ *Grais juncta*, Cockpit Country, Nov., 2014.

Figure 7. *Grais juncta*, ♀ Cockpit Country, Oct., 2014.

Rinthon cubana (Herrich-Schäffer, 1865) (Hesperiidae: Hesperiinae)

This skipper is very uncommon, found only on occasion in mesic habitats across the island. The taxonomic status of the Jamaican population needs to be resolved. The Jamaican insect is significantly smaller in size than those of populations from Cuba, Hispaniola and Puerto Rico, and also shows minor differences in the genitalia. In 1926, Kaye described this species as *Rinthon thermae*. Smith *et al.* (1994) and others regard all the Greater Antillean insects as *Rinthon cubana*. In Jamaica, the insect is recognized as subspecies *R. cubana thermae* (Turner & Turland, 2017).

Recommendations: This species is rarely collected. A series of specimens is required for examination and comparative studies to resolve differences of taxonomic opinions.

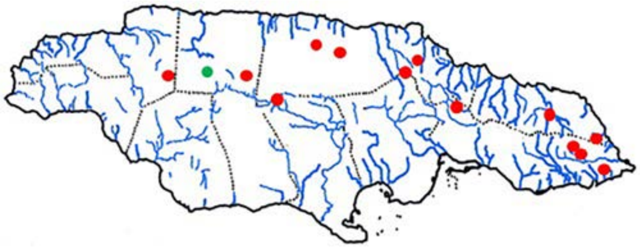


Figure 8. Distribution map, *Rinthon cubana*.

♂ dorsal, avg ws 36 mm, Barrett's Gap, St. Thomas, Jul., 1984.

♂ ventral (abdomen removed), (specimen courtesy of Ron King).

♀ dorsal, avg ws 36 mm, Carron Hall, St. Mary, Jul., 1952

♀ ventral.

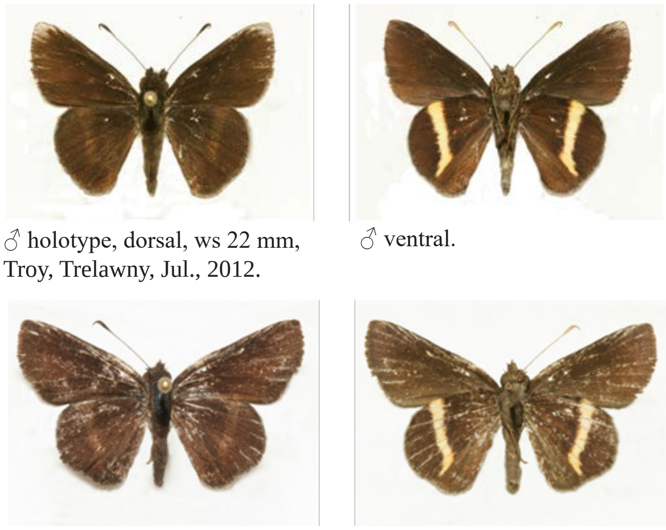
Figure 9. *Rinthon cubana* (♀ photos courtesy of Museum of Natural History Jamaica, Institute of Jamaica [MNHJ, IJ]).

Troyus turneri Warren & Turland, 2012 (Hesperiidae: Hesperiinae)

This new genus and species was discovered in the Cockpit Country in 2011 (Turland *et al.*, 2012). The site where the immature stages were found faces imminent destruction from encroachment into the forest. Up until 2022, adults had been found at just two other nearby locations. In May 2022, Turland added another location, still in Cockpit Country, but further east on the Burnt Hill Road near Barbecue Bottom in the parish of Trelawny.

Recommendations: This very uncommon species has only been found by the authors deep in the forests of the Cockpit Country. Further study and surveys are required to determine the habitat needs of the species and the current extent of its apparently very restricted territory.

Figure 10. Distribution map, *Troyus turneri*.



♂ holotype, dorsal, ws 22 mm, Troy, Trelawny, Jul., 2012.

♂ ventral.

