Full Issue

Source: The Journal of the Lepidopterists' Society, 71(2)

Published By: The Lepidopterists' Society

URL: https://doi.org/10.18473/lepi.v71i2.a11

Volume 71 Number 2
2017
ISSN 0024-0966

Journal of the Lepidopterists' Society

Published quarterly by The Lepidopterists' Society

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Journal of The Lepidopterists' Society (ISSN 0024-0966) is published quarterly by The Lepidopterists' Society, c/o Chris Grinter, The California Academy of Sciences, 55 Music Concourse Drive, San Francisco, CA 94118. Periodicals postage paid at San Francisco, CA and at additional mailing offices. POSTMASTER: Send address changes to THE LEPIDOPTERISTS' SOCIETY, c/o Chris Grinter, The California Academy of Sciences, 55 Music Concourse Drive, San Francisco, CA 94118.

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Cover illustration: Male of *Synargis gorpa* feeding on flower of *Aspilia montevidensis* in Minas, Lavalleja, Uruguay; photo taken by G. Casás.

Journal of the Lepidopterists' Society
71(2), 2017, 69–80

WASP MOTHS (LEPIDOPTERA: EREBIDAE: CTENUCHINA - EUCHROMIINA) OF THE ENTOMOLOGICAL MUSEUM "FRANCISCO LUIS GALLEGO" (MEFLG), MEDELLIN, ANTIOQUIA, COLOMBIA

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ABSTRACT. The wasp moths (Erebidae: Arctiinae: Ctenuchina and Euchromiina) deposited in the entomological museum "Francisco Luis Gallego" (MEFLG) of the Universidad Nacional de Colombia, Medellin campus, were revised and identified to species. We examined 204 specimens of wasp moths for a total of 47 species, belonging to the subtribes: Ctenuchina (27 species) and Euchromiina (20 species). A species list is presented, with their collecting data, as well as color plates of reported species.

Additional key words: Wasp moths, Ctenuchina, Euchromiina, Entomological Museum

Among the Lepidoptera, a good number of Colombian butterflies are well known since many researchers have produced several works that have allowed an inventory of the group (Salazar 1999, Le Crom et al. 2002a, 2002b, Andrade-C. 2011). However, the current knowledge and faunistic inventories of moths from this country are far from complete, even though comprehensive lists and detailed works have been written for families such as Castniidae and Saturniidae (Salazar 1999a, Amarillo-S. 2000, Lamas 2000, González & Salazar 2003). Several short and preliminary works on Colombian moths have been also published in recent years (see González et al. 2013, Hernández-Baz et al. 2012, 2016, Salazar et al. 2013a, 2013b, Vazquez et al. 2015). Part of the Colombian Erebidae (Ctenuchina and Euchromiina) has also been studied and preliminary works written (see Draudt 1917, Druce 1886, Hampson 1898, 1914, Zerny 1912) but detailed information of the remaining moth families is basically lacking.

Using the project "Taxonomy, Biogeography and Conservation wasp moths (Lepidoptera: Erebidae; Ctenuchina and Euchromiina) of the American Continent", Code DGI 22314201267", as a model, researchers of Universidad Veracruzana (UV-MEX), Universidad Nacional de Colombia (UNC-COL) and California State University Fresno, Dept. Plant Sciences, Fresno (CSU-USA) got together with the intention of starting an effort to produce inventories of the lesser known groups of Colombian wasp moths. The main objectives include: a) to publish an inventory of the Ctenuchina and Euchromiina deposited in the Entomological Museum "Francisco Luis Gallego" (MEFLG) of Universidad Nacional de Colombia, Medellin campus; and b) to elaborate a Data Base of the MEFLG including a photographic catalog available to the public.

The Entomological Museum "Francisco Luis Gallego" (MEFLG) of Universidad Nacional de Colombia, Medellin campus (N 6°15'41.22" / W 75°34'39.26"), is one of the registered Biological Collections of Colombia (RNC) under the number 8 (06/11/2015). Its activities started in 1937, making it one of the oldest entomological collections in the nation. Its

FIG. 1a. Dr. Francisco Luis Gallego (1937)

original name was Entomological Archives, which was changed in 1967 to honor the memory of its founder and most fervent promoter. From the beginning, the main interest of the institution was to collect, preserve and understand agriculturally related insects. Their priority was to solve pest problems of the main crops of Antioquia, but also from other regions of Colombia. The collection has grown due to the increase of research and surveys related to diversity, conservation and, more recently, molecular systematics. Today, this collection is one of the most relevant references for Colombian insects at the national and international levels. Currently, the MEFLG mission is to collect, preserve and investigate the insects of Colombia and to divulge any knowledge derived by their studies (Vélez 1989).

Dr. Francisco Luis Gallego (Fig. 1a) was an enthusiastic and tireless entomologist, teaching several courses (Fig. 1b) and visiting pristine sites to collect insects (Fig. 2a) with the clear intention of enhancing the knowledge of the group and to establish what would become the MEFLG as a relevant research institution. He is considered one of the pioneers of Colombian forest entomology and promoter of research and teaching about Colombian insects (Amat-Garcia et al. 2007).

The MEFLG is divided into several sections: Central

FIG. 1b. b. Francisco Luis Gallego (standing, left), teaching an entomology class to students of the Agricultural Sciences College of the Colombian National University, Medellin campus, Antioquia (1940). Pictures: Historical Archive MEFLG-UNC.

Taxonomic Collection (CTC), Didactic Taxonomic Collection (CTD), Central Economic Collection (CEC), Didactic Economic Collection (CED), Immature Insects Collection (CFI), with a Library containing Books, Newspaper and Periodicals, and file cabinets with records of all identified species in the Museum. The CTC have 86 12-drawers cabinets (Fig. 2b), with 5,460+ identified insect species and about 300,000+ specimens in total, and are all organized phylogenetically. The main relevance of this collection is that 99% of the insect species they possess are Colombian. A preliminary review indicates that 26 insect Orders are represented within the CTC. Lepidoptera is the group with the most representatives and they are all contained in 22 cabinets and 264 drawers.

The MEFLG collection is one of the oldest in Colombia and contains historically relevant material and information that dates back to the 1930's. Besides, it is considered as one of the most relevant on acquired facts about Lepidoptera of agricultural and silvicultural importance for the country.

Colombian Lepidoptera. Worldwide, there are about 145,464 species of Lepidoptera grouped in 124 families, and 126,327 of those species (and 117 families) are moths (Heppner 1991). About 1,237 moth species, included in 21 super-families and 48 families are known from Colombia (Hernández-Baz unpublished). Wasp moths, which are currently included in the Noctuoidea: Erebidae: Arctiinae: Arctiini, have been divided into two subtribes Ctenuchina and Euchromiina (Lafontaine &

Fig. 2a. One of the many collecting sites frequently visited by Dr. Francisco Luis Gallego;

Fig. 2b. Panoramic view of the insect collection of the MEFLG of Universidad Nacional de Colombia, Medellin campus, Antioquia. Pictures: Historical Archive MEFLG-UNC.

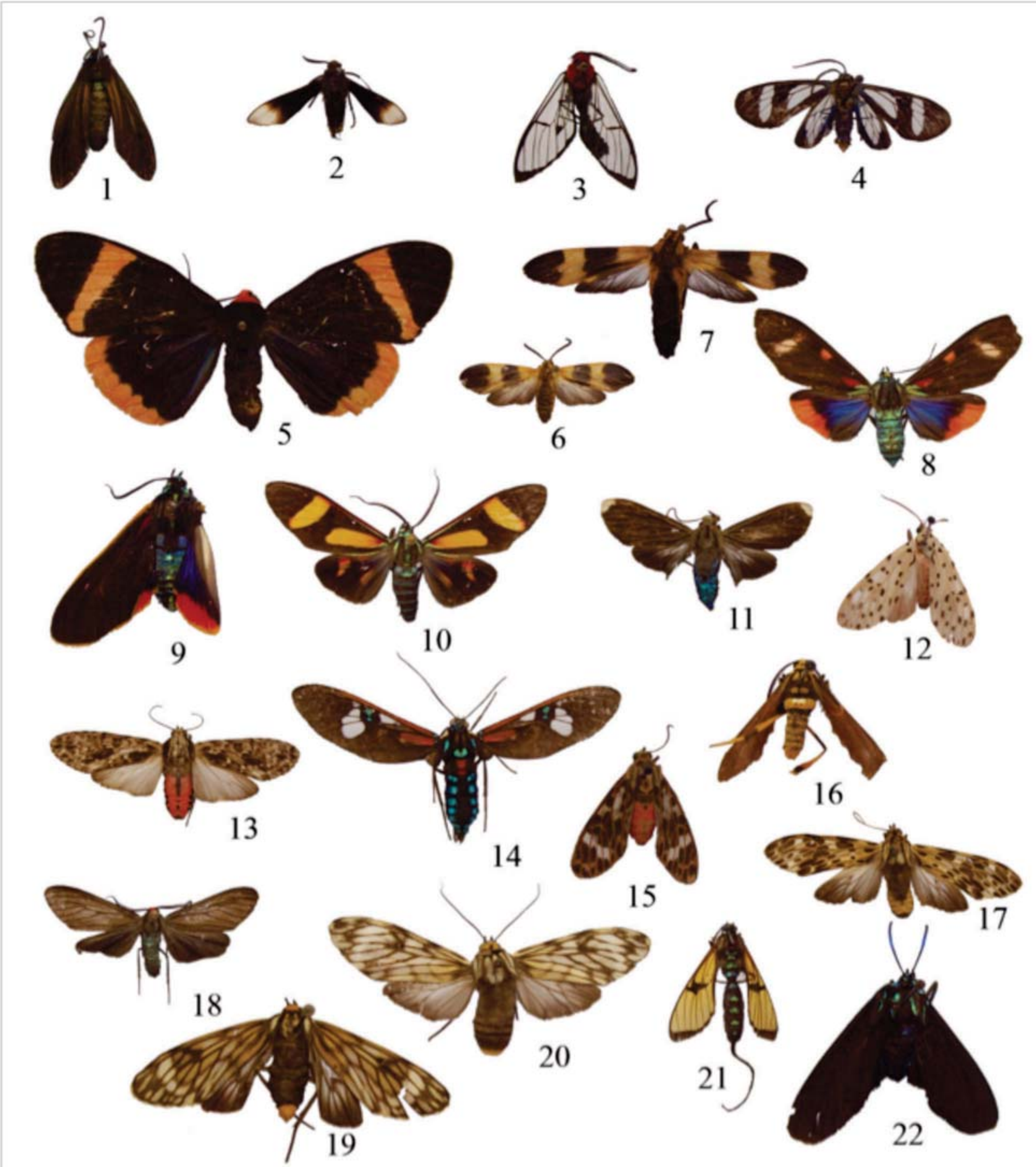

FIG. 3. Wasp-moths (Erebidae: Ctenuchina) deposited in the Entomological Museum "Francisco Luis Gallego" (MEFLG) at Facultad de Ciencias, Universidad Nacional de Colombia, Medellín campus, Antioquia.**1.** *Antichloris viridis* Druce, 1884; **2.** *Anycles anthracina* (Walker, 1854); **3.** *Argyroeides augiades* (Druce, 1896); **4.** *Cacostatia saphira* (Staudinger, 1876); **5.** *Coreura simsoni* (Druce, 1885); **6.** *Correbidia germana* (Rothschild, 1912); **7.** *Correbia lycoides* (Walker, 1854); **8.** *Cyanopepla alonzo* (Butler, 1876); **9.** *Cyanopepla cinctipennis* (Walker, [1865]); **10.** *Cyanopepla submacula* (Walker, 1854); **11.** *Episcepcis lenaeus* (Cramer, 1780); **12.** *Eucereon atrigutta* Druce, 1905; **13.** *Eucereon myrtusa* Druce, 1884; **14.** *Euclera meones* (Stoll, [1780]); **15.** *Heliura rhodophila* (Walker, 1856); **16.** *Horama panthalon* (Fabricius, 1793); **17.** *Nelphe rogersi* (Druce, 1884); **18.** *Philoros rubriceps* (Walker, 1854); **19.** *Theages flavicaput* (Hampson, 1898); **20.** *Theages xanthura* (Schaus, 1910); **21.** *Trichura cerberus* (Pallas, 1772); **22.** *Uranophora lelex* (Druce, 1890).

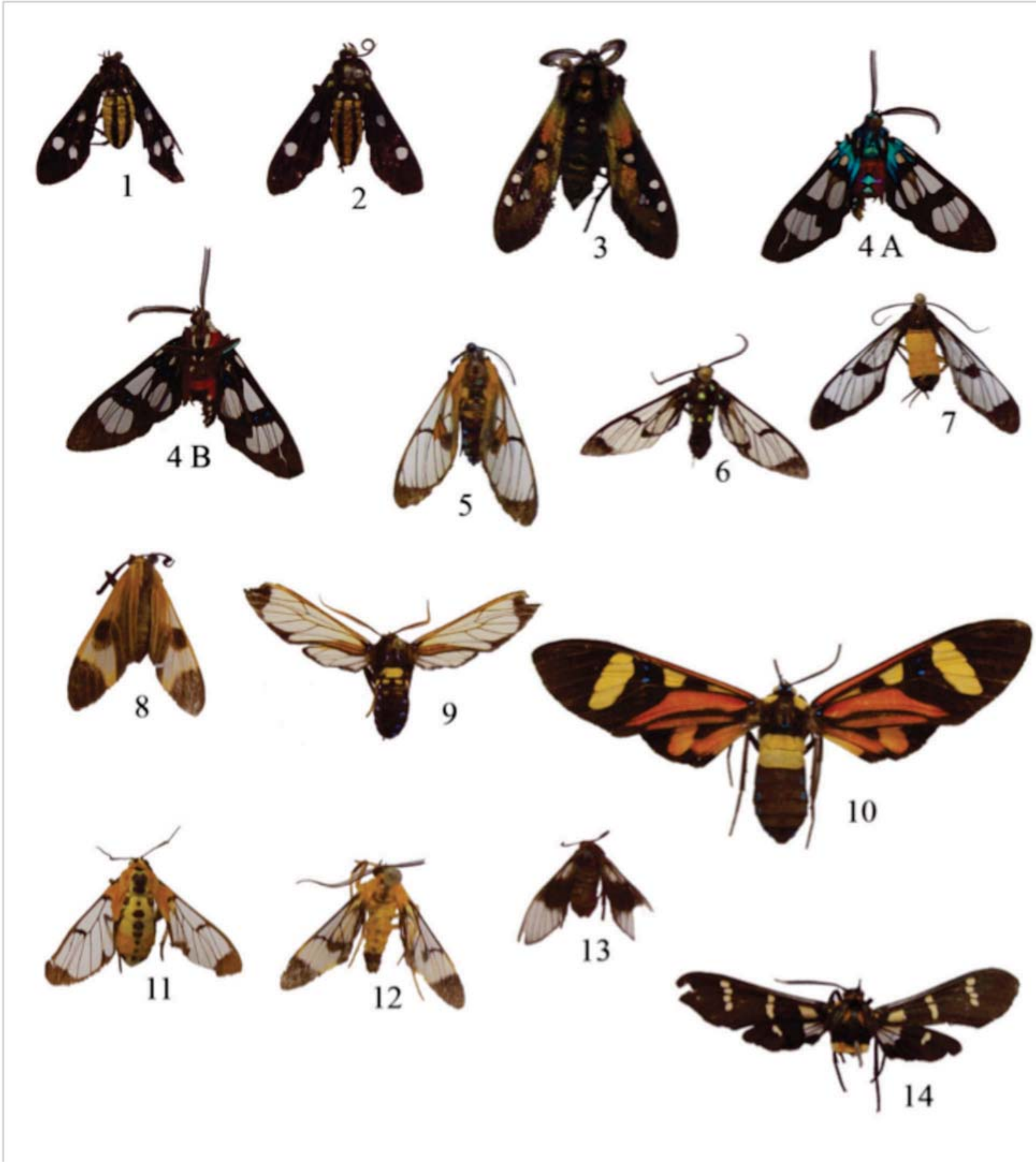

Fig. 4. Wasp-moths (Erebidae: Euchromiina) deposited in the Entomological Museum "Francisco Luis Gallego" (MEFLG) at Facultad de Ciencias, Universidad Nacional de Colombia, Medellín campus, Antioquia. **1.** *Calonotos chalcipleura* Hampson, 1898; **2.** *Calonotos tiburtus* (Cramer, [1779]); **3.** *Chrysocale regalis* (Boisduval, 1836); **4A, 4B** (ventral view) *Cosmosoma bogotensis* (Felder, 1869); **5.** *Cosmosoma centralis* (Walker, 1854); **6.** *Xanthyda xanthosticta* (Hampson, 1898); **7.** *Cosmosoma stilbosticta* (Butler, 1876); **8.** *Dycladia correbioides* Felder, 1874; **9.** *Gymnelia lucens* (Dognin, 1902); **10.** *Histioea bellatrix* (Walker,1854); **11.** *Hyda basilutea* (Walker, 1854); **12.** *Loxophlebia flavipicta* Schaus, 1912; **13.** *Pseudohyaleucerea melanthoides* (Schaus, 1920); **14.** *Syntomeida melanthus* (Cramer, [1779]).

TABLE 1. List of wasp moths (Erebidae: Ctenuchina & Euchromiina) of the Entomological Museum Francisco Luis Gallego (MEFLG), Universidad Nacional de Colombia, Medellín campus, Antioquia.Nacional de Colombia, Medellín campus, Antioquia.

Taxa Erebidae: Arctiinae: Ctenuchina		Number of Speciments
1	*Antichloris viridis* Druce, 1884	6
2	*Anycles anthracina* (Walker, 1854)	8
3	*Argyroeides augiades* (Druce, 1896)	5
4	*Belemniastis troetschi* (Druce, 1896)	1
5	*Cacostatia saphira* (Staudinger, 1876)	1
6	*Coreura simsoni* (Druce, 1885)	3
7	*Correbia lycoides* (Walker, 1854)	5
8	*Correbidia germana* (Rothschild, 1912)	3
9	*Cyanopepla alonzo* (Butler, 1876)	10
10	*Cyanopepla cinctipennis* (Walker, [1865])	1
11	*Cyanopepla lystra* (Druce, 1896)	4
12	*Cyanopepla submacula* (Walker, 1854)	10
13	*Dinia mena* (Hübner, [1827])	18
14	*Episcepsis lenaeus* (Cramer, 1780)	1
15	*Eucereon atrigutta* Druce, 1905	1
16	*Eucereon myrtusa* Druce, 1884	3
17	*Eucereon nervulum* Rothschild, 1912	2
18	*Euclera meones* (Stoll, [1780])	2
19	*Heliura rhodophila* (Walker, 1856)	2
20	*Horama panthalon* (Fabricius, 1793)	1
21	*Nelphe rogersi* (Druce, 1884)	6
22	*Philoros rubriceps* (Walker, 1854)	16
23	*Theages flavicaput* (Hampson, 1898)	3
24	*Theages xanthura* (Schaus, 1910)	2
25	*Trichura cerberus* (Pallas, 1772)	3
26	*Uranophora lelex* (Druce, 1890)	1
27	*Uranophora leucotelus* (Butler, 1876)	3
	Subtotal	121

Table 1. List of wasp moths (Erebidae: Ctenuchina & Euchromiina) of the Entomological Museum Francisco Luis Gallego (MEFLG), Universidad Nacional de Colombia, Medellín campus, Antioquia.Nacional de Colombia, Medellín campus, Antioquia. (CONTINUED from previous page)

Taxa Erebidae: Arctiinae: Ctenuchina		Number of Speciments
	Euchromiina	
28	*Calonotos chalcipleura* Hampson, 1898	3
29	*Calonotos tiburtus* (Cramer, [1779])	4
30	*Chrysocale ignita* (Henrrich-Schäffer, [1853])	1
31	*Chrysocale regalis* (Boisduval, 1836)	8
32	*Cosmosoma auge* (Linnaeus, 1767)	7
33	*Cosmosoma bogotensis* (Felder, 1869)	1
34	*Cosmosoma centralis* (Walker, 1854)	7
35	*Xanthyda xanthosticta* (Hampson, 1898)	2
36	*Cosmosoma teuthras* (Walker, 1854)	1
37	*Cosmosoma stilbosticta* (Butler, 1876)	18
38	*Dycladia correbioides* Felder, 1874	10
39	*Gymnelia lucens* Dognin, 1902	4
40	*Histioea bellatrix* (Walker,1854)	1
41	*Hyda basilutea* (Walker, 1854)	3
42	*Loxophlebia flavipicta* Schaus, 1912	1
43	*Macrocneme aurifera* Hampson 1914	3
44	*Macrocneme thyridia* Hampson 1898	5
45	*Nyridela chalciope* (Hübner, [1831])	2
46	*Pseudohyaleucerea melanthoides* (Schaus, 1920)	1
47	*Syntomeida melanthus* (Cramer, [1779])	1
	Subtotal	83
	Total	204

TABLE 2. Collecting localities of wasps moths (Erebidae: Ctenuchina & Euchromiina) held in the Entomological Museum Francisco Luis Gallego (MEFLG), Universidad Nacional de Colombia, Medellín campus, Antioquia.