♀ paratype, dorsal, ws 26 mm, Troy, Trelawny, Jul., 2011.

♀ ventral.

Figure 11. *Troyus turneri* (photos courtesy of Natural History Museum Jamaica, Institute of Jamaica).

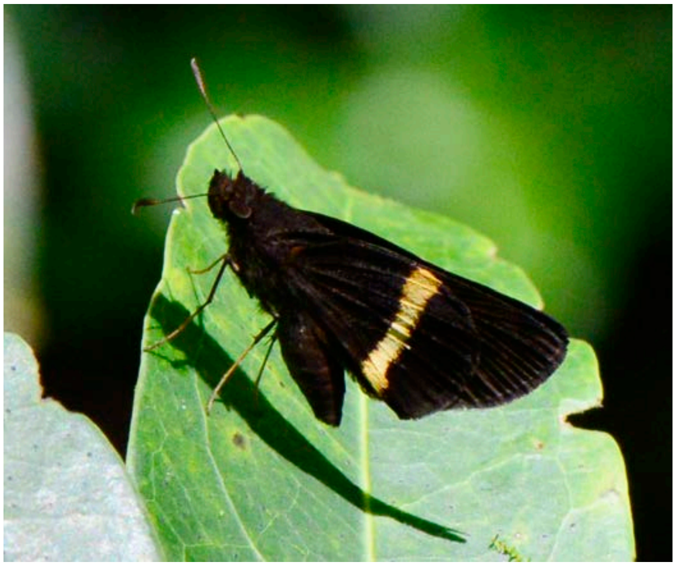


Figure 12. ♀ *Troyus turneri*, Cockpit Country, Trelawny, Sep. 2014.

Panoquina panoquinoides (Skinner, 1891) (Hesperiidae: Hesperiinae)

This coastal species is not uncommon throughout the Caribbean and the adjoining mainland, but in Jamaica this insect is represented by very small colonies found at the tops of sandy beaches near the confluence with permanent vegetation. Adults are usually found no further than 1.5 km from the sea. However, adults are not present at any one location throughout the year but appear briefly at a chosen location before disappearing again, presumably migrating to alternative sites along Jamaica's coastline. Full surveys are needed especially along southern and western beach heads. Because there are numerous hotels and privately owned villas along the Jamaican coast, beaches have been cleaned of native plants and are often landscaped, making those beaches unsuitable for even temporary occupation by this species.

Recommendations: Island-wide beach surveys are required, including those of the offshore keys. Several such surveys will need to be completed to locate isolated occupation sites which can be utilized at different times of the year.

Figure 13. Distribution map, *Panoquina panoquinoides.*

♂ dorsal, avg ws 23 mm, St. Thomas, May, 1972.

♂ ventral.

Figure 14. *Panoquina panoquinoides*.

Figure 15. ♀ *Panoquina panoquinoides*, Silver Sands, Trelawny, Nov., 2008.

Panoquina ocola ocola (Edwards, 1863) (Hesperiidae: Hesperiinae)

This skipper enjoys a wide circum-Caribbean distribution, but for reasons unknown in Jamaica it is found only in discrete locations from sea level up to 840 m in mesic locations, or in mesic habitats such as freshwater marshes within otherwise arid areas of the island. The reasons for such a random selection of occupation sites are unknown. The insect is generally uncommon and the immature stages in Jamaica have not been described.

Recommendations: Field surveys are required to locate occupation sites. The immature stages need to be discovered and described so comparisons can be made between these and other circum-Caribbean populations.

Figure 16. Distribution of *Panoquina ocola ocola.*

♂ dorsal, avg ws 31 mm, Fellowship, Portland, Sep., 1963.

♂ ventral.

Figure 17. *Panoquina ocola ocola*.

Figure 18. ♀ *Panoquina ocola ocola*, Black River Morass, St. Elizabeth, Aug., 2013.