Deparment	Municipality	Locality and altitude	Latitude	Longitude
Antioquia	Amagá	Camilo C. Restrepo, 1437 m.	06 02 01	75 41 60
Antioquia	Andes	Andes, 1333 m.	05 39 23	75 52 47
Antioquia	Bello	Bello, 1475 m.	06 20 23	75 33 44
Antioquia	Cáceres	Cáceres, 98 m.	07 39 58	75 19 59
Antioquia	Caldas	Caldas, 1764 m.	06 05 24	75 38 15
Antioquia	Caldas	Caldas, 1771 m.	06 50 23	75 38 15
Antioquia	Campamento	Campamento, 1692 m.	06 58 42	75 17 50
Antioquia	Caucasia	Caucasia, 54 m.	07 57 59	75 11 54
Antioquia	Cocorná	Cocorná, 1109 m.	06 02 58	75 10 00
Antioquia	Concepción	Concepción, 1861 m.	06 23 44	75 15 25
Antioquia	Dabeiba	Dabeiba, 462 m.	06 59 58	76 16 04
Antioquia	Frontino	Frontino, 1449 m.	06 46 49	76 08 08
Antioquia	Guadalupe	Guadalupe, 1873 m.	06 48 54	75 14 36
Antioquia	Itagüí	Itagüí, 1578 m.	06 10 05	75 36 51
Antioquia	La Estrella	La Estrella, 2197 m.	06 10 00	75 40 00
Antioquia	Medellín	Medellín, 1633 m.	06 14 57	75 37 12
Antioquia	Medellín	San Cristóbal, 1806 m.	06 16 33	75 38 00
Antioquia	Medellín	Valle de Medellín, 1469 m.	06 15 41	75 34 35
Antioquia	Medellín	Corregimiento Santa Elena, Piedras Blancas, 1209 m.	06 14 48	74 58 18
Antioquia	Medellín	El Picacho, Valle de Medellín, 2052 m.	06 18 14	75 35 15
Antioquia	Medellín	Robledo, 1599 m.	06 16 36	75 35 48
Antioquia	Medellín	Santa Elena, Piedras Blancas, 2358 m.	6 17 40	75 30 06
Antioquia	Medellín	Universidad Antioquia, 1464 m.	06 16 01	75 34 06
Antioquia	Medellín	Universidad Nacional, 1467 m.	06 15 37	75 34 37
Antioquia	Medellín	Universidad Nacional, 1460 m.	06 15 53	75 34 34
Antioquia	Medellín	Valle de Medellín, 1468 m.	06 15 37	75 34 34
Antioquia	Porce	Porce, 1134 m.	06 37 25	75 08 42

Table 2. Collecting localities of wasps moths (Erebidae: Ctenuchina & Euchromiina) held in the Entomological Museum Francisco Luis Gallego (MEFLG), Universidad Nacional de Colombia, Medellín campus, Antioquia. (CONTINUED)

Deparment	Municipality	Locality and altitude	Latitude	Longitude
Antioquia	Rionegro	Rionegro, 2105 m.	06 09 14	75 23 21
Antioquia	San Jerónimo	San Jerónimo, 967 m.	06 25 51	75 42 47
Antioquia	San José de Nus	San José de Nus, 2578 m.	07 03 27	75 59 02
Antioquia	San Luis	San Luis, 1067 m.	06 02 39	74 59 38
Antioquia	San Luis	San Luis, 1097 m.	06 02 41	74 59 50
Antioquia	Santa Bárbara	Santa Bárbara, 1768 m.	05 52 25	75 34 10
Antioquia	Santa Rosa de Osos	Santa Rosa de Osos, 2540 m.	06 38 51	75 27 24
Antioquia	Segovia	Segovia, 663 m	07 04 41	74 41 52
Antioquia	Sopetrán	Sopetrán, 736 m.	06 30 11	75 44 42
Antioquia	Támesis	Támesis, 1663 m.	05 39 47	75 43 05
Antioquia	Tarazá	Tarazá, 92 m.	07 35 00	75 24 00
Antioquia	Tarso	Tarso, 1354 m.	05 51 48	75 49 17
Antioquia	Turbo	Turbo, 7 m.	08 05 35	76 43 31
Antioquia	Urabá	Villa Arteaga, 144 m.	07 22 30	76 29 01
Antioquia	Yarumal	Yarumal, 2206 m.	06 57 32	75 25 21
Atlántico	Barranquilla	Barranquilla, 29 m.	10 59 05	74 50 43
Cauca	Popayán	Popayán, 1784 m.	02 27 02	76 36 55
Caldas	Tolda Fría	Tolda Fría, 2987 m	04 57 01	75 26 12
Cesar	Agustín Codazzi	Agustín Codazzi, 174 m.	10 01 46	73 13 54
Chocó	Carmen de Atrato	Carmen de Atrato, 1664 m.	05 53 06	76 13 41
Chocó	Medio Atrato	Medio Atrato, 25 m	05 58 33	76 43 44
Chocó	Quibdó	Quibdó, 55 m.	05 41 29	76 38 38
Córdoba	Atlántico	Costa Atlántica, 45 m.	08 24 05	75 54 37
Cundinamarca	Norte Redondo	Norte Redondo, 2547 m.	04 42 08	74 08 21
Cundinamarca	Quetame	Quetame, 1441 m.	04 19 50	73 51 52
Cundinamarca	Quetame	Quetame, 1454 m.	04 19 52	73 52 04

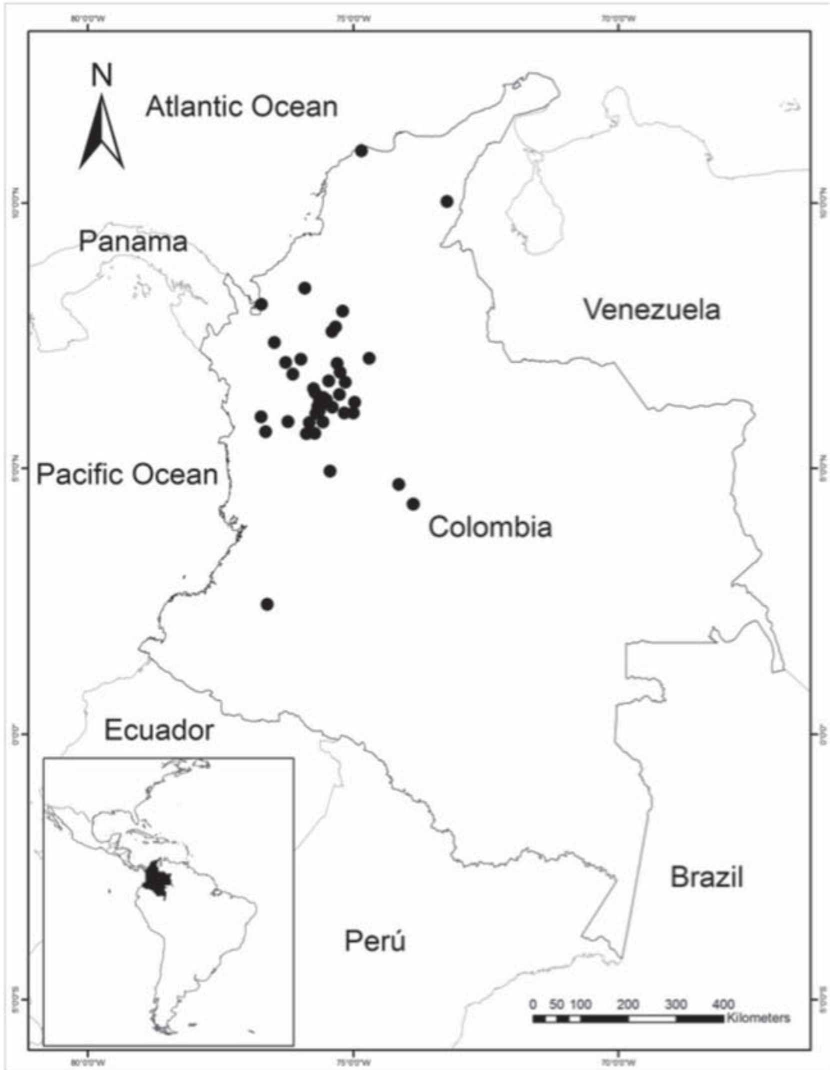

FIG. 5. Geographic distribution of collecting sites (black dots) of wasp moths (Lepidoptera: Erebidae: Ctenuchina and Euchromiina) found in the insect collection of MEFLG of Universidad Nacional de Colombia, Medellin campus, Antioquia.

Fibiger 2006, Lafontaine & Schmidt 2010). These wasp moths are captured at lights (Hernández-Baz & Bailey 2006, Hernández-Baz et al. 2012, 2013) and present a species richness that reaches a number that varies between 2532 to 3000 species, with 2475 being exclusively Neotropical (Heppner 1991). Only 36 species in the group are Nearctic (Lafontaine & Schmidt 2010, Simmons et al. 2012). About 120 species of wasp moths were previously known from Colombia (Hernández-Baz, unpublished).

MATERIAL AND METHODS

All wasp moth specimens of MEFLG were organized as morph-species following (Triplehorn & Johnson 2005). Their genera were identified following Hampson (1898, 1914), and for species identification, we followed Druce (1886), Draudt (1917), Dietz & Duckworth (1976), Dietz (1994) and Hernández-Baz (2012). Genera and species for each subtribe are listed alphabetically here (Table 1). The information on each and all specimens studied was integrated to the "Polilla" database of the project Taxonomy, Biogeography and Conservation wasp moths (Lepidoptera: Erebidae; Ctenuchina and Euchromiina) of the American Continent", Code DGI 22314201267, at Universidad Veracruzana, Xalapa, Veracruz, México. A duplicate of the data base "Polilla" is now deposited at the MEFLG of the UNC Medellin campus.

All taxa were organized by subtribes in an Excel spreadsheet (Microsoft 2016). All Ctenuchina and Euchromiina registers in the MEFLG collection were georeferenced based on a cartographic physical map with 1:500 000 and 1:100 000 scales designed by the Geographic Institute Agustín Codazzi (IGAC 2016). The catalogs of the Colombian territories were also used (IGAC, 1995). We checked the obtained information in http://www.google.com/earth/. The dates taken from the "Polilla" database were converted into sexagesimal data for inclusion in a geographical information system for the Arc View 2.0 program (Esri 1998) to obtain a species/localities distribution map.

Results and Discussion

A total of 1,032 drawers containing Lepidoptera specimens within the MEFLG collection were examined, 264 of which contained several families and only two contained exclusively wasp-moths. Out of the 204 wasp moth specimens found, 47 species were represented. Among them, 27 were Ctenuchina, containing 20 genera and 121 specimens, while Euchromiina was represented by 20 species and 12 genera, in a total of 83 specimens (Table 1, Figs. 3 & 4). Gallego (1938, 1946) had previously identified only five of those wasp moths' species (within the old families Syntomidae and Amatidae) in the MEFLG collection. Those identifications were then corroborated by W. Schaus of the Smithsonian Institution—United States National Museum (USNM). Hernández-Baz (unpublished) reports 120 species of Ctenuchina and Euchromiina for Colombia, thus the 43 species held by MEFLG represent 35 % of the species of those groups for the country.

After curation of the wasp moths of MEFLG, we found that they were collected at 49 collecting sites from six Colombian Departments: Antioquia (with 41), Cauca (2), César (1), Chocó (1), Córdoba (1) and Cundinamarca (3), with altitudinal ranges fluctuating between 7 and 2,197 masl, and covering a wide range of vegetation types from mangroves to wet forests of the Central Mountain Range (Cordillera Central) of Colombia (Table 2). About 85% of the collecting sites are from Antioquia Department and the remaining 15% represents other localities (Fig. 5). The particular bias towards Antioquian insects is explained by the fact that the institution was originally created with the main purpose of collecting and identifying agricultural and silvicultural pests of the area around the Aburrá river valley, which was a region surrounded by crops and logging forests.

The studied collection (MEFLG) and the wasp moths in particular (Erebidae: Ctenuchina y Euchromiina) can be considered small (only 204 specimens and 47 species). That only shows the little interest in collecting these moths, which is a phenomenon that is frequently repeated in numerous Latin-American collections. The importance and value of this particular set of wasp-moths is that they were collected during the years 1930 to 1950, when the vegetation of the collecting sites was in more pristine conditions.

The 47 wasp moth species found at MEFLG were included in the data base "Polilla" enhancing the number of registered and georeferred Colombian species to 130. This could be considered a low number of known species for the group based on the fact that Colombia is not only a neotropical country but a megadiverse one (Amat-Garcia et al. 2007). This conclusion could be easily understood when we compare such number with those found in the neotropical French Guyana and the neighboring Ecuador having each more than 400 wasp-moth species (Cerda 2008; Piñas & Manzano 2003) and even México (with a combination of neartic and neotropical fauna) that have more than 200 (Hernández-Baz 2012).

We have been revising all Colombian scientific collections since 2010. The main goal of this effort is to locate all wasp moths deposited in them with the purpose of building a comprehensive and precise list that will lead us to better understand their richness in the country. This is also a preliminary step to generate a more ambitious public data base of wasp moths of the Americas.

Acknowledgements

We are deeply indebted to professors Adelaida M. Gaviria Rivera, Coordinator of MEFLG, and Sergio Ordúz from UNC, for allowing us to study the collections under their care. Our appreciation goes also to Dr. Charles Covell (McGuire Center for Lepidoptera & Biodiversity) who provided us insightful comments on the original manuscript. JMG was partially supported by the CSUF Provost's Assigned Time for Research (Summer 2016).This paper is part of project "Taxonomy, Biogeography and Conservation wasp moths (Lepidoptera: Erebidae; Ctenuchina and Euchromiina) of the American Continent", Code DGI 22314201267., Universidad Veracruzana, Xalapa, México

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Submitted for publication 4 August 2016; revised and accepted 20 October 2016.

Journal of the Lepidopterists' Society
71(2), 2017, 81–91

A SECOND EDITION OF *LEPIDOPTERA, RHOPALOCERES AND HETEROCERES* BY HERMAN STRECKER, WITH NOTES ON THE FIRST EDITION AND SUPPLEMENTS

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ABSTRACT. The first edition of the book *Lepidoptera, Rhopaloceres and Heteroceres, Indigenous and Exotic* by F. H. Herman Strecker was originally published in 15 parts between 1872 and 1878. The first few parts were partially financed by Edward P. Boas, a banker in Reading, Pennsylvania. Contrary to popular accounts, Emily L. Morton was employed to color many of the plates for the first edition. Strecker suffered a great deal of criticism for his scathing remarks about other lepidopterists. Based on new evidence, the publication date of Part 15 is amended to 9 July 1878. Virtually overlooked in entomological literature, a rare second edition of the book was published as a single volume in 1879. At least five plates were ultimately reproduced for this edition using a photo-mechanical process with hand-coloring. Five signatures of letterpress were slightly revised for the second edition. The three supplements to the book are also discussed, including a one-page description, which is best treated as an addendum to the third supplement. Finally, a summary of the publication of *Rhopaloceres and Heteroceres*, including its supplements, is presented.

Additional key words: lithography, publication dates, wrappers

The book *Lepidoptera, Rhopaloceres and Heteroceres, Indigenous and Exotic* was originally issued in 15 parts (installments), each comprised of one hand-colored lithographic plate and several pages of accompanying letterpress. The author, lepidopterist Ferdinand H. Herman Strecker (1836–1901), initially planned to produce one part of the book per month over the course of a single year, but the project proved too difficult. It was ultimately published over a period of six years, from April 1872 to July 1878 (Brown 1964). Intended for more serious students of Lepidoptera, it included original descriptions, systematic lists, taxonomic discussions, and anecdotal observations. Two decades after the publication of the book had seemingly ceased, Strecker (1898, 1899, 1900a) issued three supplements without plates. A single page was also issued (Strecker 1900b), which is sometimes regarded as a fourth supplement.

The production of *Rhopaloceres and Heteroceres* (Strecker 1872–[1878]) was costly and time-consuming. Strecker, a stonemason and sculptor by trade, worked on the book mostly at night — by the light of an "old burner" — on the third floor of his home at 1325 Mineral Spring Road, Reading, Pennsylvania (Barber 1885, Anonymous 1888, Weiss 1953) (Fig. 1). The home still stands today, having long ago been converted into a tenement house. Due to financial constraints, Strecker was able to purchase only a single lithographic stone for the creation of the plates. After drawing and etching the figures for a given plate on the stone, he sent the stone to Philadelphia, where 300 copies of that print were struck (Anonymous 1888, 1901a; Weiss 1953). The stone was afterwards returned to Strecker to be scraped clean and reused for the next plate. Strecker hand-colored the printed plates, which were combined with letterpress to complete each part of the book. All 300 copies of the book were supposedly sold, yet demand continued to increase. Because Strecker had destroyed his lithographic work after each plate was printed, it was reported that no more copies of the book could be issued (Anonymous 1888, 1901a). This popular narrative was repeated many times in obituaries and biographies of Strecker (e.g. Anonymous 1901b, Mengel 1902, Weiss 1953, Mallis 1971, Leach 2013). Nonetheless, I became aware of copies of *Rhopaloceres and Heteroceres* that are identified as a second edition, containing a preface dated "Nov., 1879." I subsequently acquired an original copy of this edition (in original wrappers) for comparison against a first edition already in my possession. I also discovered additional information about the first edition and the supplements, including the fact that Strecker did not color all the plates of his book as he maintained.

METHODS

Copies of the first and second editions of *Rhopaloceres and Heteroceres*, as well as the supplements, were personally examined. These copies are deposited in my own library and the Library and Archives of the Field Museum of Natural History (Chicago, Illinois; FMNH). The copy of the first edition at FMNH includes the original front wrappers for all the parts as issued. Images were obtained of all the front and rear wrappers of a first edition at the Library of the Academy of Natural Sciences (Philadelphia, Pennsylvania; ANSP). Three online copies of the book

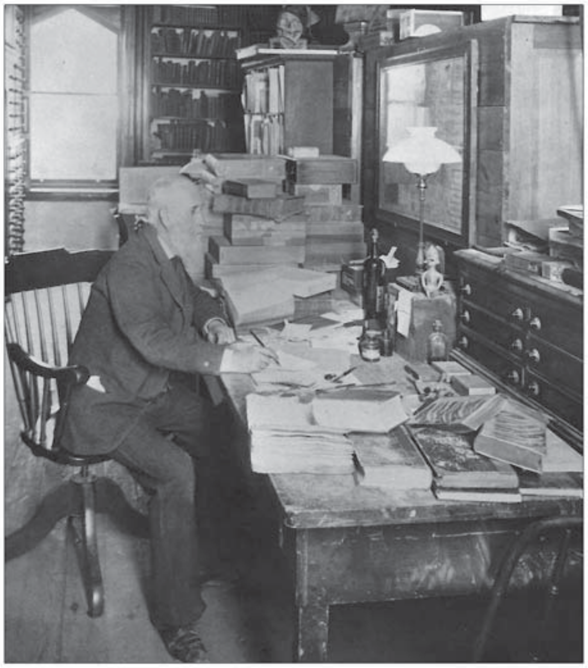

FIG. 1. F. H. Herman Strecker, c. 1895, at his desk on the third floor of his home, where he wrote *Rhopaloceres and Heteroceres* (FMNH).

were evaluated, and facts about two other copies were received from booksellers. Information was also obtained regarding a copy of the rare second edition in the possession of Eric H. Metzler. Previous studies by Griffin (1931), Oiticica (1946) and Brown (1964) were reviewed. Strecker's correspondence was studied for references to *Rhopaloceres and Heteroceres* (originals at FMNH; photocopies of most at McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History, Gainesville, Florida). Lepidoptera specimens from Strecker's collection (FMNH) were examined and compared with figures in the book.

RESULTS

First edition. The 15 parts of the first edition of *Rhopaloceres and Heteroceres* were issued in colored paper wrappers (covers), with printed titles and price information. The color of the wrappers varied between copies. A comparison of wrappers associated with copies at FMNH and ANSP show only one difference: Part 9 is blue in the former and buff in the latter. Most wrappers were blue, buff, or yellow. Additional evidence, including a copy recently offered for sale (of which I received images), indicates that green and pink wrappers were also used.

Appearing on the verso of the front wrapper of Part 1, among seven advertisements, was an announcement from Strecker with the heading "To Publishers, &c.":

> "Advertisements of Publishers, Taxidermists, dealers in specimens of Natural History, Public Lecturers, Bird Fanciers, &c., inserted on the cover and fly leaves of each number, at very low rates, as my object is not to make money in this instance, but merely to cover the expense of issuing this work. Parties choosing to avail themselves of this means of advertising will please address, HERMAN STRECKER, Box 111 Reading P. O., Berks Co., Pa."

One of the paid advertisements that Strecker included on this part was for the book *The Butterflies of North America* by William H. Edwards, who would later become a staunch critic of *Rhopaloceres and Heteroceres* (see below). After the first part, advertisements appeared only on the verso of the rear wrapper and were mostly for express shipping companies, which Strecker often employed to send and receive specimens.

The verso of the front wrapper of Parts 2 and 3 also included a "Notice" to subscribers:

> "As none of us, unfortunately or otherwise, can always do as we please, I was unable, owing to adverse circumstances, to continue this work last year further than the first number, but I have now so arranged it as to be able to issue a part regularly each month.
>
> "Subscribers who prefer to do so can remit the money for each part as they receive it, which will be in United States, 55 cents per part, inclusive of postage. As soon as I have subscribers sufficient to pay the extra expense of printing, I will add another plate, so I trust Lepidopterists and Naturalists generally will exert themselves to increase my subscription list, which is not at present as large as that of the London Times."

As Strecker stated, Part 2 was delayed for over a year after the publication of the first part. Although he promised to issue successive parts on a monthly basis, this was done only for Parts 3, 4, and 6, after which the parts appeared on an increasingly irregular basis (Brown 1964). Consequently, Strecker did not include the notice to subscribers after Part 2. The publisher's announcement was discontinued after Part 5. For Parts 12–15 it was advertised that the work was "Issued Quarterly," but this strategy failed as well.

Rear wrappers of Parts 2–15 included an ever-expanding list of Lepidoptera species that Strecker desired, with additional remarks:

> "Of the following species I am anxious to obtain examples, either by exchange or purchase; any Naturalists having duplicates of any of them will confer a great favor by communicating with Herman Strecker. . . These are a few of the very many of the rarer species that I am eager to procure; of course there are numberless others from all parts of the world, equally desirable and coveted by me."

This list was greatly enlarged for Parts 14 and 15, when Strecker included an additional closing statement:

> "Lepidoptera, native and exotic either on hand or can be obtained for clients at short notice. Coleoptera and other insects occasionally on hand and can always be obtained if ordered—particularly given on application by letter. I will also sell Insects on commission for persons having such to dispose of. I am always glad to exchange for any species of Lepidoptera not in my collection, or to obtain such by purchase if exchanging be not desirable."

In addition to the price of "50 Cents" printed on the front wrapper, Parts 13–15 included the statement "In Europe, 2 Shillings." Subscribers who wished to pay in advance could purchase a subscription for six dollars (Strecker 1872-[1878]). If an "adequate number" of subscribers was secured, Strecker planned to include two plates per part at the same price, but this was never realized. In a stand-alone advertisement that was issued after the completion of Part 4, Strecker announced that only a limited number of copies of each part were being printed, adding that "persons can remit the money as they receive the parts, or pay a year's subscription in advance, as best may suit their convenience" (Strecker [1873]). Strecker's correspondence (FMNH) suggests that most subscribers paid after they received each part.

Strecker wished to keep *Rhopaloceres and Heteroceres* within financial reach of most lepidopterists, but the inexpensive price of 55 cents per part (equivalent to $11–13.50 in today's economy) was not enough to cover production. As revealed in the preface for the second edition (see below), Edward P. Boas was credited as providing additional financial support for the first four parts of the first edition, after which the publication "began to pay for itself." Edward Payson Boas (1840-1889) was born in Reading, Pennsylvania. Military records indicate that he served in the Army during the Civil War with the 20th Illinois Volunteer Infantry Regiment, Company G. Entering the military as a private in 1861, he quickly rose to the rank of captain. He was captured in 1862 and held at Libby Prison in Virginia, as well as a Confederate prison camp in South Carolina (Anonymous 1865, 1889). After the war he returned to Reading and worked in banking for many years, initially as the assistant cashier at the First National Bank in Reading, which was co-founded by his father, Augustus F. Boas, who was also the cashier. When Strecker began work on *Rhopaloceres and Heteroceres*, E. P. Boas was employed as cashier of the Reading Savings Bank, where his father was president. During the early 1870s Boas also served as a director of the newly opened Southern Pennsylvania Railroad (Poor 1872), which is ironic given that he was involved in a terrible accident on a nearby stretch of railroad about ten years earlier, when the train on which the 20th Illinois Volunteer Infantry Regiment was traveling collided with another train heading in the opposite direction, killing four soldiers and injuring many others (Richards 1883). In late 1877 the Reading Savings Bank was driven into involuntary bankruptcy, partly as a result of mismanagement (Anonymous 1878a). A great scandal ensued and at least one investor reportedly committed suicide when his life savings were lost in the collapse (Anonymous 1878b). Shortly after, E. P. Boas was arrested and charged with embezzling over $25,000 from the bank during his tenure as cashier (Anonymous 1877, 1878c, 1878d). Although Boas was not convicted, it is conceivable that some of the money used to keep *Rhopaloceres and Heteroceres* afloat was derived from ill-gotten gains.

Strecker acknowledged no help in the production of his book and claimed that the plates were "drawn, lithographed and even coloured" by himself (Strecker [1879]). However, Newcomb (1917) asserted that many plates were colored by Emily L. Morton (1841–1920), an insect collector and entomological artist who lived in Newburgh, New York. Except for a passing allusion to this claim by Walton (1921), Morton's potential involvement in the production of *Rhopaloceres and Heteroceres* was ignored.

A review of Strecker's correspondence at FMNH reveals that Morton was indeed hired to color plates for *Rhopaloceres and Heteroceres*. The earliest surviving communication is a card to Strecker, dated 6 October [1876], in which Morton advises Strecker that his "plates arrived safely," promising to "return them colored in a few days." This was apparently her first job coloring plates: "I have drawn and colored insects ever since I was ten years old but only for my own amusement, never before having know[n] any one who cared to pay to have them done" (13.ii.1877). Strecker sent completed pattern plates, which Morton used to color the new plates. "I have finished the plates and hope they will meet with your approbation," she wrote. "I have copied them as exactly as possible from the plates you sent already colored . . ." (9.x.1876). She complimented Strecker's lithographic work, noting that his plates were "most beautifully delineated, which greatly reduces the labor of coloring . . ." (ibid). Morton improved her coloring using real specimens: "Will you let me know whether you prefer my copying exactly from your colored plates or from the insects, when I have them?" (20.x.1876). She later added, "The instant I see the insect I know almost exactly what colors will imitate it best; but from a copy [I] have to mix sometimes half a dozen different colors, and even then not be able to get the right tint" (22.ii.1877). Morton was very careful to perform her work as Strecker directed, asking if he desired to have the figures "glazed after they are painted or a little more highly colored, rendering the glazing unnecessary" (ibid.). She also was concerned that she was applying the correct amount of paint (3.x.1877).

Not only did Morton color plates for Parts 13–15 as they were issued, she also colored plates for new copies of Parts 1–12, which were needed to bring later subscribers up to date on the work. For Parts 14 and 15, Morton worked "all day for two or three months" (22.vii.1878), suggesting that she was probably the sole colorist for those parts. By then she found it much easier to "get the exact color" than when she first started, recognizing that the later versions of Plate 10 were only "a facsimile" of her first attempt (i.e. they were much improved), but admitted to Strecker that they "may not be exactly like yours" (ibid.). She stated that Part 15 was not easy, "taking longer to color than any except Nos 10 and 7 which are the most troublesome of the whole . . ." (3.xi.1878).

After Part 15 of *Rhopaloceres and Heteroceres* was issued, Morton advised Strecker, "If you want me to color more back numbers, you might send me forty or fifty sets and I will do them at my leisure, ten or twelve sets at a time, and you can send for them as you want them . . ." (22.vii.1878). Morton frequently mentioned sending "sets" of plates for all the parts issued up to that point. On 2 February 1879 she listed the inventory of all the uncolored plates to complete, from 1 to 15. This reveals that Strecker did not just issue the book as the parts were published, but filled many orders for previous parts during the entire production of the book and beyond. This process is analogous to the production of the three-volume book on North American butterflies by W. H. Edwards (Calhoun 2013), which was partially published contemporaneously with Strecker's work. It appears that Strecker grew weary of coloring the plates after Part 12 was published, thus Morton was hired to color the plates for Parts 13–15 and for all orders of previous parts of the first edition. Morton colored a surprising number of plates, including 117 in February 1877, 144 in October 1877, 230 in December 1877, 84 in March 1878, 244 in March 1878, and 149 in February 1879.

Morton was paid ten cents for each plate (about $2.35 today), regardless of the number of figures, some of which were quite difficult to color. One particularly problematic figure was that of the African moth *Nudaurelia eblis* on Plate 14 (Strecker described this species in the book as *Bunaea eblis*). Comparing her version of this figure with that on the original pattern plate by Strecker, Morton reported, "I find much difficulty in putting the color on smoothly, and I don't think mine is quite as rich a brown" (15.x.1877). Referring to this plate, she later added, "I found little difficulty in coloring the figures with [the] exception of *Bunaea Eblis* in which I could not make the paint work smoothly in burnt sienna, but finally succeeded in imitating the color almost exactly with scarlet lake, indian yellow & India ink, though even then it required always four and generally six coats of paint, to make it as dark as yours" (18.xii.1877). Because Morton did not have specimens of all the species portrayed, she "could not seem to hit the right shade" for some figures (22.ii.1877). She remarked to Strecker that the figure of *Battus loadamas copanae* (Reakirt) on Plate 8 (identified as *Papilio copanae*), "puzzles me very much in the green and I could not get the peculiar transparent green with which yours was colored" (ibid.).

In addition to receiving payment from Strecker, Morton requested complete sets of Parts 1–13. After receipt she confessed that it was the first work on Lepidoptera that she personally owned, and it was valued "very highly indeed" (22.ii.1877). While coloring plates for Part 14, she asked for a copy of the accompanying letterpress, noting that Strecker's descriptions "often state the exact color" (15.x.1877). Unfortunately, Strecker was sometimes tardy with payment, prompting Morton to complain that "it is disappointing to work so hard and wait so long after to be paid . . ." (7.vi.1878). Although she had previously asked to receive payment only after Strecker approved her work (11.i.1877), she later expected "to receive at least part of the bill," or else she would "feel not at all disposed to send in the finished numbers" (7.vi.1878). In 1878, Morton offered to personally create new plates for Strecker using the new "autographic process," a more cost-effective means of lithographic printing. Strecker did not take her up on the offer.

Morton considered Strecker to be a close friend, sending specimens for identification, purchasing insect pins from him, and often relating personal events. She visited Strecker at his home in Reading in May 1879, and admonished him the following month for being ill: "I cannot say [I] wonder at it — if you work all day with your hands and all night (or nearly) with your brain what else can be expected. You do not even rest on Sunday" (16.vi.1879). That year she lamented the death of the English entomologist William V. Andrews (1811–1878). During his residence in Brooklyn, New York, Andrews had helped Morton immensely in identifying insects, offering advice, and allowing the use of his library. This loss greatly decreased her "love for, and interest in Entomology" (12.ii.1879). On the recto of the rear wrappers for Parts 11–15 of the first edition of *Rhopaloceres and Heteroceres*, Strecker included an advertisement for Andrews as a "Purchasing Agent for

FIGS. 2–5. Features of the first and second editions of *Rhopaloceres and Heteroceres*. **2.** Publication date from the wrapper of the second edition (top), and portion of the preface for same edition. Inset is the date given in the preface. **3.** Detail of Plate 10 from the first (left) and second editions. Note gray background on the plate for the second edition (red arrow) and poor quality coloring of the figures. **4.** Dorsal figure of male *Lycaena rubidus sirius* (W. H. Edwards) from Pl. 10 of the first (left) and second editions. This figure is likely based on an existing specimen from Strecker's collection (FMNH), labeled "*c*" from Colorado. **5.** Comparison of letterpress between the first and second editions: **a**, imperfect "G" from pg. 5 of first edition; **b**, corrected "G" from same page in the second edition; **c**, **d**, defective "w" and imperfect "s" from pg. 89 of both editions.

Books and Apparatus in connection with Natural History."

The last reference to Morton doing coloring work for Strecker is a card dated 27 June 1879, when she advised that she had just sent "the finished plates." I found no direct evidence that she knowingly completed any plates for the second edition, but at least some of those previously sent to Strecker were probably used for that purpose. Despite the careful attention of Strecker and Morton, Walton (1921) evaluated the plates of *Rhopaloceres and Heteroceres* as "good but not of the very highest quality . . . The coloring also is of mediocre quality and this is particularly noticeable in some of the larger moths . . . ." Although most of the species are readily identifiable, the quality of the figures is irregular, perhaps illustrating the differences between those colored by Strecker and Morton.

In addition to his work on the plates, it was reported that Strecker also set the type for the letterpress of *Rhopaloceres and Heteroceres* (Leach 2013), possibly based on the claim by Barber (1888) that Strecker had "set up the type and done the printing" for his earlier works." However, I found no evidence that he had set the type for his book and he took credit only for the plates (Strecker [1879]). Each part was printed by Owen's Steam Book and Job Printing Office, operated by Benjamin F. Owen (1831–1917) on Court Street in Reading. With the exception of his time in the Union Army during the Civil War, Owen operated print shops in Reading beginning in 1857 (Anonymous 1917). He was also responsible for printing the supplements of *Rhopaloceres and Heteroceres*, as well as Strecker's other book, *Butterflies and Moths of North America* (Strecker 1878).

Strecker ([1879]) admitted that he suffered "adverse criticism" during the production of the first edition. This mostly stemmed from his abrasive comments about other lepidopterists and habit of redescribing known taxa. Exposing the tremendous conflicts that had arisen between several nineteenth century lepidopterists, Strecker brazenly attacked Samuel H. Scudder, Augustus R. Grote, and William Saunders within the pages of his book. Grote later responded to these insults, accusing Strecker of "casting great reproach upon Entomology," adding "You must know of course how you misrepresent me and I spare myself any written defense in consequence. . . while you cannot injure me you are hurting interests which we both have at heart" (3.iv.1878, FMNH). Because of Strecker's "vulgar abuse of Grote," the Harvard entomologist

Hermann A. Hagen advised Strecker that he would have nothing to do with him. Pastor and lepidopterist George D. Hulst cautioned Strecker: "I am sorry you go after Messrs. Grote & Scudder to such a length, I think it a great mistake" (28.ii.1876, FMNH). After receiving a later installment of the book, Hulst brusquely stated that he did not wish to see "personalities in a scientific work" (21.v.1878, FMNH). Even Strecker's staunch ally, the New York stock broker and entomologist Berthold Neumoegen (or Neumögen), was troubled by the "old bickering at Grote" (22.iii.1878, FMNH). Saunders (1873) accused Strecker of launching "a most uncalled for and ungentlemanly attack" against him. Never shying away from further controversy, Strecker republished Saunders' comments in Part 5 of *Rhopaloceres and Heteroceres*, adding a disparaging rebuttal while calling Saunders' remarks a "splendid and entirely unexpected advertisement of this work." William H. Edwards asked Strecker why subscribers should "be bothered with your grievances against Mr. Saunders" and condemned the attack on Scudder as "entirely uncalled for," asserting that a scientific publication "ought not to be a vehicle for everybody's private grief" (18.ix.1873, FMNH). In his review of Part 14 of *Rhopaloceres and Heteroceres*, Saunders (1878) expressed his regret that Strecker's work "should be marred by such gross personal abuse as he so frequently indulges in." Saunders insisted that such "low and ungentlemanly language is entirely unworthy of any one aspiring to the humblest position in the scientific world, and can only result in injury to himself." Of course, there were those who were sympathetic to the opinions expressed in the book, boldly declaring their viewpoints in letters to Strecker and others. Despite the intense criticism of certain aspects of *Rhopaloceres and Heteroceres*, those who condemned it continued to subscribe, something that Strecker probably took as validation of this work. Undaunted, and inspired by the praise of others, Strecker reissued the book in 1879 as originally published, with only minor corrections (see below).

Not only was Strecker criticized for his outspoken opinions in *Rhopaloceres and Heteroceres*, he was accused of intentionally antedating parts of the book. Brown (1964) determined that none of the month/year publication dates printed on the parts were accurate, with some being off by many months. Although Part 5 is dated "July 1873," the text refers to a letter dated 5 August 1873, which Strecker reportedly received as that part was going to press. Grote (1875) accused Strecker of misdating Part 11 to supersede some earlier moth descriptions. Part 14 was predated by many months, purportedly in an effort to claim authorship of several taxa that had been described by Scudder and W. H. Edwards ([Saunders] 1877, Aaron 1884). Part 15 was issued eight months after its published claim of "November, 1877."

Brown (1964) proposed a publication date of 16 July 1878 for Part 15 based on an entry in Strecker's ledger. However, a letter to Strecker from B. Neumoegen, dated 12 July 1878 (FMNH), acknowledges receipt of "book no. 15." Because Strecker's correspondence typically reached New York from Reading in two or three days, the publication date for Part 15 should be amended to 9 July 1878. This affects only the publication of the name *Melitaea alma* (=*Chlosyne leanira alma*), which was described by Strecker in that part. In a previous letter, dated 22 March 1878, Neumoegen mentions receiving "books 14 & 15," but this is apparently in error for Parts 13 and 14.

Second edition. Weiss (1953) alluded to a second edition of *Rhopaloceres and Heteroceres*, citing a 1953 catalog of the bookseller Edward Morrill & Son, who listed a second edition of "(1879)." Weiss did not elaborate or investigate further. I have found no other references to this edition in published bibliographies of entomological works, except Holland (1898, 1931), who may have inadvertently alluded to it when stating that the book "came out from 1872 to 1879." Numerous copies of *Rhopaloceres and Heteroceres* are preserved in libraries, but I was able to locate only eight that are identified as the second edition. An additional copy was found in the library of Eric H. Metzler. A copy at The Ohio State University can be viewed online (HathiTrust 2016). An incomplete copy of the second edition (lacking Pl. 4) was auctioned several years ago by a bookseller in Texas and images of some of its plates are also available online (Sloan 2009).

The second edition (Strecker [1879]) was published as a complete book (i.e. not in parts) in paper wrappers, which varied in color (e.g. buff and yellow). Despite accusations that Strecker had intentionally misdated several parts of the first edition, the original publication dates of the first and last parts are repeated on the front wrapper of the second edition as "Jan. 1, 1872 to Nov., 1877" (Fig. 2). In the upper left hand corner of the front wrapper is "No. 1 to 15." Also on the cover, but oddly out of place and not applicable to this edition, is the statement "Issued Quarterly, at 50 Cents per Part in U.S. / In Europe, 2 Shillings, exclusive of postage." This was possibly included in error by the printer, carried over from the last few parts of the first edition.

Like the title page of the first edition, that of the second edition gives a publication date of "January 1, 1872." Rather than crediting Owen's Steam Book and Job Printing Office as the printer, the front wrapper and title page of the second edition states "Printed for the Author." While the first edition includes a prefatory "Advertisement" detailing Strecker's original plans to issue parts of the book, this page in the second edition was printed under the heading "Preface to the First Edition," without alteration to the original text. This page is preceded by a "Preface to the Second Edition," dated "Nov., 1879" (Fig. 2), which is the only physical evidence of this edition's publication date. This page offers insight into the production of the first edition and summarizes the history of the second edition:

> "When this work was commenced, seven years ago, it was more with a view to private distribution among a few interested friends than with any idea that it would be deemed of sufficient value to ensure a more extended demand. And, after the issue of the first number, there seemed every prospect that the expectation of a limited circulation would be realized; for, notwithstanding that the plates were drawn, lithographed and even coloured by myself, the cost of paper, printing and incidentals was more than I felt able to invest in so non-paying an enterprise. But the powers interested will otherwise, for to a friend not specially interested in any one branch of science or art, but who had warm appreciation of the beautiful and curios in both, I was indebted for the opportunity of continuing the work until it reached the fourth part; after which, despite adverse criticism, which was dealt out with unsparing liberality, and the prognostications of those who were not enamored of my style, it began to pay for itself, and has continued to do so ever since, until the first edition has been entirely exhausted. Perhaps no more fitting place may offer wherein to express my gratitude to this gentleman, Mr. Edward P. Boas, of this city, for his unasked and liberal aid.
>
> "My impecuniosity at the time of the publication of the first few plates would not allow me to retain the drawings on the stone, but of necessity I was obliged to obliterate each one after the impressions were struck off, in order to use the same stone for the drawing of the next. Hence when the first edition was exhausted, the few hundred extra impressions of the later plates that I had the precaution to have printed, were of no use unless the earlier ones were reproduced. The number of inquiries for the work now demands that this be done, and a second edition is herewith submitted to the public. It is, with the exception of the correction of a few typographical errors, an exact reproduction of the first."