Lerodea eufala eufala (Edwards, 1869) (Hesperiidae: Hesperiinae)

Although this insect occupies a wide geographic range from the southern United States, through the Caribbean and Central America to South America, for unknown reasons this insect is very uncommon in Jamaica. During the last 300 years it has been collected in very small numbers in isolated locations across the island from sea level to 1,500 m in the eastern Blue Mountain range, but it is rarely seen. Reasons for this rarity need to be determined.

Recommendations: Field surveys are required to determine reasons for the distribution patterns of this species and whether additional conservation measures are necessary.

Figure 19. Distribution map, *Lerodea eufala eufala*.

Figure 20. ♀ *Lerodea eufala eufala*, dorsal, avg ws 27 mm, Cinchona, St. Andrew, Apr., 1965, (photo courtesy of NHMJ, IJ).

Figure 21. ♀ *Lerodea eufala eufala*, Shooters Hill, Manchester, Sep., 2015.

Protographium marcellinus (Doubleday, 1845) (Papilionidae: Papilioninae) **VULNERABLE**

There are four very small confirmed breeding sites for this species, each approximately 1.5 km^2 in area. The habitat at two of these sites is heavily damaged and a third site is subject to disturbance. The fourth site in the Cockpit Country is currently undisturbed but is only 2.5 km from the forest edge, where destruction of the rainforest is nearly complete and is ongoing.

Recommendations: Additional surveys are urgently required during the short annual flight season to reassess the present state of each of the four subpopulations and to examine a possible fifth site. Recent assessments suggest the conservation status should be upgraded from Vulnerable to Endangered or Critically Endangered.

Figure 22. Distribution map: *Protographium marcellinus.*

Figure 23. ♂ *Protographium marcellinus*, Cockpit Country, Trelawny, Apr., 2015.

Figure 24. ♀ *Protographium marcellinus*, Cockpit Country, Trelawny, Apr., 2015.

Pterourus homerus (Fabricius, 1793) (Papilionidae: Papilioninae) **ENDANGERED**

The population is now reduced to five small separate subpopulations, each with even smaller overwintering ranges. Each subpopulation is in urgent need of protection against further forest destruction.

Recommendations: While the summer distribution of adults has been documented, the overwintering areas are in urgent need of definition as these are the localities occupied by this swallowtail when population numbers are at their lowest and most critical period. Fragmented subpopulations in and around the Cockpit Country, in particular, need urgent investigation.

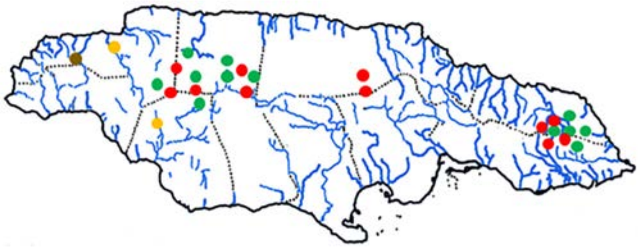


Figure 25. Distribution map, *Pterourus homerus*.

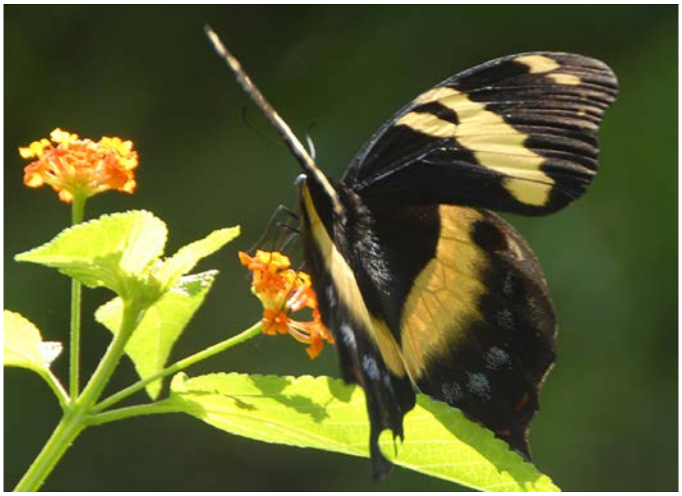


Figure 26. ♂ *Pterourus homerus*, Cockpit Country, Trelawny, Oct., 2011.