This confirms that Strecker ordered extra plates during the production of the first edition in the event that the book was successful and he desired to issue additional copies.

Despite Strecker's claim that he replaced only "earlier" plates, my analysis indicates that he also reproduced at least two later plates. Plates 1–3 in my copy, as well that of E. H. Metzler, are hand-colored photomechanical reproductions of the original plates. They are printed on thinner, coated paper, most likely using the heliotype process. A very subtle plate mark is present near the outside margins of these plates. Plates 10 and 11 of my copy were printed on thicker, cream-colored coated paper using the same process. Four of these five plates (1, 3, 10, and 11) exhibit a shadowy gray background extending beyond the figures, which is an artifact of the photographic process (Fig. 3). The gray background on Plate 10 indicates that there was a small, rectangular piece missing from the left margin of the film negative used for this print. This is also clearly evident on this plate in the second edition sold by Sloan (2009). All other plates in my copy of the second edition are hand-colored lithographs printed on thicker, uncoated paper, as published in the first edition. Of the twelve plates in the second edition figured by Sloan (2009), 1, 10 and 11 are reproductions (Pls. 2 and 3 are not figured). Plates 1–3 and 10 of the Ohio State copy (HathiTrust 2016) are also reproductions (Pl. 11 is missing). Interestingly, Plates 10 and 11 of Metzler's copy are not reproductions, suggesting that Strecker was still using inventory of the original lithographs when he assembled Metzler's copy, and perhaps others. He was forced to reproduce these plates for additional copies of the book, explaining why he made no mention of these later plates in the preface of the second edition.

Many of the figures in the second edition were colored in a sloppy fashion, with heavier, unnaturally vivid applications of paint (Fig. 4). The quality varies considerably between plates, suggesting that more than one colorist was involved. Many figures were haphazardly varnished after being colored and this coating is often yellowed. Strecker possibly waited to color some of the extra plates from the first edition until they were employed for the second edition. The plates in the second edition were inserted into the volume to be viewed in the recto position, with their left margins toward the gutter. Each was preceded by a blank sheet of coated protective paper.

My examination of the second edition reveals that Strecker also retained extra copies of letterpress from the original parts of the first edition, thus he reprinted very little of the original book. Comparing the text from both editions reveals that only five signatures of the second edition exhibit differences (pgs. 5–[8], 9–12, 13–[16], 17–20, and 21–24). These changes mostly involve the addition of page numbers, but defects in the letterpress were also inadvertently corrected when those signatures were reprinted with new type (Figs. 5a, b). Pages 21 and 22 were slightly reformatted, but the content remained unchanged. All other pages are the same as those in the first edition, with identical

TABLE 1. Summary of the publication of *Rhopaloceres and Heteroceres*. Wrapper abbreviations: FR=front recto; FV=front verso; RR=rear recto; RV=rear verso.

Issue	Publication Date	Pagination	Wrapper Details
First Edition			
Part 1	5 April 1872	[1-8]; pl. [1]	FR: dated "January 1, 1872" with "Price 50 Cents." RR: notice to publishers with seven advertisements.
Part 2	14 May 1873	[9], 10-12, [13-14], 15, [16]; pl. 2	FR: dated "April, 1872" with "Price 50 Cents." FV: two notices. RR: list of 26 species desired by Strecker. RV: advertisement for North Atlantic Express Co.
Part 3	17 June 1873	17-24; pl. 3	FR: dated "May, 1873," with "Price 50 Cents." FV: two notices. RR: list of 51 species desired by Strecker. RV: advertisement for North Atlantic Express Co.
Part 4	18 July 1873	25-32; pl. 4	FR: dated "June, 1873," with "Price 50 Cents." FV: two notices. RR: list of 51 species desired by Strecker. RV: advertisement for North Atlantic Express Co.
Part 5	14 September 1873	33-43, [44]; pl. 5	FR: dated "July, 1873," with "Price 50 Cents." FV: two notices. RR: list of 86 species desired by Strecker. RV: advertisement for North Atlantic Express Co.
Part 6	17 October 1873	45-50; pl. 6	FR: dated "August, 1873," with "Price 50 Cents." RR: list of 96 species desired by Strecker. RV: advertisement for North Atlantic Express Co.
Part 7	13 December 1873	51-60; pl. 7	FR: dated "September, 1873," with "Price 50 Cents." RR: list of 101 species desired by Strecker. RV: advertisement for North Atlantic Express Co.
Part 8	27 February 1874	61-70; pl. 8	FR: dated "1874," with "Price 50 Cents." RR: list of 104 species desired by Strecker RV: advertisement for North Atlantic Express Co.
Part 9	8 May 1874	71-80; pl. 9	FR: dated "1874," with "Price 50 Cents." RR: list of 105 species desired by Strecker. RV: advertisement for North Atlantic Express Co.

TABLE 1. Summary of the publication of *Rhopaloceres and Heteroceres*. Wrapper abbreviations: FR=front recto; FV=front verso; RR=rear recto; RV=rear verso. CONTINUED from previous page.

Issue	Publication Date	Pagination	Wrapper Details
First Edition			
Part 10	28 August 1874	81-94; pl. 10	FR: dated "1874," with "Price 50 Cents." RR: list of 105 species desired by Strecker. RV: advertisement for American Oceanic Express Co.
Part 11	28 November 1874	95-100; pl. 11	FR: dated "1874," with "Price 50 Cents." RR: list of 105 species desired by Strecker. RV: advertisement for American Oceanic Express Co.
Part 12	18 May 1875	101-108; pl. 12	FR: dated "1875," with "Issued Quarterly at 50 Cents per Part." RR: list of 105 species desired by Strecker. RV: advertisement for the express company, S. D. Jones.
Part 13	20 February 1876	109-123, [124]; pl. 13	FR: dated "1876," with "Issued Quarterly at 50 Cents per Part in U.S. / In Europe, 2 Shillings." RR: list of 108 species desired by Strecker. RV: three advertisements.
Part 14	18 March 1878	125-134; pl. 14	FR: dated "1877," with "Issued Quarterly at 50 Cents per Part in U.S. / In Europe, 2 Shillings. RR/RV: list of 219 species desired by Strecker. RV: advertisement for W. V. Andrews. "
Part 15	9 July 1878	135-143, [144]; pl.15	FR: dated "1877," with "Issued Quarterly at 50 Cents per Part in U.S. / In Europe, 2 Shillings." RR/RV: list of 219 species desired by Strecker. RV: advertisement for W. V. Andrews.
Second Edition	November 1879	[1-4, 5-7, [8], 9-15, [16], 17-43, [44], 45-123, [124], 125-143; pls. 1-15	Buff wrappers dated "Jan. 1, 1872 to Nov., 1877," with "Issued Quarterly at 50 Cents per Part in U.S. / In Europe, 2 Shillings, Exclusive of Postage." Signatures 5-[8], 9-12, 13-[16], 17-20, and 21-24 reprinted with changes/corrections. Plates 1-3 reproduced. Plates 10 and 11 reproduced in later copies. Remainder of text and plates as in first edition.
Supplements			
No. 1	15 September 1898	[1-5], 6-12	Unable to locate original wrappers.
No. 2	30 June 1899	[1-3], 4-11, [12]	Unable to locate original wrappers.
No. 3	9 March 1900	[13-17], 18-37	Light gray or blue wrappers dated "1900."
Addendum to No. 3	21 April 1900	38	Dated "April 21, 1900."

impressions that exhibit analogous imperfections and defects, which are present in all four copies of the first edition that I consulted (Figs. 5c, d). The fact that Strecker used previously-printed letterpress for the second edition is most obvious on pages 101–108, which were printed on dusky paper, conspicuously matching the same pages in Part 12 of the first edition. Though not stated on the title page, the printer of the second edition is implied to be B. F. Owen.

The number of copies of the second edition is unknown, but it was probably 50 or fewer. The date "Nov., 1879" is consistent with a letter to Strecker, dated 6 November 1879, from the entomologist Joseph A. Lintner, who wrote, "I am glad that . . . the demand for the work authorizes you to issue another edition" (FMNH). According to Strecker's correspondence, he usually sold copies of the second edition for $7.50, which is equivalent to about $180 in today's economy.

Supplements. The three supplements to *Rhopaloceres and Heteroceres* were issued in paper wrappers. The first two supplements, dated 15 September 1898 and 30 June 1899, were offered for twenty-five cents. The third supplement, dated 9 March 1900, was priced at fifty cents. Bridges (1993) suggested that the third supplement was issued after 10 December 1900, but a copy was received in Washington, D.C. on 13 March 1900 by the Smithsonian entomologist Harrison G. Dyar. Strecker was apparently working on the third supplement two months earlier, when Dyar remarked, "I shall be glad to see your supplement 3" (28.i.1900, FMNH). Few surviving copies of *Rhopaloceres and Heteroceres* include all three supplements, as they were issued long after most owners had already bound their copies of the book (many of the original subscribers had died or were no longer active). My own copy of the first edition includes only the first two supplements. The supplements were more often bound together as a stand-alone volume.

Within days of learning that a new butterfly was to be described by the Illinois lepidopterist William Barnes, Strecker rushed to press with his own one-page description of *Neophasia epyaxa* (Strecker 1900b), apparently in a deliberate attempt to steal authorship. Skinner (1900) exposed this offense and confirmed that he received a copy of Strecker's description "a couple of days" after 19 April 1900. Skinner's copy is currently preserved in the library of the Academy of Natural Sciences (Philadelphia, Pennsylvania), and it is date-stamped "April 24 1[900]." Across the top, Skinner scrawled, "This special sheet was gotten out to steal the authorship of this species description & represents the most contemptible piece of work that has come to my notice." Dated "April 21, 1900," Strecker did not include a separate title page to clearly identify this description as a fourth supplement to *Rhopaloceres and Heteroceres*. However, the page number "38" is printed on the sheet, indicating that it was to follow the third supplement, which ended on page 37. Pelham (2008) suggested that this single page was issued separately, then also published as part of the third supplement. Evidence reveals that it was actually issued only once and was not physically part of the third supplement. A letter from H. G. Dyar, dated 27 April 1900, thanked Strecker for sending the one-page description, which was more than six weeks after he received the third supplement on 13 March (FMNH). Carlvert (1900) listed the third supplement as including "Pp. 15–37," with no reference to a 38th page. An original copy of the third supplement at FMNH contains only pages [13]–37. My own copy of the first edition of *Rhopaloceres and Heteroceres* includes an old Photostat (pre-1953) of the third supplement, which ends on page 37. In addition, page 37 of the third supplement is printed on the recto of the sheet; the verso is blank. As suggested by Oiticica (1946), it is perhaps best to treat this one-page description as an addendum to the third supplement. The date-stamp on the copy of this sheet at ANSP ("April 24 1[1900]") reinforces the printed publication date of 21 April 1900. In the end, Strecker received no reward for his impulsive description of *N. epyaxa*. Almost immediately after publishing his description, H. G. Dyar wrote that it represented the female of a known species: "But it seems to me that you have but the ♀ of *N. terlooii* Behr." (27.iii.1900, FMNH). Skinner (1900) and Poling (1900) soon confirmed that *N. epyaxa* was indeed the female of *Neophasia terlooii.* This was to be Strecker's last bid for fame. He died the following year.

Table 1 offers an updated summary of the entire publication history of *Rhopaloceres and Heteroceres*, including page numbers and other aspects of the work. All but one of the publication dates listed for the first edition are consistent with the conclusions of Brown (1964).

ACKNOWLEDGEMENTS

Thanks are extended to John King and Tom Heitjan of John K. King Used and Rare Books in Detroit, Michigan, for helping me acquire the second edition of *Rhopaloceres and Heteroceres*. Staff of the Field Museum of Natural History, namely Crystal A. Maier, Rebekah S. Baquiran, and Gretchen Rings, were extremely helpful and extended many courtesies during my visit. Armand Esai (Field Museum of Natural History Archives) kindly arranged for me to examine letters from Strecker's correspondence. Jacqueline Y. Miller and Andrew D. Warren (McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History, Gainesville, Florida) permitted access to manuscripts under their care. Kelsey Manahan (Library and Archives, Academy of Natural Sciences) generously provided numerous images and answered my many questions. Dorothy Sloan (Dorothy Sloan Rare Books, Austin, Texas) offered information about a copy of the second edition of Strecker's book. Donald G. Kohrs (Stanford University, Pacific Grove, California) and Chad Pearson (Texas A&M University, College Station, Texas) assisted with literature. I also offer sincere thanks to Eric H. Metzler for sharing information about his copy of the second edition and for reviewing a draft of the manuscript. Charles V. Covell, Jr. and an anonymous reviewer also provided helpful comments on the final manuscript.

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Submitted for publication 30 September 2016; revised and accepted 4 November 2016.

Journal of the Lepidopterists' Society
71(2), 2017, 92–108

A NEW GENUS OF ANDEAN MIMALLONIDAE (MIMALLONOIDEA), WITH THE DESCRIPTIONS OF FOUR NEW SPECIES

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ABSTRACT. *Isoscella*, **gen. n.**, is newly described in the family Mimallonidae with *Isoscella ventana*, **comb. n.** (Dognin, 1897), as its type species, transferring this taxon from *Psychocampa* Grote & Robinson, 1866. We describe and figure the female of *I. ventana* for the first time. Our investigation into this species resulted in the recognition of the following new species: *I. ecuadoriana*, **sp. n.**, from Ecuador, *I. leva*, **sp. n.**, from Peru and Bolivia, *I. peigleri*, **sp. n.**, from Colombia and Ecuador, and *I. andina*, **sp. n.**, from Ecuador and Peru. Both sexes of all species are figured, along with their genitalia. Finally, we discuss the potential close relatives of *Isoscella*.

Additional key words: *Isoscella*, gen. n., *Isoscella andina*, sp. n., *Isoscella ecuadoriana*, sp. n., *Isoscella peigleri*, sp. n., *Isoscella leva*, sp. n.

Until recently, very little revisionary work has been conducted on the family Mimallonidae, and no comprehensive study has utilized modern morphological or molecular methods to understand phylogenetic relationships and generic boundaries. Therefore, Mimallonidae pose a difficult problem in terms of classification.

Since 2012, eight new genera have been described to include likewise new species or previously described, enigmatic species (Herbin 2012, Herbin 2016, St Laurent 2016, St Laurent & Mielke 2016). The family Mimallonidae now contains 35 genera; therefore, the relative increase in the number of genera is high, and is evidence of the inadequacy of the historical generic framework of the family (Becker 1996, St Laurent unpublished).

We focus on a group of Andean Mimallonidae that share several external and genitalia characters, setting them apart from others in the family and hereby describe a new genus in which to place them. *Isoscella ventana* (Dognin, 1897) comb. n. is the only currently described taxon treated herein, which, based primarily on male genitalia, does not belong in its current genus, *Psychocampa* Grote & Robinson, 1866. We recognize three separate species currently all considered to be as *ventana*, describing two of them as new, as well as two additional unique species reported here for the first time.

MATERIALS AND METHODS

Dissections were performed as in Lafontaine (2004). Morphological (including genitalia) terminology follows Kristensen (2003). Genitalia preparations are either slide mounted (those from Museum Witt, Munich) or maintained in glycerol filled microvials to allow for three-dimensional analysis of complex structures.

Specimens from the following collections were examined:

AMNH	American Museum of Natural History, New York, New York, USA
CMNH	Carnegie Museum of Natural History, Pittsburgh, Pennsylvania, USA
CUIC	Cornell University Insect Collection, Ithaca, New York, USA
EMEC	Essig Museum of Entomology, University of California Berkeley, California, USA
MGCL	McGuire Center for Lepidoptera & Biodiversity, Gainesville, Florida, USA
MPUJ	Pontificia Universidad Javeriana, Bogotá, Colombia
MWM	Museum Witt, Munich, Germany
NHMUK	The Natural History Museum, London, U.K.
NHRS	Entomological Collections, Swedish Museum of Natural History, Stockholm, Sweden
UGCA	University of Georgia Collection of Arthropods, Athens, Georgia, USA
USNM	National Museum of Natural History [formerly United States National Museum], Washington D.C., USA

Figures were manipulated with Adobe Photoshop CS4, male genitalia are figured in natural color with CS4 "auto color" used to improve white backgrounds

(Adobe 2008). Genitalia were photographed in ethanol under glass, unless otherwise noted. All geographical coordinates are inferred based on the localities provided on specimen labels when explicit coordinates were not present. GPS data were acquired with Google Earth and Google Maps. Maps were made with SimpleMappr (Shorthouse 2010).

RESULTS AND DISCUSSION

ISOSCELLA, new genus

Type species: *Perophora ventana* Dognin, 1897

Etymology. The name for this genus is derived from elongate, isosceles triangle-like shape of the forewings, as well as from the shape the tegumen and uncus, which together also form a triangle.

Diagnosis. All species in the genus can be recognized by the following combination of external characters: narrow, elongate, triangular or subtriangular wings, and a single, circular to ovoid hyaline patch occupying the discal region of each wing. The male genitalia have triangular or subtriangular valves, a triangular uncus, a rectangular gnathos with a pair of thin, fingerlike projections mesally, as well as a pair of heavily sclerotized, outwardly curved arms and broad plates protruding outward from the base of the saccular region of the vinculum. Both pairs of arms and the plates are covered in setae. The most similar genus, *Roelmana* Schaus, 1928, containing the sole species *R. maloba* (Schaus, 1905) (but see remarks below), can be recognized by the light gray tornal and apical suffusions on the forewings and by the more robust, rounded gnathos of the male genitalia and more elongated vincular projections.

Description. Male. *Head*: Light orange to dark red or brown-red, interspersed with dark petiolate scales; antenna dark brown to dark yellow, basally bipectinate; labial palpus very small, indistinct, not extending beyond frons, colored as for head, segments not easily differentiable due to thick vestiture. *Thorax*: Coloration as for head, interspersed with dark petiolate scales, prothoracic collar lined with prominent gray scales. Coloration of legs as for thorax, slight pinkish hue evident in thick vestiture. Forewing length 21–38 mm, wingspan 42–65 mm. Forewing elongate, triangular, margin nearly straight, concave along falcate apex. Dorsum ground color pale orange, brown-orange, or purplish-brown. Overall lightly speckled by dark and bicolored petiolate scales. Antemedial line faint to nearly absent, wavy, black. Postmedial line nearly straight from tornus until just before Rs4 where line becomes fainter and angles perpendicularly to costa. Discal cell marked with oblong to nearly circular hyaline patch bisected by M_2. Ventrum similar to dorsum but generally more homogenously colored, darker petiolate scales more numerous and distinct, especially antemedially and medially, antemedial line absent, postmedial line reduced to wavy, outwardly curved traces in most species, or follows same pattern as on dorsum. Hindwing triangular or rounded, dorsum coloration and markings as for forewing dorsum, but antemedial line absent, postmedial line continuously dark to anterior wing margin, hyaline patch smaller, narrower, situated nearer to postmedial line, sometimes touching it. Hindwing ventrum follows same pattern as forewing ventrum. Frenulum apparently absent or highly reduced. Venation typical of Mimallonidae, namely *Cicinnus* Blanchard, 1852, but discal cell and all regions between veins particularly narrow considering elongation of wings in *Isocella*. *Abdomen*: Concolorous with thorax, or slightly darker orange-pink ventrally, distal tip with pair of elongated, dark scale tufts. Genitalia with vinculum widened basally with paired, setae covered, curved, hornlike structures emanating outward toward valves, valves with cup-like indentation where hornlike structures approach preventing interference with valves. Cup-like indentation variously lined with heavily sclerotized teeth of varying arrangement, in some species teeth absent, and in one species indentation absent. Second paired structure attached to vincular arms by membrane and weak sclerotization, this secondary structure surrounds either side of phallus, situated behind the more heavily sclerotized aforementioned arms, secondary structure edged with sharp setae pointed outward, length of setae variable. Uncus simple, triangular. Gnathos as two separate, thin, fingerlike processes reaching nearly to base of uncus, gnathos processes joined by narrow mesal bridge. Shape of valves variable, from triangular to rounded, weakly angled away from uncus. Juxta partially fused to phallus. Phallus somewhat cylindrical to substantially broadened, especially distally, distally encircled by short setae, vesica weak, roughly phallus-length, somewhat conical.

Female. *Head*: As in male but antennal rami shorter. *Thorax*: As in male. Forewing length 30.0–35.5 mm, wingspan 61–71 mm. Similar overall to male, but broader, margin slightly convex. Dorsum ground color as in male but with variation including individuals somewhat lighter and darker in shading. Postmedial line nearly straight from tornus until just before Rs4 where line becomes very faint and runs perpendicular to costa. Discal cell marked with oblong, somewhat B-shaped, hyaline patch bisected by M_2 and encircled by black scales. Forewing ventrum similar to dorsum but ground color uniformly lighter orange-yellow, darker petiolate scales more numerous and distinct; antemedial line absent, postmedial line nearly absent with only traces present near tornus and costa. Hindwing rounded, dorsum coloration and markings as in forewing dorsum, but antemedial line absent, postmedial line continuously dark to anterior wing margin, hyaline patch smaller, narrower, situated nearer to postmedial line. Hindwing ventrum follows same pattern as forewing ventrum. Frenulum apparently absent. *Abdomen*: As in male, but more robust, distal tufts of scales reduced. Genitalia robust; tergite of VIII forms posteriorly directed arch. Apophyses anteriores roughly same length as apophyses posteriores, but thicker proximally. Lamella antevaginalis as distally smooth, basally wrinkled concave plate of varying size. Lamella postvaginalis heavily sclerotized, broad, with amorphous masses covered in short, thick setae located on either side of lamella postvaginalis, either distinctly differentiated from lamella postvaginalis or homogenous in overall structure. Lamella postvaginalis smooth and variously structured mesally, from concave to outwardly projected. Ductus bursae short, not clearly differentiated from long, tubular corpus bursae. Base of papillae anales with robust sclerotizations dorsolaterally, covered in short, thick setae. Papillae anales somewhat box-like, covered in long, fine setae, setae much shorter basally.

Remarks. The closest relatives of *Isoscella*, based on similarities in male genitalia as well as arrangement and shape of the fore and hindwing hyaline patches, are currently scattered in several genera. Similarities are present in *Roelmana maloba*, *Cicinnus fenestrata* Jones, 1912, *C. brasiliensis* Herbin & Mielke, 2014, *Psychocampa doralica* Schaus, 1928, *P. pluridsicata* (Dognin, 1916), and *P. vitreata* (Schaus, 1905). Although these five species share similarities with *Isoscella*, they form a distinct group in which they are more similar to one another and to the type species of *Roelmana*, *R. maloba*, than to any species of *Isoscella*. It is therefore likely that these species belong in a single separate genus near *Isoscella*. The most conservative placement for these species would be in the currently monotypic *Roelmana* because it is the only genus for which the type species displays these male genitalia characteristics (J. G. Franclemont genitalia dissection 1427, CUIC). None of the previously listed species currently placed in *Cicinnus* and *Psychocampa* Grote & Robinson, 1866 are similar to the type species of their respective genera, and thus *Roelmana* is the only available name to include these related species (St Laurent unpublished, Herbin 2012). These species share with *Isoscella* the following characters in male genitalia: a pair of long, fingerlike mesal projections of the gnathos, valvae with a mesal indentation, and paired vincular arms. However, unlike *Isoscella*, the gnathos is rounded and more heavily sclerotized, the valvae more sharply angled, and the vincular arms narrower and longer. Revisions of *Cicinnus*, *Psychocampa*, and *Roelmana*, as well as phylogenetic analyses of the family will eventually help tease apart these groups and allow for a more robust consolidation of these similar species (likely to be placed) in *Roelmana*. We do believe, however, that male genitalia characteristics are significantly different enough in *Isoscella* to warrant the placement of species covered here, as separate from *Roelmana sensu lato*. *Isoscella* is an entirely Andean genus, whereas *Roelmana* is broadly distributed in Central America and throughout South America, including low elevations, therefore we do not include the latter in the current treatment.

Key to species of *Isoscella* gen. n.

1 Forewing postmedial line nearly straight, diagonal on dorsum, outwardly curved toward wing margin on ventrum of wing (Figs 1–10, 12–14).............**2**

\- Forewing postmedial line with the same, straight, diagonal pattern on both dorsum and ventrum of wing (Figs 15–17)…................***I. andina* sp.n.**

2 Medial area, especially along the costa, light orange to orange-brown (old specimens) or pink to salmon (fresh specimens) colored. Medial and submarginal areas contrasting, submarginal area nearly always much darker than medial area….....**3**

\- Medial area, especially along the costa, pale to very dark brown (old specimens) or purplish brown (fresh specimens) colored (Figs 12–13). Medial and submarginal areas barely contrasting, both areas very dark overall ....***I. peigleri* sp. n.**

3 Male forewing with submarginal area suffused with black, forming a lunule-like pattern, valva indentation teeth usually absent; female genitalia with lamella postvaginalis bent mesally, rectangular laterally. Ecuador...........................…
....***I. ecuadoriana* sp. n.**

\- Male forewing with submarginal area homogenously colored, orange, black suffusion absent or faint, not forming lunule shape, valva indentation teeth usually present or very reduced; female genitalia with lamella postvaginalis bowl-like or keeled mesally, somewhat globularly expanded laterally. Venezuela, Colombia, Peru, and Bolivia..**4**

4 Dorsum usually with speckling due to numerous dark petiolate scales, including submarginally, male hindwing margin convex. Valva indentation teeth reduced, genitalia structures overall less robust (compare Figs 19, 20 to 23, 24). Northern Andes: Venezuela and Colombia
……..…...............................***I. ventana* comb. n.**

\- Speckling mostly absent from dorsum, especially reduced submarginally, male hindwing margin nearly straight with slightly accentuated anal angle, if convex consider degree of speckling and geographic distribution. Valva indentation teeth heavily sclerotized, genitalia structure overall very robust. Southern Andes Mountains: Peru and Bolivia……………………..…….....***I. leva* sp. n.**

Isoscella ventana (Dognin, 1897), **new combination**
(Figs 1–5, 19, 20, 29, 34)
Perophora ventana Dognin, 1897: 243–244
Psychocampa ventana; Schaus 1928: fig. ♂ 87a
Psychocampa ventana; Gaede 1931
Psychocampa ventana; Becker 1996

Holotype. VENEZUELA: Mérida: ♂, MÉRIDA, TERRE TEMPÉRÉE, VÉNÉZUELA/ *Perophora Ventana* Druce, type/ Type No. 29679/ Dognin Collection/ [+ 2 illegible labels]/ USNM-Mimal: 1007/ St Laurent diss.: 8-22-16:1/ (USNM, examined).

Additional material examined. (18 ♂, 2 ♀ total) **VENEZUELA: Mérida:** 1 ♂, Pedregosa [Norte], 3000 m: 1897, Briceno, St Laurent diss.: 4-4-16:1, NHMUK010355074 (NHMUK). 3 ♂, Mérida: Briceno NHMUK010355076 (NHMUK, 2 ♂); Dognin Collection, USNM-Mimal: 1231 (USNM, 1 ♂). 1 ♂, Mérida: Ex. Coll. Ed. Brabant 1920, Joicey Coll., Brit. Mus. 1925-157 (NHMUK). **Barinas:** 2 ♂, Near Altamira village, 8°50'N, 70°30'W, 750 m: 11–22.XI.2012, Y. Bezverkhov, coll. Dr. Ronald Brechlin leg. [label reads "Merida" but this is incorrect], genitalia prep. 30.004 (MWM). **No state:** 1 ♂, Collection Wm Schaus, USNM-Mimal: 1232, St Laurent diss.: 5-3-16:1 (USNM). **COLOMBIA: Boyacá:** 1 ♂, Garagoa, Reserva "El Secreto", 2320 m: 12.X.2001, T. luz [light] at 10:20 pm, nublado [cloudy], col. Zubiria et al. (MPUJ). 1 ♂, Garagoa: 9.IV.2003, A. Ríos et al. (MPUJ). **Cundinamarca:** 1 ♂, Pacho, Eastern Cordillera, 2200 m: Coll. Fassl, Dognin Collection, USNM-Mimal: 1233 (USNM). 1 ♂, 1 ♀, Pacho, 2200 m: Coll. Fassl, NHRS-TOBI 1949, 1950 (NHRS). 1 ♀, Finca San Pablo, 3 km. N. Albán, 1800 m: 1–12.VIII.1967, P. & B. Wygodzinsky [leg.], St Laurent diss.: 3-7-16:1 (AMNH). **Valle de Cuaca:** 6 ♂, 4 km NW San Antonio, 6500': 5.X.1958, A. H. Miller [leg.] (EMEC).

Diagnosis. *Isoscella ventana* can be distinguished from *I. ecuadoriana*, sp. n., *I. leva*, sp. n., and *I. peigleri* sp. n. by the relatively small size (wingspan and overall size of genitalia); shorter, broader wings; and usually larger hyaline patches. The phallus is slightly shorter and broader than in other species. This species is the only member of the genus present in Venezuela, and is

FIGS. 1–5. Adults of *Isoscella ventana*, a=recto, b=verso. **1.** Male holotype, Venezuela, Meridá, Terre Tempérée [photo courtesy of Daniel Herbin] (USNM). **2.** Male, Venezuela, Meridá, Pedregosa, 3000 m (NHMUK). **3.** Male, Venezuela, Barinas, near Altamira village, 750 m (MWM). **4.** Male, Colombia, Cundinamarca, Pacho, 2200 m (NHRS). **5.** Female, Colombia, Cundinamarca, Pacho, 2200 m (NHRS). Scale bar=1 cm.

FIGS. 6–10. Adults of Isoscella, a=recto, b=verso. 6. *I. ecuadoriana*, male holotype, Ecuador, Napo, Cordillera Guacamayos, 2181 m (MWM). **7.** *I. ecuadoriana* male paratype, Ecuador, Napo, Puente Azuela, 1560 m (MGCL). **8.** *I. ecuadoriana* female paratype, Ecuador, Napo, 5 km SE Cosanga, 2240 m (MWM). **9.** *I. leva* male holotype, Peru, Puno, Carabaya, Santo Domingo, 6000 ft (NHMUK). **10.** *I. leva* female paratype, Peru, Cusco, Huayapata, 2400 m (MWM). Scale bar=1 cm.

FIG. 11. *Isoscella ecuadoriana* in situ, Ecuador, Napo, Wildsumaco Biological Station, ~1400 m (Photo courtesy of Chris Hamilton, used with permission).

apparently allopatric from the larger, darker *I. peigleri* sp. n., which is found farther south in Colombia and Ecuador, but see remarks.

Description. *Head*: As for genus. *Thorax*: As for genus. Forewing length 25–27 mm (mean=25.6 mm), wingspan 49–54 mm (n=5), forewing as for genus but less elongate, margin slightly convex, concave along falcate apex. Ground color pale pinkish orange or dull pinkish brown. Discal hyaline patch large relative to small wing. Forewing ventrum as for genus, but generally darker than dorsum due to high concentration of dark petiolate scales. Hindwing rounded, dorsum coloration, markings as in forewing dorsum. Hindwing ventrum patterning as for forewing ventrum but lighter overall due to lower concentration of dark petiolate scales. *Abdomen*: Concolorous with thorax, slightly darker orange-pink ventrally, distal tip with pair of elongated scale tufts terminating in dark scales. Male genitalia (Figs 19, 20) (n=5) as for genus but teeth of cup-like indentation of valva reduced or absent. Valva broad, somewhat pointed apically. Phallus narrow, mostly smooth, elongate, notched apically due to narrow extension of sclerotization. **Female.** *Head*: As in male but antennal rami shorter. *Thorax*: As in male. Forewing length 33.5 mm, wingspan 62 mm (n=1); forewing similar overall to male, but broader, margin slightly convex. Ground color as in male but somewhat lighter, paler coloration extends outward from medial region nearly to apex beyond postmedial line. Discal cell marked with oblong, somewhat B-shaped, hyaline patch bisected by M_2 and encircled by black scales. Forewing ventrum similar to dorsum but ground color uniformly lighter pale orange, darker petiolate scales more numerous and distinct; antemedial line absent, postmedial line nearly absent with only traces present near tornus and costa. Wing margins darker orange-brown, appearing somewhat singed. Hindwing rounded, markings and coloration as for forewing dorsum, but antemedial line absent, postmedial line reduced to traces. Hindwing ventrum pattern as for forewing ventrum. *Abdomen*: As in male but more robust. Genitalia (Fig. 29) (n=1) robust; tergite of VIII forms smooth, posteriorly directed arch. Apophyses anteriores roughly same length as apophyses posteriores, but thicker proximally. Lamella antevaginalis wide, robust, concave, smooth distally, wrinkled basally; lamella postvaginalis broad with amorphous masses covered in short, thick setae located on either side. Ductus bursae short, not clearly differentiated from long, tubular corpus bursae. Base of papillae anales with robust sclerotizations dorsolaterally, covered in short, thick setae. Papillae anales somewhat box-like, covered in long, fine setae, setae much shorter basally.

Distribution (Fig. 34). *Isoscella ventana* is an Andean species found in northwestern Venezuela and central Colombia, at elevations of 750–3000 m.

Remarks. In addition to the discussion offered in the remarks of *Isoscella*, we transfer *I. ventana* from *Psychocampa* due to the complete disagreement in male genitalia characters with *P. concolor* (Grote & Robinson, 1866), the type species of *Psychocampa*. *Psychocampa sensu stricto* is restricted to a group of similar species that have male genitalia bearing strong similarity to that of *P. concolor*, and thus several species currently placed in this genus will eventually be transferred out of *Psychocampa*.

We here describe and figure the female as well as the genitalia of both sexes of *I. ventana* for the first time. Previous literature references to *Isoscella ventana* (as *Psychocampa ventana*) include *I. ecuadoriana*, sp. n. and *I. leva*, sp. n. as well, but we restrict the name *I. ventana* to those populations of northwestern Venezuela and central Colombia, nearer to the type locality of *I. ventana*.

Isoscella ventana is generally consistent in wing shape and orange to orange-brown coloration, but we note significant variation in size of discal hyaline patches. Unfortunately, large series of material from Venezuela and Colombia are lacking, thus it is difficult to determine if variation within this species is correlated with distribution in Venezuela and Colombia. We are also aware of a darker specimen (Fig. 3) from Venezuela, but collecting locality, wing shape, maculation, and genitalia are all consistant with *I. ventana*.

Six specimens in the EMEC from Valle de Cuaca are rather variable in coloration and were collected near the locality of the putative Colombian population of *I. peigleri* (see remarks of *I. peigleri*, sp. n.). These specimens in western Colombia further support the need to locate additional material from surrounding regions to determine the actual distribution of *I. ventana* and *I. peigleri*, sp. n., in Colombia.

Isoscella ecuadoriana, new species
(Figs 6–8, 11, 21, 22, 30, 34)

Psychocampa ventana; Piñas and Manzano-Pesántez 1997, fig. 448 (see remarks)

Psychocampa ventana; Piñas 2007, fig. 217 (see remarks)

Holotype. ECUADOR: Napo: ♂, ECUADOR, NAPO Prov., Cordillera Guacamayos, 0°37'15''S; 77°49'28''W, 11.11.2011; H=2181, leg. V. Siniaev & O. Romanov/ Genitalpräparat Heterocera Nr. 29.262 Musuem WITT München/ HOLOTYPE ♂ *Isoscella ecuadoriana* St Laurent & Carvalho, 2017 [handwritten red label]/ (MWM).

Paratypes. (30 ♂, 1 ♀ total) **ECUADOR: Napo:** 2 ♂, Puente, 1560 m: 1.IV.1976, Coll. Vénédictoff, Allyn Museum Acc. 1986-26 (MGCL). 4 ♂, 1 ♀, 5 km SE Cosanga, 0°37'14''S, 77°54'08''W, 2240 m: 22.I.2012, R. Brechlin & V. Siniaev leg., genitalia prep. 29.244 MWM (MWM). 2 ♂, Cosanga, 2150 m: 4–5.I.2005, Andreas Riekert leg. (MWM). 1 ♂, 6 km SE Cosanga, 0°37'14''S, 77°54'08''W, 2240 m: 22.I.2012, R. Brechlin & V. Siniaev leg. (MWM). 1 ♂, Cordillera Guacamayos, 0°37'15''S, 77°49'28''W, 2181 m: 11.XI.2011, V. Siniaev & O. Romanov leg. (MWM). 2 ♂, Papallacta, Rio San Pedro, 0°22'56''S, 78°7'27''W, 3010 m: 4.XI.2011, V. Siniaev & O. Romanov leg.; 18.I.2012, R. Brechlin & V. Siniaev leg., genitalia prep. 30.002 (MWM). **Morona-**

FIGS. 12–17. Adults of *Isoscella*, a=recto, b=verso. **12.** *I. peigleri*, male holotype, Ecuador, Carchi, Road El Chical to Carolinae, 1970 m (MWM). **13.** *I. peigleri* [putative], male, Colombia, Tolima, San Antonio, 5800 ft (NHMUK). **14.** *I. peigleri*, female paratype, Ecuador, Cotopaxi, San Francisco de Las Pampas, Otonga, 2600 m (CMNH). **15.** *I. andina*, male holotype, Peru, Junín, Cerro Pichita Res. Sta. near San Ramón, 2165 m (MGCL). **16.** *I. andina*, male paratype, data as for Figure 15. **17.** *I. andina*, [putative], female, Ecuador, Morona Santiago, Road Gualaceo to Plan de Milagro, 2601 m (MWM). Scale bar=1 cm.

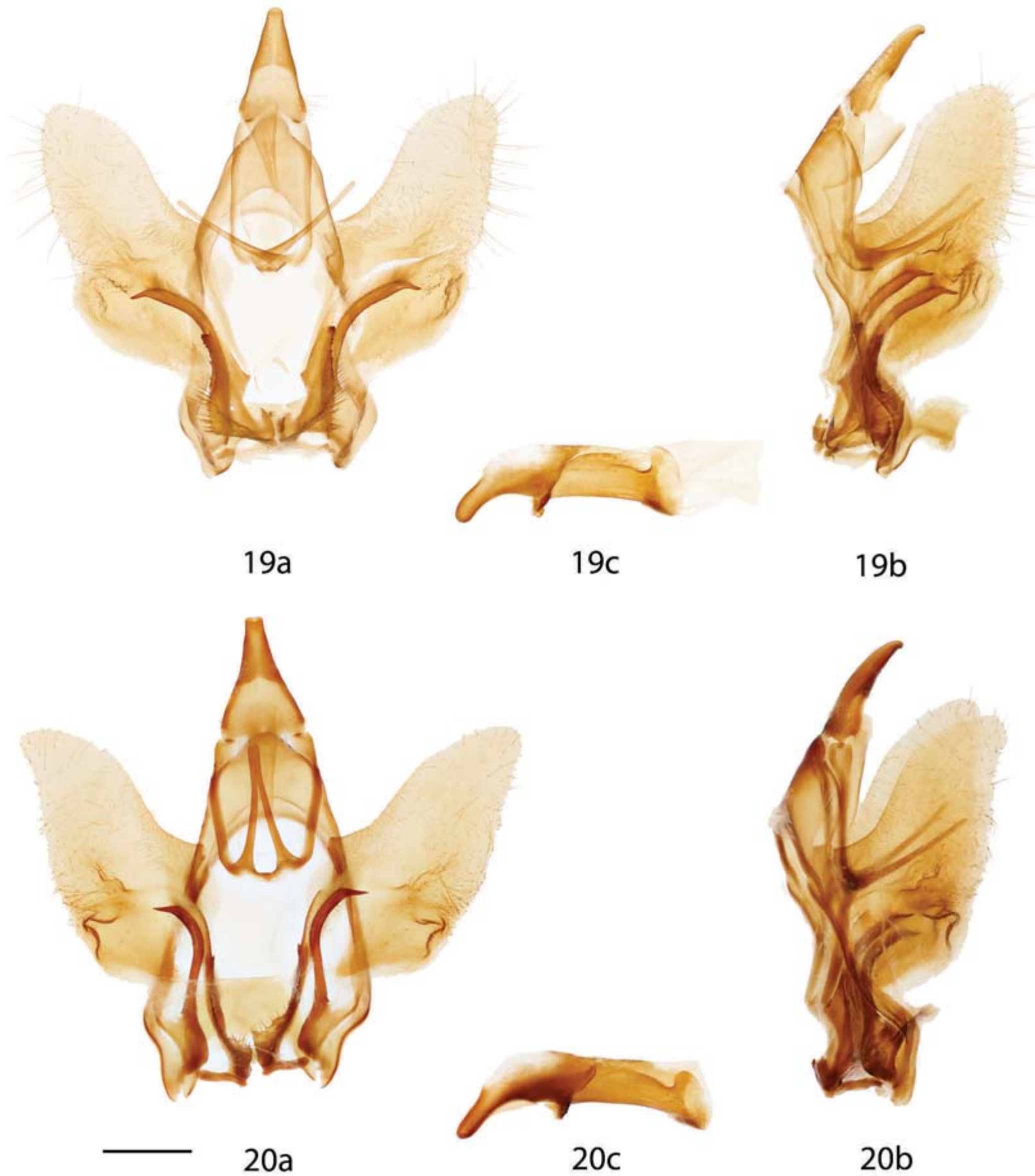
FIG. 18. Putative specimen of *I. peigleri* in situ, Ecuador, Imabura, Cuellaja, Intag Valley, 2400 m (Photo courtesy of Andreas Kay, used with permission).