Figure 27. ♀ *Pterourus homerus*, Cockpit Country, Trelawny, Jul., 2012.

Cyanophrys hartii Turner & Miller, 1992 (Lycaenidae: Theclinae)

The male type was collected on the southern flanks of Dallas Mountain above the Hope River in July 1979 while feeding on *Cordia* flowers (Boraginaceae). The collection site has not since been thoroughly investigated. Additional information is discussed in Discovering Jamaican Butterflies (Turner & Turland, 2017).

Recommendations: Optimal times to find abundant nectar plants on which this species might be found are July-August and November-December. Fieldwork is urgently needed.

Figure 28. Distribution map, *Cyanophrys hartii*.

♂ holotype, dorsal, Dallas Mountain, St. Andrew, Jul., 1979.

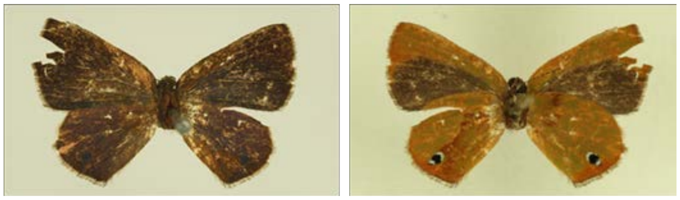
♂ holotype, ventral (abdomen removed).

Figure 29. *Cyanophrys hartii* (Florida Museum of Natural History, McGuire Center for Lepidoptera and Biodiversity).

Chlorostrymon orbis K. Johnson & D. Smith, 1993 (Lycaenidae: Theclinae)

The female type of this distinctive species was collected in November 1919 by Frederick W. Jackson while this insect was visiting *Eupatorium villosum* Sw. (Asteraceae), on the southern flanks of Dallas Mountain. Details of the identification of this site are described in Discovering Jamaican Butterflies (Turner & Turland, 2017). The type locality has not been visited in recent years and the insect might still be found there even though it has been many years since this butterfly was collected.

Figure 30. Distribution map, *Chlorostrymon orbis*.



♀ holotype, dorsal, Dallas Mt., St. Andrew, Nov., 1919.

♀ holotype, ventral (head and abdomen missing).

Figure 31. *Chlorostrymon orbis* (photos © Trustees Natural History Museum, London).

Recommendations: The habitat needs to be visited in June-August and November-December to see if this insect might still be present. This is the same location where *C. hartii* and other hairstreaks have been collected.

Cyclargus shuturn K. Johnson & Balint, 1995 (Lycaenidae: Polyommatinae)

Although this species has been found at three locations along the north coast of Jamaica, only two breeding sites have been found. Both are in dry limestone habitat encroached upon by the clearing of forest for housing developments. The insect can be found in shrubbery at the margins of these developments

Figure 32. Distribution map, *Cyclargus shuturn*.

♂ Silver Sands, Trelawny, Dec., 2009.

♂ Silver Sands, Trelawny, Nov., 2008.

♀ Silver Sands, Trelawny, Dec., 2009.

♀ Silver Sands, Trelawny, Dec., 2009.

Figure 33. *Cyclargus shuturn*.

with some adults feeding on low-growing flowering plants in empty lots. As development proceeds and the surrounding vegetation, including the larval foodplant, are destroyed, the fate of this endemic species is uncertain. Fortunately, both housing developments are proceeding very slowly.

Recommendations: The extent of these coastal subpopulations needs to be determined along with land ownership and the boundaries of the present developments. It may be possible to find a landowner who could assist in protection of this species.

Greta diaphanus (Drury, 1773) (Nymphalidae: Danainae)

There are two isolated subpopulations of this endemic species in the Blue Mountains of eastern Jamaica. The first is centered around the confluence of the John Crow Mountains and the Blue Mountain range. Certain gaps between peaks of the Blue Mountains harbor additional clusters of the insect which may or may not be contiguous with the eastern center. There is a second subpopulation toward the western end of the Blue Mountain chain that is now separated from the first subpopulation by land cleared for coffee growing and settlements. This insect occurs in small, isolated groups.