Santiago: 1 ♂, 9 km W Plan de Milagro to Gualaceo, 3°00'04''S, 78°30'49''W, 2375 m: 6–7.III.2013, Ackermann, Käch, & Dr. R. Brechlin leg., genitalia prep. 30.005 (MWM). 2 ♂, Road Gualaceo-Plan de Milagro, 3°0'21''S, 78°29'53''W, 2033 m: 22.XI.2011, V. Siniaev & O. Romanov leg. (MWM). 7 ♂, Road Gualaceo-Plan de Milagro, 3°01'24''S, 78°35'06''W, 2157 m: 21.XI.2011, V. Siniaev & O. Romanov leg. (MWM). 1 ♂, 34 km Road Plan de Milagro to Gualaceo, 3°00'13''S, 78°38'46''W, 3200 m: 30.I.2012, R. Brechlin & V. Siniaev leg. (MWM). 4 ♂, 34 km Road Plan de Milagro to Gualaceo, 3°01'24''S, 78°35'6''W, 2157 m: 28.I.2012, R. Brechlin & V. Siniaev leg. (MWM). 1 ♂, 9 km Road Plan de Milagro to Gualaceo, 3°00'04''S, 78°30'49''W, 2375 m: 26.I.2012, R. Brechlin & V. Siniaev leg. (MWM). **Zamora-Chinchipe:** 1 ♂, 4.5 km N Zamora, 4°01'51''S, 78°57'29''W, 1270 m: 24.II.2012, R. Brechlin & V. Siniaev leg. (MWM). **Loja:** 1 ♂, Road Loja-Zamora, 3°58'45''S, 79°08'28''W, 2700 m: 22.II.2012, R. Brechlin & V. Siniaev leg. (MWM). – Paratypes with the following yellow label: PARATYPE ♂/♀ *Isoscella ecuadoriana* St Laurent & Carvalho, 2017.

Additional specimens/photographs examined. [Not included in type series] (4 ♂ total) **ECUADOR: Tungurahua:** 1 ♂, Baños [Baños de Agua Santa?], 1800 m: 16.II.1940, WCM leg., St Laurent diss.: 2-26-16:2 [locality data not entirely clear] (CUIC). **Napo:** 1 ♂, Cosanga, Anaycu Biological Station: live specimen photographed by Andreas Kay. 1 ♂, Wildsumaco Biological Station, 0°40'17.2''S, 77 °35'55.1''W, ~1400 m: live specimen photographed by Chris Hamilton (Fig. 11). 4 ♂, Wildsumaco Biological Station, 0°40'17.2''S, 77 °35'55.1''W, ~1400 m: 1–14.VIII.2016, Kawahara + Barber Labs et al., DNA voucher numbers 40624, 40641, 41026, 43142 (MGCL, molecular collection). **Azuay:** 1 ♂, Oriente, Plan de Milagro, 2100 m: Figured in Piñas and Manzano-Pesántez (1997).

Diagnosis. This species is recognizable by the contrast between the medial and submarginal areas; black and gray scaling along the particularly elongated, falcate forewing apex; and by the male genitalia which have elongate, smooth valves and usually lack the heavily sclerotized teeth of the mesal valve indentation (if present, they are highly reduced). Female genitalia are also unique in having a rectangular, but mesally bent (though not projected outward as in *I. leva*, sp. n.) lamella postvaginalis with the setae covered portions largely homogenous with the smooth portion. *Isoscella peigleri*, sp. n. and *I. andina*, sp. n. are also known from Ecuador, but these species are much darker, dark purplish brown (*I. peigleri*, sp. n.) or red (*I. andina*, sp. n.), rather than salmon to pink-orange as in *I. ecuadoriana*. However, some specimens of *I. ecuadoriana* are quite dark (see Fig. 11) when fresh or alive, such that the medial ground color is purplish brown and more similar to that of *I. peigleri*, sp. n. Despite this, the contrast between medial and brown-orange submarginal areas is still diagnostic of *I. ecuadoriana*. Furthermore, *I. andina* sp. n. is a much smaller species and neither this species nor *I. peigleri*, sp. n. is so far known to be sympatric with *I. ecuadoriana* in Ecuador.

Description. Male. *Head*: As for genus. *Thorax*: As for genus. Forewing length 28–32 mm (mean=30.4 mm), wingspan 50–65 mm (n=9); forewing dorsum as for genus but particularly elongate, apex falcate. Ground color pale pinkish orange, darker orange submarginal area strongly contrasting with lighter antemedial and medial areas. Some specimens darker when very fresh, appearing almost purple medially. Apex marked with black and gray scales, black scales of apex continue as dark, concave suffusion along postmedial line until tornus. Fringe rather contrasting, vibrant pale orange. Forewing ventrum as for genus, but with high concentration of dark petiolate scales and darker orange suffusion medially and along costa. Hindwing subtriangular, dorsum coloration, markings as in forewing dorsum. Hindwing ventrum with continuation of pattern of forewing ventrum but lighter overall. *Abdomen*: As for genus, concolorous with thorax slightly darker orange-pink ventrally. Genitalia (Figs 21, 22) (n=4) as for genus but teeth of cup-like indentation of valva usually absent, though minute teeth occasionally present. Valva elongated, smooth, narrow. Phallus narrow, mostly smooth, elongate, notched apically due to narrow extension of sclerotization. **Female.** *Head*: As in male but antennal rami shorter. *Thorax*: As in male. Forewing length 32.5 mm, wingspan 71 mm (n= 1); forewing similar overall to male, but broader, margin slightly convex. Dorsum ground color as in male but somewhat more pink with faint black suffusion medially, black and gray suffusions near apex and submarginally absent, postmedial line less well-defined after passing Rs4. Discal cell marked with oblong hyaline patch bisected by M_2 and encircled by black scales. Forewing ventrum similar to dorsum but ground color uniformly lighter orange-yellow, darker petiolate scales more numerous and distinct; antemedial line absent, postmedial line nearly absent with only traces present near tornus and costa. Wing margins darker orange-brown, appearing somewhat singed. Hindwing rounded, dorsum coloration, markings as for forewing dorsum, but antemedial line absent, postmedial line continuously dark to anterior wing margin, hyaline patch smaller, narrower, situated nearer to postmedial line. Hindwing ventrum with continuation of pattern of forewing ventrum but pinker rather than orange. *Abdomen*: Concolorous with thorax, slightly darker orange



FIGS. 19, 20. Male genitalia of *Isoscella ventana*, a=ventral, b=lateral, c=phallus. **19.** Venezuela, Meridá, Pedregosa, 3000 m, St Laurent diss.: 4-4-16:1 [vesica partly everted] (NHMUK). **20.** Colombia, Cundinamarca, Pacho, 2200 m, St Laurent diss.: 4-29-16:2 [vesica not everted] (USNM). Scale bar=1 mm.

ventrally. Genitalia (Fig. 30) (n=1) robust; tergite of VIII forms smooth, posteriorly directed arch, arch slightly accentuated mesally. Apophyses anteriores roughly same length as apophyses posteriores, but apophyses posteriores more robust. Lamella antevaginalis wide, not robust, wrinkled. Lamella postvaginalis rectangular, bent mesally, either side of lamella postvaginalis covered in short setae, setae covered region not as distinct structure from smooth mesal portion. Ductus bursae short, not clearly differentiated from corpus bursae, corpus bursae lost [absent in single genitalia preparation]. Base of papillae anales with weak sclerotizations dorsolaterally, covered in short, thick setae. Papillae anales box-like, covered in long, fine setae, setae much shorter basally.

Distribution (Fig. 34). This new species is known only from Ecuador at elevations of 1270–3200 m.

Etymology. *Isoscella ecuadoriana* is named for Ecuador, the only country from which this taxon has been collected.

Remarks. *Isoscella peigleri*, sp. n. is also known from Ecuador, however, it seems to be allopatric with *I. ecuadoriana*, which is restricted to the eastern Andes of Ecuador, while *I. peigleri*, sp. n. is from northwestern Ecuador on the western side of the Andes. Characters given in the diagnosis, namely the dark red-purple coloration of *I. peigleri*, sp. n. and genitalia, allow differentiation of these two species.

Both Piñas and Manzano-Pesántez (1997) and Piñas (2007) figure the same specimen of *I. ecuadoriana* as *Psychocampa ventana*. The locality data for this specimen is given as "Plan de Milagro, Azuay, Oriente, Ecuador" which probably refers to a location in or near Azuay Province on the eastern slopes of the Andes. We include this data here as it is the only record of *Isoscella* from Azuay Province.

***Isoscella leva*, new species**

(Figs 9, 10, 23, 24, 31, 34)

Psychocampa ventana; Schaus 1928 [in part]

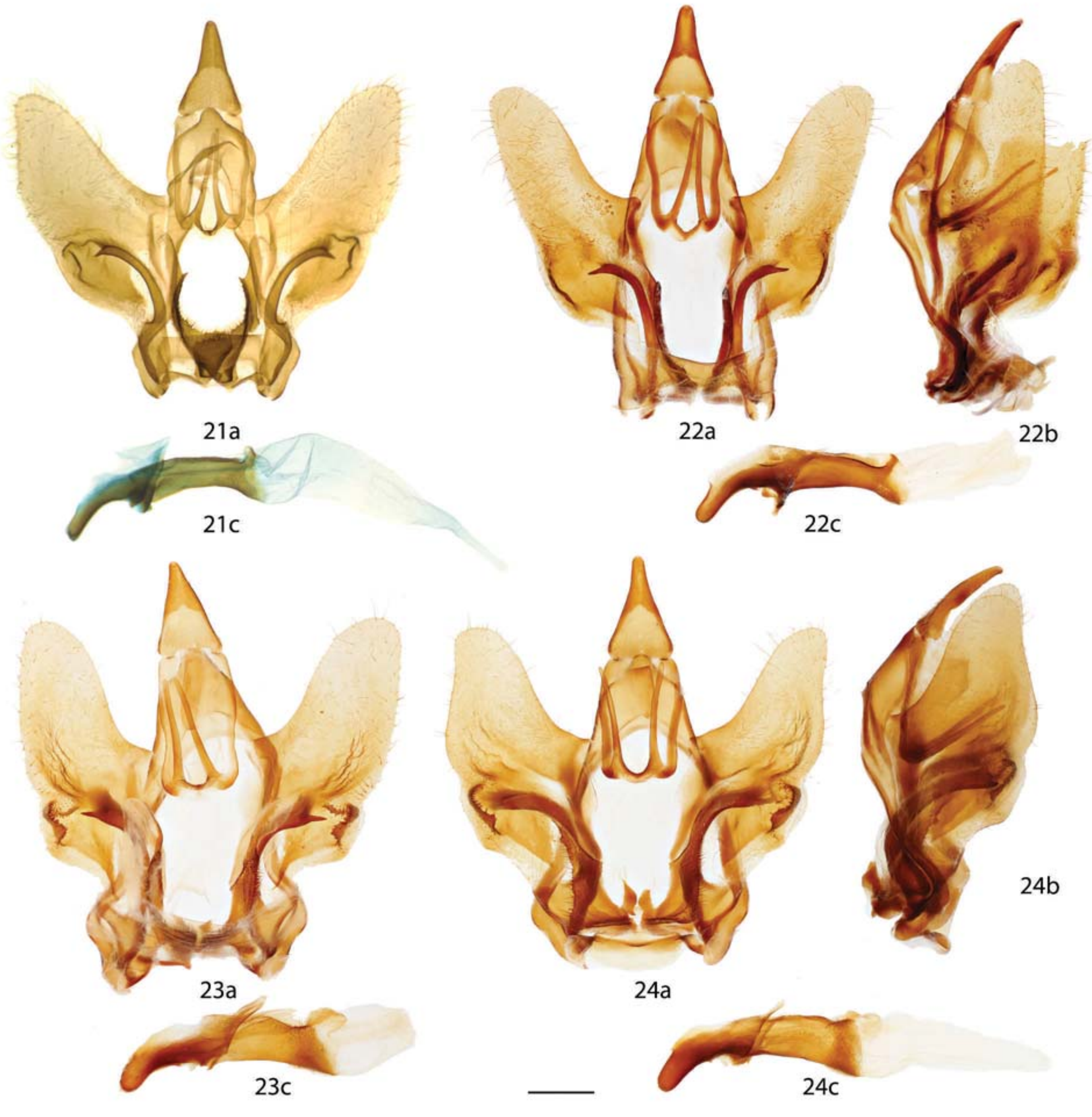
Holotype. ♂, **PERU: Puno:** S. Domingo, Carabaya [Puno], 6000 ft., VI. 02, Dry seas[on]. (Ockenden)/ Rothschild Bequest BM 1939-1, NHMUK010355077/ St Laurent diss.: 5-3-16:2/ HOLOTYPE ♂ Isoscella leva St Laurent & Carvalho, 2017 [handwritten red label]/ (NHMUK).

Paratypes. (35 ♂, 5 ♀ total) **PERU: Cusco:** 1 ♂, Wayqecha Biological Station, 13°10'S, 71°35'W: 30.X.2010, Charles V. Covell Jr. leg., C.V. Covell colln., MGCL Accession 2013-5 (MGCL). 1 ♀, Huayapata, 2400 m: II.2005, local people leg., Coll. Frank Meister (MWM). 5 ♂, Reyna Virgen, 2400 m: XII.2005 (4 ♂), XII.2005–I.2006 (1 ♂), R. Marx leg., Coll. F. Meister 17291 Prenzlau (MWM). 1 ♂, Nueva Virgen, 2500 m: XI.2005–XII.2005, local people leg., Coll. F. Meister 17291 Prenzlau (MWM). 1 ♂, Alfamayo, 2500 m: I–II.2006, R. Marx leg., Coll. F. Meister 17291 Prenzlau, genitalia prep. 29.263 MWM (MWM). 1 ♂, Vallé de Quillabamba, 2500 m: XI–XII.2005, local people leg., Coll. F. Meister 17291 Prenzlau (MWM). 1 ♂, Reyna del Carmen, 2400 m: II–III.2006, R. Marx leg., Coll. F. Meister 17291 Prenzlau (MWM). 1 ♂, San Pedro, Manu Park, 1800 m: II.1998 (MWM). 1 ♀, Manu Park, San Pedro, 1800 m: III.1997, local people leg. (MGCL). **Puno:** 7 ♂, 3 ♀, Carabaya, Santo Domingo, 6000 ft: VI.1901 (1 ♂); V.1902 (1 ♂); VI.1902, St Laurent diss.: 7-7-16:1 [♀], (5 ♂, 3 ♀); dry season, G. Ockenden [leg.], Joicey Coll., Brit. Mus. 1925-157, Rothschild Bequest B.M. 1939-1, NHMUK010355078 (NHMUK). 3 ♂, Santo Domingo, Carabaya [Puno], 6500 ft: X.1902, dry season (2 ♂), XII.1902, wet season (1 ♂), G. Ockenden [leg.], Rothschild Bequest B.M. 1939-1 (NHMUK). 1 ♂, Carabaya, Tinguri, 3400 ft: VIII.1904, dry season, G. Ockenden [leg.], Rothschild Bequest BM 1939-1, St Laurent diss.: 4-4-16:3, NHMUK010355079 (NHMUK). 1 ♂, Oconeque, Carabaya [Puno], 7000 ft: G. Ockenden [leg.], Joicey Coll., Brit. Mus. 1925-157 (NHMUK). 1 ♂, Santo Domingo to Limbani, 3000–9000 ft: VI.1904, dry season, G. Ockenden [leg.], Rothschild Bequest B.M. 1939-1 (NHMUK). **BOLIVIA: La Paz:** 1 ♂, Rio Songo [Río Zongo], 750 m: Coll. Fassl, Dognin Collection, USNM-Mimal: 1234, St Laurent diss.: 5-3-16:3 (USNM). 3 ♂, Rio Songo [Río Zongo], 750 m: Coll. Fassl, NHRS-TOBI 1946–1948 (NHRS). 1 ♂, North Yungas, Road Caranavi to Coroico, ca. 100 km NE La Paz, ca. 16.2°S, 67.6°W, 1000–1800 m: V–VI.2009, R. Brechlin & F. Meister leg. (MWM). **Cochabamba:** 1 ♂, El Limbo [Chapare, Alto Chapare]: 9.V.1954, Allyn Museum Acc. 1966-1 (MGCL). 1 ♂, El Limbo [Chapare, Alto Chapare], 2011 m: 15.V.1954, 1966-1 (MGCL). 1 ♂, Chapare, Incachaca, 2220 m: IV.1947, Allyn Museum Acc. 1966-1, St Laurent diss.: 8-29-16:4 (MGCL). 1 ♂, Incachaca: J. Steinbach [leg.], Collection Wm Schaus, USNM-Mimal: 1236 (NHMUK). 1 ♂, Sant [San?] Pedrito, 33 km SW Villa Tunari, 17°4.4'S, 65°41.5'W, 1070 m: 10–12.X.2010, V. Sinjaev & O. Romanov leg., coll. Dr. Ronald Brechlin (MWM). **Santa Cruz:** 1 ♂, Amboro National Park, 16 km N Mairana, 17°59.0'S, 63°59.5'W, 1900 m: 3–4.XI.2010, V. Sinjaev & O. Romanov leg., coll. Dr. Ronald Brechlin, genital prep. 30.003 (MWM). – Paratypes with the following yellow label: PARATYPE ♂/♀ *Isoscella leva* St Laurent & Carvalho, 2017.

Additional specimens examined. [Not included in type series] **PERU: Piura:** 1 ♂, Penaci, Motupe, 1500 m: V.2005, R. Marx leg., Coll. F. Meister 17291 Prenzlau (MWM). **BOLIVIA: Santa Cruz:** 1 ♂, Achira, rd. to Amboro National Park, 5800 ft: 14–20.XI.2003, Morris, Nearns, Wappes leg., "*Psychocampa* sp. (?) *ventana* Dognin (or near) Det. C.L. Smith (UGCA). **Cochabamba:** 1 ♂, Yungas de Palmar, 2000 m: [collector name illegible, near Ziebke], HRP No. 1310, USNM-Mimal: 2431 (USNM).

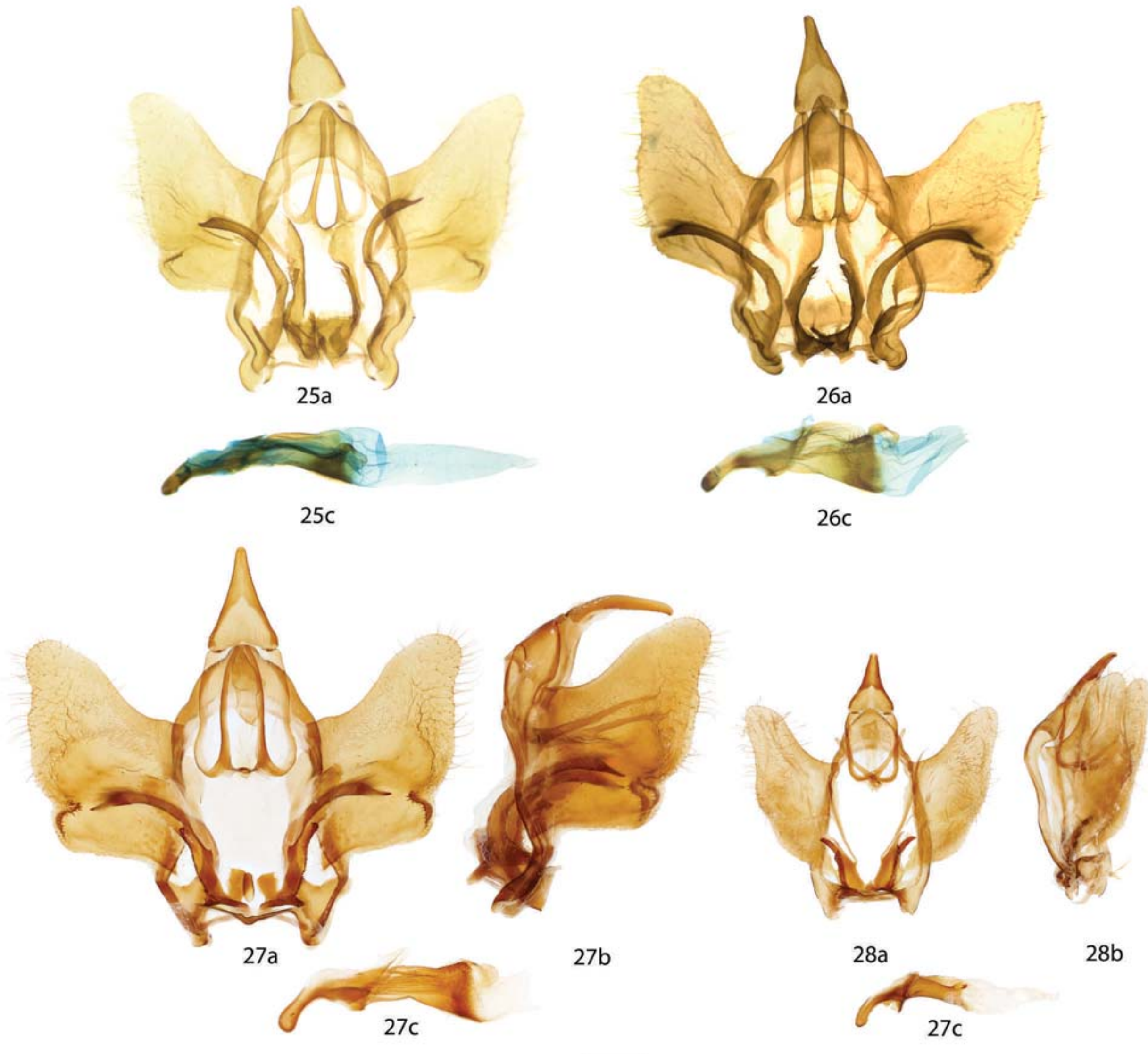
Diagnosis. In wing size and shape, this southernmost *Isoscella* species is most similar to *I. ecuadoriana*; the wings are highly elongated, but the apex is not as falcate. The coloration, however, differs, being more subdued pale orange-pink medially (darker pink in fresh specimens) and light orange submarginally, lacking the gray and black shading of the forewing apices or the strongly contrasting medial and submarginal areas as in *I. ecuadoriana.* In this way, *I. leva* is somewhat similar to *I. ventana*, but is larger, with smaller hyaline patches, and more subdued markings. The male genitalia are very robust, with well-developed teeth in the valva indentation, and a relatively broad phallus. The female genitalia are more distinctive in this species than those of the male, having a broad lamella postvaginalis that mesally protrudes outward like a bird's beak.

Description. Male. *Head*: As for genus. *Thorax*: As for genus. Forewing length 21–30 mm (mean=27.6 mm), wingspan 48–61 mm (n=24); forewing as for genus but particularly elongate. Dorsum ground color pale pinkish orange, darker orange submarginal area contrasting against lighter antemedial and medial areas. Submarginal area generally without dark suffusion, though if present, very faint, not forming lunule-like shape. Apex may be lightly suffused with gray. Fringe dull orange. Forewing ventrum as for genus, but appearing lighter due to much fewer dark petiolate scales. Hindwing



FIGS. 21–24. Male genitalia of *Isoscella*, a=ventral, b=lateral, c=phallus. **21.** *I. ecuadoriana*, holotype, Ecuador, Napo, Cordillera Guacamayos, 2181 m, genitalia prep. 29.262 [vesica fully everted] (MWM, slide mount photo courtesy of A. Prozorov). **22.** *I. ecuadoriana*, Ecuador, Tungurahua, Baños [Baños de Agua Santa?], 1800 m, St Laurent diss.: 2-26-16:2 [right valve damaged, repaired in CS4, vesica partly everted] (CUIC). **23.** *I. leva*, holotype, Peru, Puno, Carabaya, Santo Domingo, 6000 ft, St Laurent diss.: 5-3-16:2 [vesica partly everted] (NHMUK). **24.** *I. leva*, paratype, Bolivia, Cochabamba, Incachaca, St Laurent diss. 4-29-16:3 [vesica fully everted] (USNM). Scale bar=1mm.

subtriangular, dorsum coloration, markings as for forewing dorsum. Hindwing ventrum with continuation of pattern of forewing ventrum but slightly lighter overall. *Abdomen*: As for genus, concolorous with thorax, slightly darker orange-pink ventrally. Genitalia (Figs 23, 24) (n=7) as for genus but cup-like indentation of valva heavily sclerotized and lined with sharp teeth. Valva elongated, triangular, usually somewhat truncated distally. Phallus cylindrical, slightly broadened distally. **Female.** *Head*: As in male but antennal rami shorter. *Thorax*: As in male. Forewing length 30–34 mm (mean=32 mm), wingspan 61–67 mm (n=3), forewing similar overall to male, but broader, margin slightly convex, apex more sharply pointed. Dorsum ground color as in male but somewhat darker due to black suffusion medially, postmedial line usually darker and broader than in male, particularly well-defined after passing Rs4. Discal cell marked with oblong hyaline patch bisected by M_2 and encircled by black scales. Forewing ventrum similar to dorsum but ground color uniformly lighter orange-yellow, darker petiolate scales more numerous and distinct; antemedial line absent, postmedial line nearly absent with only traces present near



FIGS. 25–28. Male genitalia of *Isoscella*, a=ventral, b=lateral, c=phallus. **25.** *I. peigleri*, holotype, Ecuador, Carchi, road El Chical to Carolinae, 1970 m, genitalia prep. 29.246 [vesica fully everted] (MWM, slide mount photo courtesy of A. Prozorov). **26.** *I. peigleri*, paratype, Ecuador, Carchi, Road El Chical to Carolinae, 1970 m, genitalia prep. 29.245 [vesica partly everted] (MWM, slide mount photo courtesy of A. Prozorov). **27.** *I. peigleri* [putative], Colombia, Tolima, San Antonio, 5800 ft, St Laurent diss.: 4-4-16:2 [vesica partly everted] (NHMUK). **28.** *I. andina*, holotype, Peru, Junín, Cerro Pichita Res. Sta. nr San Ramón, 2165 m, St Laurent diss.: 2-26-16:1 [vesica fully everted] (MWM). Scale bar=1 mm.

tornus and costa. Wing margins darker orange-brown, appearing somewhat singed. Hindwing rounded, dorsum coloration, markings as for forewing dorsum, but antemedial line absent, postmedial line continuously dark to anterior wing margin, hyaline patch smaller, narrower, situated nearer to postmedial line. Hindwing ventrum with continuation of pattern as forewing ventrum but pinker rather than orange. *Abdomen*: Concolorous with thorax, slightly darker orange ventrally. Genitalia (Fig. 31) (n=1) robust; tergite of VIII forms smooth, posteriorly directed arch, arch slightly accentuated mesally. Apophyses anteriores roughly same length as apophyses posteriores, but apophyses posteriores more robust. Lamella antevaginalis reduced, thin, wrinkled. Lamella postvaginalis wide, robust, heavily sclerotized, angled mesally, with mesal angle protruding outwards as truncated beak-like process, each side of lamella postvaginalis broadened, covered in short setae. Ductus bursae short, not clearly differentiated from corpus bursae. Base of papillae anales with robust, sclerotizations dorsolaterally, covered in short, thick setae. Papillae anales box-like, covered in long, fine setae, setae much shorter basally.

Distribution (Fig. 34). This species is distributed from central Peru south to Bolivia where it is found at elevations of 750 to 2500 m. See remarks for a single specimen from Piura, Peru.

Etymology. From Latin levo/levare meaning to make smooth or polish, referring to the smooth patterning dorsally and ventrally, mostly not obfuscated by petiolate scales or black suffusions as in other taxa in the genus. Additionally, the lamella postvaginalis in the female genitalia is remarkably smoothly keeled mesally.

Remarks. *Isoscella leva* has the broadest documented distribution along the Andes Mountains of any taxon in the genus, but is morphologically consistent along this range, particularly externally. However, in specimens from Peru the valva tends to be slightly more truncated distally than in those from farther south in Bolivia.

A single specimen at MWM from Piura, Peru externally matches *I. leva* from central and southern Peru, but considering the fact that this single specimen is from a rather unique location, and very distant from all other known populations of *I. leva*, and our inability to examine the genitalia of this specimen, we decided to omit it from the type series. We are unclear as to whether this species is present in northwest Peru.

Isoscella peigleri, new species

Psychocampa sp. 3; Piñas 2007, fig. 216 (questionable, see remarks)

(Figs 12–14, 18, 25–27, 32, 34)

Holotype, ♂: **ECUADOR: Carchi:** ECUADOR, CARCHI prov., road El Chical - Carolinae, 0°49'49''N/ 78°13'15''W, 16. Nov. 2012; 1970 m, leg. Sinyaev & Romanov, Expedition Ron Brechlin, genitalia prep. 29.246 Museum WITT München / HOLOTYPE ♂ *Isoscella peigleri* St Laurent & Carvalho, 2017 [handwritten red label]/ (MWM).

Paratypes. (8 ♂, 1 ♀ total) **ECUADOR: Carchi:** 2 ♂, Road El Chical to Carolinae, 0°50'20''N, 78°13'39''W, 2360 m: 20.XI.2012, Sinyaev & Romanov leg., Expedition Ron Brechlin (MWM). 6 ♂, Road El Chical to Carolinae, 0°49'49''N, 78°13'15''W, 1970 m: 16.XI.2012, Sinyaev & Romanov leg., Expedition Ron Brechlin, genitalia preps. 29.245, 30.001 (MWM). **Cotopaxi:** 1 ♀, San Francisco de Las Pampas, Otonga, 2600 m: 22.III.1993, Jan Hillman leg., undisturbed cloud forest, St Laurent diss.: 3-14-16:1 (CMNH). – Paratypes with the following yellow label: PARATYPE ♂/♀ *Isoscella peigleri* St Laurent & Carvalho, 2017.

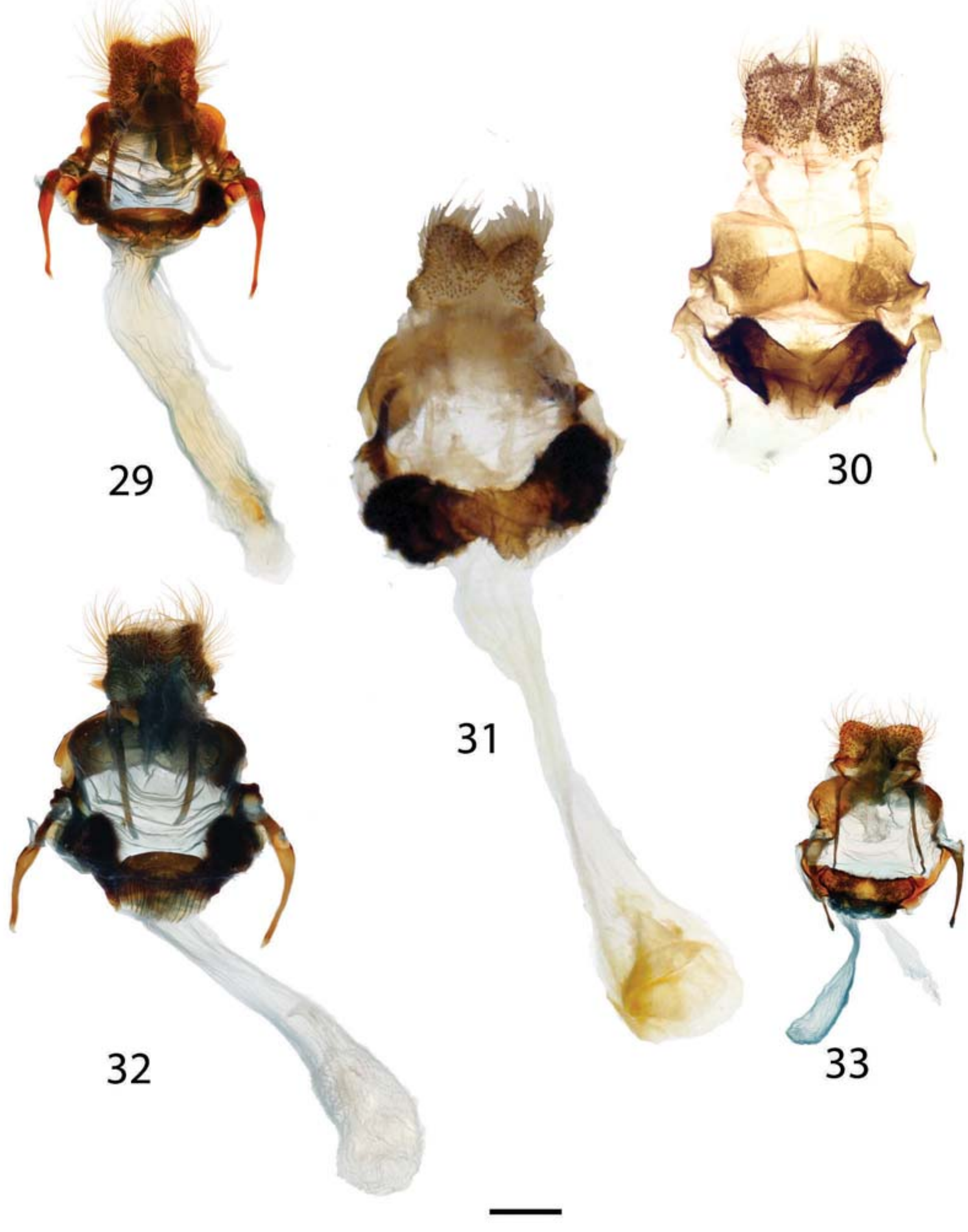
Additional specimens examined. [Not included in type series] **COLOMBIA: Tolima:** 4 ♂, San Antonio, 5800 ft: XI.1907 (1 ♂), XII.1907 (2 ♂), no date (1 ♂), M.G. Palmer leg., Brit. Mus. 1931-471, Joicey Coll Brit. Mus. 1925-157, St Laurent diss.: 4-4-16:2, NHMUK010355075 (NHMUK). **ECUADOR: Imabura:** 1 ♂, Cuellaja, Intag Valley, 0°27'50"N, 78°32'52"W, 2400 m: live specimen photographed by Andreas Kay, not collected (Fig. 18).

Diagnosis. This species, like *I. andina*, sp. n., is darker in coloration compared to all the previous species. The overall wing shape and maculation are most similar to the previous species and can be distinguished from *I. andina*, sp. n. by the more triangular, broader wings and overall larger size. While the maculation is reminiscent of *I. ecuadoriana*, the darker ground color immediately distinguishes this species. The male genitalia are recognizable in having the broadest valvae of the genus, which are distinctly angled upward, not smoothly curving upward as in all other species. Valva indentation teeth are well developed, and the phallus is the broadest in the genus. Female genitalia are essentially indistinguishable from those of *I. ventana*, but are larger.

Description. Male: *Head*: Dark rusty red-brown, interspersed with dark petiolate scales; antenna brown. *Thorax*: Coloration as for head, interspersed with dark petiolate scales, prothoracic collar lined with prominent gray scales. Forewing length 26–38 mm (mean=28.9 mm), wingspan, 52–60 mm (n=8); forewing elongate, triangular, margin nearly straight, concave along falcate apex. Dorsum ground color dark brown with slight purplish hue. Submarginal area darker brown than antemedial and medial areas, black suffusion present submarginally, especially along postmedial line. Overall lightly speckled by dark and bicolored white and black petiolate scales. Antemedial line faint to nearly absent, wavy, black. Postmedial line black, nearly straight from tornus until just before Rs4 where line becomes fainter and angles perpendicularly to costa. Discal cell marked with B-shaped to nearly circular hyaline patch bisected by M_2. Forewing ventrum similar to dorsum but lighter, more homogenously colored, darker petiolate scales more numerous and distinct, especially antemedially and medially; antemedial line absent, postmedial line reduced to wavy traces. Hindwing triangular, dorsum coloration, markings as for forewing dorsum, but antemedial line absent, postmedial line slightly undulated, hyaline patch smaller, situated nearer to postmedial line. Hindwing ventrum with same pattern as forewing ventrum but lighter. *Abdomen*: As for genus, concolorous with thorax, thus darker. Genitalia (Figs 25–27) (n=4) as for genus but valvae more outwardly situated, cup-like indentation of valva lined with heavily sclerotized teeth. Valva triangular, very broad basally, distinctly angled upward (viewed ventrally). Phallus widely broadened distally. **Female:** *Head*: As for male antenna smaller, pectinations shorter. *Thorax*: As for male. Forewing length 35.5 mm, wingspan 70.5 mm (n=1); forewing as for male, but broader, convex mesally, dorsum ground color rusty reddish brown, with black suffusions throughout submarginal area, overall heavily speckled by dark petiolate scales. Antemedial line black, wavy. Postmedial line nearly straight from tornus until reaching Rs4 where line becomes faint and angled perpendicular to costa, dark suffusion follows outer edge of postmedial line from tornus until passing angle at Rs4 giving impression of postmedial line being continuous from tornus to apex, suffusion curves approaching apex; apical quarter of wing slightly darker between postmedial line and costa. Discal cell marked with oblong, somewhat B-shaped hyaline patch bisected by M_2. Fringe somewhat contrasting, dull orange. Forewing ventrum similar to dorsum but lighter, dull pink, darker petiolate scales as numerous and distinct as on dorsum, but basal half of many of these scales white; antemedial line absent, postmedial line faint, vaguely S-shaped. Hindwing rounded, dorsum coloration and markings as for forewing dorsum, but antemedial line absent, postmedial line continuously dark to anterior wing margin, hyaline patch smaller, narrower, situated nearer to postmedial line. Hindwing ventrum follows same pattern as forewing ventrum. *Abdomen*: As for male but more robust. Genitalia (Fig. 32) (n= 1). Robust; tergite of VIII forms smooth, posteriorly directed arch. Apophyses anteriores roughly same length as apophyses posteriores, but thicker proximally. Width of lamella antevaginalis roughly equal to that of papillae anales, robust, concave, wrinkled mesally. Lamella postvaginalis with dark, amorphous masses covered in short, thick setae located on either side. Ductus bursae short, not easily differentiable from long, tubular corpus bursae. Base of papillae anales with robust sclerotizations dorsolaterally, covered in short, thick setae. Papillae anales somewhat box-like, covered in long, fine setae, setae much shorter basally.

Distribution (Fig. 34). *Isoscella peigleri* is found in the western Andes of northwestern Ecuador from 1900 to 2600 m elevation. It may also be present in central Colombia, but see remarks for information regarding this population.

Etymology. *Isoscella peigleri* is named for Richard Peigler, a



FIGS. 29–33. Female genitalia of *Isoscella*, ventral. **29.** *I. ventana*, Colombia, Cundinamarca, Finca San Pablo, 3 km N Albán, 1800 m, St Laurent diss.: 3-7-16:1 (AMNH). **30.** *I. ecuadoriana*, paratype, Ecuador, Napo, 5 km. SE Cosanga, 2240 m, genitalia prep. 29.244 [corpus bursae damaged, absent from preparation] (MWM, slide mount photo courtesy of A. Prozorov). **31.** *I. leva*, paratype, Peru, Puno, Carabaya, Santo Domingo, 6000 ft, St Laurent diss.: 7-7-16:1 [apophyses anteriores are damaged and not shown here, otherwise very similar to those of other *Isoscella* species] (NHMUK). **32.** *I. peigleri*, paratype, Ecuador, Cotopaxi, San Francisco de Las Pampas, Otonga, 2600 m, St Laurent diss. 3-14-16:1 (CMNH). **33.** *I. andina* [putative], Ecuador, Morona Santiago, Road Gualaceo to Plan de Milagro, 2601 m, St Laurent diss.: 4-29-16:1 (MWM). Scale bar=1 mm.

researcher known for his substantial contributions to the study of Saturniidae. He has been incredibly generous and supportive to both of the authors and has shown great enthusiasm for our research.