Recommendations: Considerable fieldwork in difficult terrain is required to define the boundaries of present distribution of this insect and to more accurately determine its conservation status. Sites already identified have only small numbers of adults present.

Figure 34. Distribution map, *Greta diaphanus*.

Figure 35. ♂ *Greta diaphanus*, Hardwar Gap, St. Andrew, Aug., 2013.

Figure 36. ♀ *Greta diaphanus*, Hardwar Gap, St. Andrew, Aug., 2013.

Danaus cleophile yameyensis Turner & Turland, 2018 (Nymphalidae: Danainae)

Although this endemic subspecies was last collected in 1941, surveys in the central mountains of Jamaica have not been completed and, as discussed in the introduction, several species of Jamaican butterflies have been found after long absences.

Recommendations: Surveys need to be conducted in the central mountains, beginning with Mount Diablo and then expanding outwards into neighboring forested areas.

Figure 37. Distribution map, *Danaus cleophile yamayensis*.

♀ dorsal, holotype (purchased from P. H. Gosse).

♀ ventral, holotype (purchased from P. H. Gosse).

Figure 38. *Danaus cleophile yamayensis* (photos © Trustees Natural History Museum, London).

Atlantea pantoni (Kaye, 1906) (Nymphalidae: Nymphalinae)

Atlantea is a genus endemic to the Greater Antilles with a single endemic species present in each of the islands of Cuba, Jamaica, Hispaniola and Puerto Rico. The Jamaican species originally possessed a single population that extended from the western edge of the Cockpit Country east to the Town of Kellits in central Jamaica. However, since its discovery, much of the land has been cleared for coffee-growing, forestry projects, and small-scale agriculture, and up until 2013 it was believed that only the population in the Cockpit Country remained. Then, in 2014, Turland found an isolated subpopulation in Peckham Woods in northern Manchester Parish and another segregate in 2015 in Matheson Forest in southern St. Ann Parish. The latter may or may not be contiguous with the Cockpit Country subpopulation. Another small site is located west of the main Cockpit Country between Elderslie and Niagara.

Recommendations: All four sites are located in very rugged, near impenetrable forested karst limestone terrain and require further investigation. The larval food plant and immature stages have not yet been described from Jamaica and finding these would assist in determining the best conservation measures. Both the significant loss of area occupied since 1940, and fragmentation of a once single population, suggest this species could be considered Endangered.

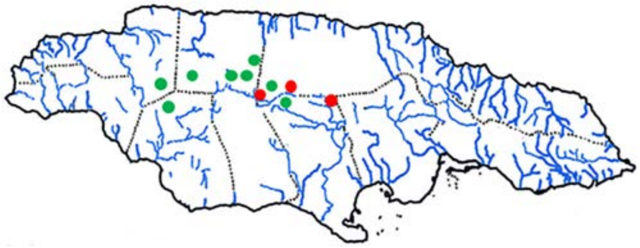


Figure 39. Distribution map, *Atlantea pantoni*.

Figure 40. ♂ *Atlantea pantoni*, Cockpit Country, Trelawny, Nov., 2014.

Figure 41. ♀ *Atlantea pantoni*, Cockpit Country, Trelawny, Nov., 2014.

Antillea pelops pygmaea (Godart, 1819) (Nymphalidae: Nymphalinae)

This endemic subspecies occurs in small shifting colonies and is nowhere common. Colonies exist for no more than two years before disappearing. New colonies are established some distance away but are difficult to locate. Over the last 200 years colonies have been found across the island, giving the impression that this species is not uncommon, but virtually all locations previously identified are now abandoned.

Recommendations: The reason for colonies dying out at a given location may be related to parasitic wasp attacks, but this hypothesis requires confirmation. While most adults remain at the emergence site after emerging from pupae, some disperse for considerable distances to form new colonies. Additional investigations are required.

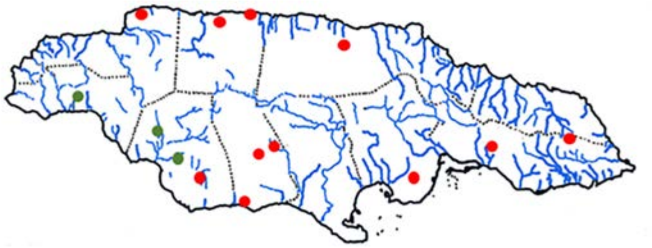


Figure 42. Distribution map, *Antillea pelops pygmaea*.

Figure 43. ♂ *Antillea pelops pygmaea*, Santa Cruz, St. Elizabeth, Sep., 2013.

Figure 44. ♂ *Antillea pelops pygmaea*, YS, St. Elizabeth, Jun., 2009.

CONCLUSIONS

As stated earlier, a problem that has persisted in Jamaica in historic times is that there have rarely been more than three researchers of Lepidoptera in the island at any given time, and even fewer resident collectors. Overseas visitors to the island have collected specimens during the winter months, a few extensively, such as Bernard Heineman, but most only as occasional collectors. Brown & Heineman (1972), Riley (1975), and Smith *et al.* (1994) in particular have all have contributed to our knowledge of Jamaican butterflies, but a more expansive treatment, including much life history information, was provided by Turner & Turland (2017). This last publication also highlighted the need for conservation of several of Jamaica's butterflies.

Another fact that requires recognition, with particular regard to Jamaica, concerns type series. From a scientific viewpoint it is clearly preferable, whenever possible, for new species descriptions to be based on series of both male and female specimens. Specimens from the type series can then be deposited in more than one institution, for archival purposes as well as facilitating access to the material by other researchers. However, populations of some species of Jamaican butterflies appear to be very small and localized, and species descriptions have often been made from just a male or female holotype. It is obvious that not enough systematic collecting has been done on the island, with several new species being discovered in recent years. *Troyus turneri* Warren & Turland was discovered on a trail visited many times by scientists over the last seventy years, including by the present authors, yet it was only on 23 July 2011 that Turland discovered this species for the first time, and return visits to the site resulted in the discovery and description of the life history. In most instances, locations where new species have been collected have not been thoroughly reinvestigated.

This first list of Jamaican butterflies in need of conservation is just the beginning, and this list will change over time. Species not seen for years may be rediscovered; others might not be found and may be declared extinct. At the same time, continued habitat loss may result in additional species being added to the list of species in need of conservation.

One condition that has changed in recent years is that to collect and study any Jamaican Lepidoptera requires prior approval from the Jamaican National Environment and Planning Agency, NEPA, thus making the unpermitted collection of specimens by visiting scientists or casual collectors illegal. This does provide some additional protection for Jamaica's butterflies. A major conservation achievement has been the recent designation as a protected area of a part of the Cockpit Country, where there is high endemism in both flora and fauna. The boundary is marked on the ground and although mining will not be permitted, it remains to be seen if incursions into and destruction of the forest within this boundary will be allowed to continue.

Jamaica is incredibly fortunate in having the largest butterfly in the western hemisphere, the Homerus Swallowtail, which also happens to be the second largest butterfly in the world. It also has the second smallest butterfly in the world, *Brephidium exilis isophthalma* (Herrich-Schäffer, 1862), the Pygmy Blue. These are a part of Jamaica's natural heritage. Butterflies can be considered indicator species for habitat types, their presence or absence reflecting the state of the habitats they now occupy and which we also share. Their loss of habitat range or extinction also provides us with a warning that our shared surroundings are also changing. It is important for us to monitor their populations and ensure their well-being even as the adverse effects of climate change have begun to become more noticeable. Perhaps, more than at any other time, field surveys are urgently required to define more accurately the present state of populations of those butterflies listed here.

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