Remarks. When examining series of *I. peigleri* and *I. ecuadoriana* from Ecuador at the MWM, it became apparent that in addition to being much darker, *I. peigleri* has slightly narrower wings than *I. ecuadoriana.* It is somewhat easy to mistake greasy specimens of *I. ecuadoriana* with *I. peigleri*, but on close examination the ground color is distinctly different between these two. Furthermore, these two species do not seem to be sympatric as *I. peigleri* is only known

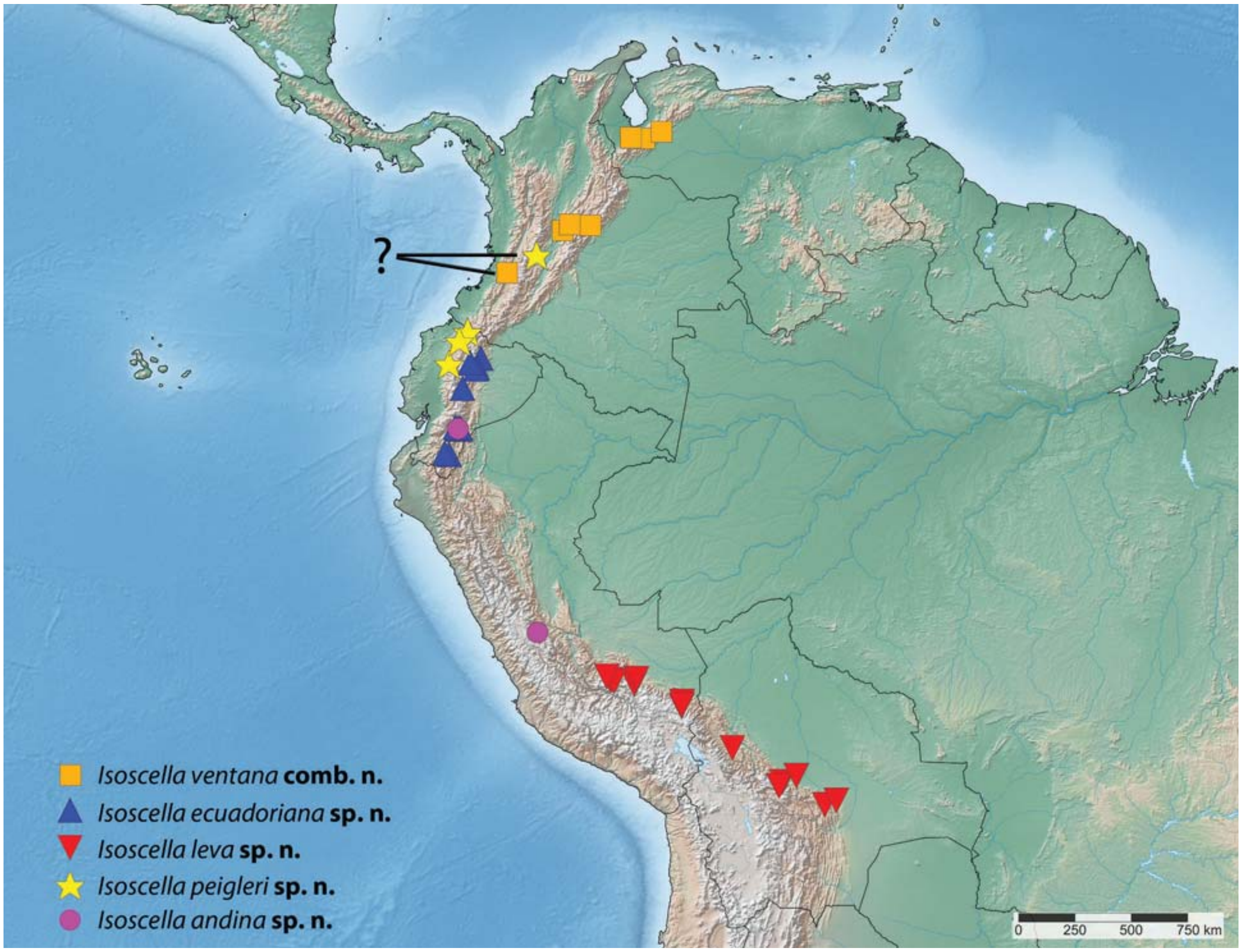


FIG. 34. Known distribution of *Isoscella*. The question mark denotes inconclusively determined *Isoscella* populations.

from the northwestern Andes of Ecuador, while *I. ecuadoriana* is broadly distributed along the eastern Andes from north central to southern Ecuador.

In the NHMUK there are four specimens from Tolima, Colombia, which we have putatively identified as *I. peigleri*. They are dark in color like typical *I. peigleri*, and show the same male genitalia characters, namely the broad, outwardly situated valvae and a distally broadened phallus. However, the Colombian specimens are larger and have broader and more convex wings than any of the examined Ecuadorian material. Therefore, we exclude these specimens from the type series. Additional material from between the type locality of *I. peigleri* and Tolima should help reveal whether these populations are connected and if there is any clinal variation. The previously mentioned variable specimens that we have identified as *I. ventana* from Valle de Cuaca, Colombia, cast further doubt as to the identification of west-central Colombian *Isoscella* populations.

We include the data and a photo (Fig. 18) of a potential specimen of *I. peigleri*. The coloration, northern Ecuadorian locality, as well as elevation are all appropriate for *I. peigleri*, however, the angle at which the living moth holds its wings makes it difficult to accurately determine if the specimen in question is truly *I. peigleri* or an additional undescribed species. We note other similarities besides ground color, such as the bicolored petiolate scales covering the wings, a hyaline patch on each wing (though they are difficult to distinguish in the figure), and postmedial markings, all of which are all highly reminiscent of *I. peigleri*. Despite our uncertainty, we include this figure as it offers a glimpse of the probable natural resting posture of this species, as well as an additional (though expected) provincial record for *I. peigleri*.

Piñas (2007) figures (fig. 219) a dark *Isoscella* specimen. We putatively identify this specimen as *I. peigleri*, but considering the poor quality of the image and the lack of given locality data or genitalia, we are unable to conclusively determine the identity of this specimen.

Isoscella andina, new species

(Figs 15–17, 28, 33, 34)

Holotype. ♂, **PERU: Junín:** Dept. Junin [Junín Region], Cerro Pichita Res. Sta., nr. San Ramon [San Ramón] 2165 m, 7–9 Apr 2011, J.B. Heppner & C. Carrera/ St. Laurent diss.: 2-26-16:1/ HOLOTYPE ♂ *Isoscella andina* St Laurent & Carvalho, 2017 [handwritten red label]/ (MGCL).

Paratype. PERU: Junín: 1 ♂, Same data as holotype (MGCL). Paratype with the following yellow label: PARATYPE ♂ *Isoscella andina* St Laurent & Carvalho, 2017.

Additional specimen examined. [Not included in type series] **ECUADOR: Morona Santiago:** 1 ♀, Road Gualaceo, Plan de Milagro, 3°00'42''S, 78°36'19''W, 2601 m: V. Siniaev & O. Romanov leg., St Laurent diss.: 4-29-16:1 (MWM).

Diagnosis. *Isoscella andina* is easily distinguished from all previously described *Isoscella* by the much smaller size, the red-orange coloration with black suffusions, and the very narrow wings. Additionally, this is the only species in the genus in which the forewing postmedial line is diagonally straight on both the dorsum and ventrum of the wing. The genitalia also distinguish this species. The male genitalia of *I. andina* are recognized by their overall much smaller size, as well as by the shortness of the arm-like processes emanating from the base of the vinculum, which are shorter and broader than in all other congeners, and do not terminate in the cup-like indentation on the valvae as in the other species. The female genitalia are similar in general structure to congeners, but are much smaller, with the lamella postvaginalis being rectangular and not bent or smoothly keeled mesally. *Isoscella andina* also has a smaller corpus bursae and a more deeply concave, wider, bowl-like lamella antevaginalis.

Description. Male. *Head*: As for genus but dark rusty red, grayer ventrally, eyes bordered posteriorly by thin margin of dark scales; antenna dark khaki colored. *Thorax*: Coloration as for head, interspersed with dark petiolate scales, prothoracic collar lined with darker gray scales. Legs concolorous with thorax, but with long, gray vestiture on femur and tibia. Forewing length 21 mm (mean=21 mm), wingspan 42 mm (n=2). Forewing elongate, very narrow, margin nearly straight, apex blunt. Dorsum ground color rusty reddish brown, with black suffusions throughout but especially submarginally near tornus and medially in vicinity of discal cell, overall lightly speckled by dark petiolate scales. Antemedial line as diffuse black suffusion. Postmedial line nearly straight from tornus until reaching Rs4 where line becomes faint and angled perpendicular to costa, dark suffusion follows outer edge of postmedial line from tornus until passing the angle at Rs4 giving impression of postmedial line being continuous from tornus to apex, suffusion curves approaching apex; apical quarter of wing slightly darker between postmedial line and costa. Discal cell marked with circular hyaline patch surrounded by black scales, bisected by M_2. Fringe dull orange. Forewing ventrum similar to dorsum but darker petiolate scales more numerous and distinct; antemedial line absent, postmedial line angled perpendicularly toward costa. Hindwing subtriangular, dorsum coloration, markings, and hyaline patch as for forewing dorsum, but black suffusion situated near anterior postmedial edge of wing, hyaline patch smaller, situated nearer to postmedial line, antemedial line absent. Hindwing ventrum follows same pattern as forewing ventrum but postmedial line less straight. Frenulum present, but reduced. *Abdomen*: As for genus but smaller, less robust overall, coloration continuation of thorax. Genitalia (Fig. 28) (n=1) as for genus but cup-like indentation of valva absent. Valva short, barely reaching beyond base of uncus, somewhat triangular, truncated somewhat apically. Phallus cylindrical. Paired vincular processes short, broad, not reaching valva. **Female.** [Description based on one putative female of *I. andina*] *Head*: As in male but antenna darker brown. *Thorax*: As in male but brighter orange. Legs as in male, but gray vestiture shorter overall. Forewing length 21 mm, wingspan 40 mm (n=1). Forewing as in male but broader, dorsum brighter orange in color, postmedial line more pronounced after angle following Rs4, black suffusion which follows outer edge of postmedial line from tornus until passing angle at Rs4 darker, more pronounced. Discal cell marked with slightly ovoid hyaline patch surrounded by black scales, bisected by M_2. Fringe dull orange. Forewing ventrum similar to dorsum but antemedial line absent, postmedial line slightly more diffuse, smoothly curved toward costa rather than abruptly angled. Hindwing rounded, dorsum coloration, markings, and hyaline patch as for forewing dorsum, but hyaline patch barely smaller, touching postmedial line, antemedial line absent. Hindwing ventrum follows same pattern as forewing ventrum but postmedial line less straight. Frenulum apparently absent. *Abdomen*: Concolorous with thorax, slight golden sheen. Genitalia (Fig. 33) (n=1) with tergite of VIII forming smooth, posteriorly directed arch. Apophyses anteriores roughly same length as apophyses posteriores, but thicker proximally. Width of lamella antevaginalis slightly wider than that of papillae anales, robust, concave, bowl-like, covered in short, thick setae, with lobed protrusion extending toward ostium, ostium somewhat rectangular, wide, nearly spanning width of lamella. Ductus bursae short, narrow, corpus bursae elongated, bag-like. Base of papillae anales with robust sclerotizations dorsolaterally, lightly covered in short, thick setae. Papillae anales somewhat box-like, covered in long, fine setae, setae much shorter basally.

Distribution (Fig. 34). This new species is known only from two locations, the type locality at 2165 m in the Junín region of the Peruvian Andes and from Morona Santiago, Ecuador at 2601 m. See remarks for information regarding the Ecuadorian specimen.

Etymology. This species is named for its Andean distribution.

Remarks. *Isoscella andina* is known from only three specimens, collected at two distant localities; hence, the species appears to be relatively widespread. However, the distance between collection localities of the two male specimens (Peru) and the single female (Ecuador) prevents us from including the female in the type series. We acknowledge the possibility that the Ecuadorian population may represent an additional species, and without a male specimen from near the Ecuadorian locality, we cannot make an absolute determination of the identity of this population.

ACKNOWLEDGEMENTS

We greatly appreciate the assistance of the following individuals who provided access to material or photos of specimens from their respective institutions: John Brown (USNM), Alessandro Giusti (NHMUK), David Grimaldi (AMNH), Brian Harris (USNM), James Hayden (MGCL), Tobias Malm (NHRS), John Rawlins (CMNH), Courtney Richenbacher (AMNH), Harald Sulak (MWM), Andrew Warren (MGCL), Thomas Witt (MWM), and Sergio Andrés Vargas (MPUJ). Daniel Herbin (France) provided photos of *Psychocampa mawaja* genitalia and the holotype of *I. ventana* for comparative purposes. Kyle DeMarr (University of California, Berkeley) kindly provided images and data of material from both UGCA and EMEC. Alexey Prozorov (MWM) photographed and dissected several *Isoscella* specimens. Jason Dombroskie (CUIC) facilitated access to camera equipment, stacking software, specimens pertinent to the present research, and helpful suggestions on the manuscript. John Brown reviewed the manuscript and offered valuable feedback. Andreas Kay and Chris Hamilton (MGCL) permitted the publication of their wonderful photos from Ecuador. The Cornell University College of Agriculture and Life Sciences Alumni Award and Thomas Witt offered financial assistance to R. St Laurent.

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Submitted for publication 27 August 2016; revised and accepted 8 December 2016.

Journal of the Lepidopterists' Society
71(2), 2017, 109–114

BUTTERFLY PREDATORS IN THE NEOTROPICS: WHICH BIRDS ARE INVOLVED?

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ABSTRACT. Butterflies have evolved a variety of defensive traits against visually hunting predators, especially insectivorous and omnivorous birds. However, few bird species that attack and feed on butterflies in the Neotropical region are known. Here we present a list of 36 species belonging to 15 bird families observed to attack butterflies in different sites of Central and South America. In addition to comments on the birds involved, we also indicate which bird families are expected to reveal new butterfly predators.

Additional key words: escape tactics, insectivorous birds, mimicry, protective coloration, unpalatability

Butterflies have evolved a variety of defensive traits to avoid predation by birds. These include: defensive chemicals (Brower 1984), aposematic and cryptic coloration (Poulton 1890), Batesian and Müllerian mimicry (Bates 1862, Müller 1879), fast and unpredictable flight, weak/fragile wings that allow escape by tearing when pecked by birds (Pinheiro et al. 2016). Recent evidence indicates that palatable butterflies also use bright colors to advertise difficulty of capture to birds, and may also evolve mimetic interactions with similar (escape Müllerian mimicry) or less evasive species (escape Batesian mimicry), analogous to unpalatable butterflies and their Müllerian and Batesian mimics (reviewed in Pinheiro & Freitas 2014).

Although some evidence suggests that lizards are also involved (Boyden 1976, Ehrlich & Ehrlich 1982, Odendaal et al. 1987) the high frequency of beak marks found on the wings of live butterflies (Benson 1972, Brower 1984, Pinheiro et al. 2014) indicates that birds are likely the most important butterfly predators and, therefore, the selective agents involved in the evolution of most defensive traits listed above (Brower 1984). Despite the importance placed on adaptive coloration as a deterrent to avian predation, few birds are known to prey on butterflies, especially in the neotropics, which contains the highest diversity of both butterflies (Heppner 1991) and birds (Del Hoyo et al. 1992–2010) on Earth. Bates himself did not witness a single bird attack on aposematic and mimetic butterflies in the eleven years he stayed in the Amazon (Bates 1862). More than 150 years later, all we know about butterfly predators in this region is restricted to a jacamar (Benson 1972; Chai 1986, 1990; Pinheiro & Campos 2013), a tanager (Brown & Vasconcellos-Neto 1976), two tyrant-flycatchers (Pinheiro 1996, 2003, 2011), an ani (Burger & Gochfeld 2001) and a few other birds (Brower 1984). In consequence, many defensive traits of butterflies remain uninvestigated. Furthermore, defensive traits have been investigated mostly with caged birds that do not attack butterflies under natural conditions, sometimes with the implicit assumption that natural predators would behave in a similar fashion. Here we present a list of birds observed to attack butterflies in the neotropics. To our knowledge, this is the first list of butterfly predators ever produced for this region.

MATERIAL AND METHODS

The majority of our list of butterfly predators is based on our own field observations of interactions between butterflies and birds taken at different sites and occasions in South America. In addition, we included some reports of bird attacks on butterflies observed in Central America, and bird species utilized or observed in palatability and mimicry experiments conducted in the eastern Amazon and Central America. References on bird stomach contents and studies that report bird attacks on Lepidoptera were excluded, as they did not distinguish whether individuals attacked or consumed were butterflies (Papilionoidea), skippers (Hesperioidea) or moths (in many cases authors do not even indicate whether lepidopterans were larvae, pupae or adult individuals). Information on the butterflies attacked by birds and the location of observations are given in Table 1.

RESULTS AND DISCUSSION

Our observations combined with data from the literature document butterfly predation by 36 bird species of 15 families (Table 1). We believe, however, that many additional unobserved birds are involved, especially among the Galbulidae, Tyrannidae, and Thraupidae.

Galbulidae, Tyrannidae, and Thraupidae

Galbulidae contains 18 species (Remsen et al. 2016) including the Rufous-tailed Jacamar (*Galbula ruficauda* Cuvier), regarded as the most specialized butterfly predator in the Neotropics and utilized in several feeding and mimicry experiments with butterflies (Benson 1972; Chai 1986, 1990; Pinheiro & Campos 2013). Preliminary observations on wild Paradise Jacamar (*Galbula dea* Linnaeus) showed that this bird also feeds on a variety of butterflies. Similar to Rufous-tailed Jacamar, the Paradise Jacamar usually perches with the bill pointed upwards while moving the head in all directions, monitoring the space around, then performing a sudden and fast sally, sometimes in acrobatic loops, after flying insects like bees, dragonflies, and butterflies. Additional observations on the feeding behavior of this and other Galbulidae, which remain virtually uninvestigated, would certainly reveal many butterfly predators.

Tyrannidae is the largest Neotropical bird family (418 species; Remsen et al. 2016), most of them insectivorous (Ridgely & Tudor 2009). Wide ranging tyrant-flycatchers like the Boat-billed Flycatcher (*Megarynchus pitangua* Linnaeus), the Great Kiskadee (*Pitangus sulphuratus* Linnaeus), the Tropical Kingbird (*Tyrannus melancholicus* Vieillot), the Streaked Flycatcher (*Myiodynastes maculatus* Müller), and the Rusty-margined Flycatcher (*Myiozetetes cayennensis* Linnaeus) occur in almost all vegetation strata in wetlands and terrestrial habitats of Central and South America (Cintra 1997, 2014; Ridgely & Tudor 2009), and attack a variety of Papilionidae, Nymphalidae, and Pieridae butterflies (Cook et al. 1969; Pinheiro 1996, 2003; 2011). This is also the case for the Cliff Flycatcher (*Hirundinea ferruginea* Gmelin) (Pinheiro 2003) and many other tyrant-flycatchers sometimes observed to attack butterflies like the Grey Monjita (*Xolmis cinereus* Vieillot), the White-throated Kingbird (*Tyrannus albogularis* Burmeister), the Long-tailed Flycatcher (*Colonia colonus* Vieillot), the Short-crested Flycatcher (*Myiarchus ferox* Gmelin), and the Drab Water-Tyrant (*Ochthornis littoralis* Pelzeln). Given the large number of species in this family we suspect that many other species could be involved in predation on butterflies.

Thraupidae is a bird family restricted to the Western Hemisphere that contains 329 species (Remsen et al. 2016) and reaches maximum diversity in the tropics. These birds are usually referred to as exclusively frugivores (Ridgely & Tudor 2009), but attacks on wild butterflies have been observed in many species like the Silver-beaked Tanager (*Ramphocelus carbo* Pallas), the Blue-gray Tanager (*Tangara episcopus* Linnaeus), which occur in most of the Brazilian Amazon, and White-lined Tanager (*Tachyphonus rufus* Boddaert), also utilized in palatability experiments with butterflies (Brower 1984). Fawn-breasted Tanager (*Pipraeidea melanonota* Swainson) has been observed to feed on chemically defended Ithomiini (Nymphalidae) that form large aggregations in the dry season in southeastern Brazil (Brown & Vasconcellos-Neto 1976). According to Brown & Vasconcellos-Neto the birds consume only the abdominal contents, which contain low quantities of defensive chemicals, and reject most of the body afterwards. Summer Tanager (*Piranga rubra*, now in the Cardinalidae) breeds in North America, but overwinters in South America where it feeds on fruits (Dunn & Alderfer 2014) and insects like butterflies, termites and wasps. Such a diverse collection of examples strongly suggests that other birds in this large family also feed on butterflies.

Ground-based bird predators

In contrast to jacamars and many other birds, which are able to catch both flying and resting butterflies, the Sunbittern (*Eurypyga helias* Pallas), the Collared Plover (*Charadrius collaris* Vieillot), and the Smooth-billed Ani (*Crotophaga ani* Linnaeus) feed mostly on puddling butterflies, especially males that perch on the ground to obtain salt and other minerals (Molleman 2010). Puddling aggregations occur on humid soil, sometimes as large butterfly carpets containing several species of Pieridae, Papilionidae, and Nymphalidae that cluster by color similarity (Tyler et al. 1994). Burger & Gochfeld (2001) observed that predation by Smooth-billed Ani on these butterflies can be intense. In addition, many other birds like the Rufous-tailed Jacamar, the Drab Water-Tyrant (*Ochthornis littoralis* Pelzeln) (R.A.A. Plácido, pers. comm.) and other tyrant-flycatchers occasionally feed on puddling butterflies.

Additional groups with new records

With few exceptions, most other birds cited in Table 1 constitute new records of butterfly predators. The Amazonian Motmot (*Momotus momota* Linnaeus) and the Rufous-capped Motmot (*Baryphthengus ruficapillus* Vieillot) are widely distributed over the neotropics (Hilty 2003). Foraging in these species involves a short, fast jump from the ground to obtain small fruits, butterflies and other insects perched on herbaceous plants. Amazonian Motmot attacks both palatable and chemically defended butterflies like several Ithomiini. Carla M. Penz (pers. comm.) observed this bird unsuccessfully attacking a group of flying *Opsiphanes* in

Panama. Rufous-capped Motmot is less common, and occurs as solitary individuals or in pairs in humid and wet lowland forests from middle to upper story. They hunt by a sudden sally to catch butterflies and other insects on foliage, limbs or trunks, and follow army ants (Hilty & Brown 1986).

The Black Nunbird (*Monasa atra* Boddaert) occurs in the understory of the Amazon *terra-firme* forest and its congeneric, the Black-fronted Nunbird (*Monasa nigrifrons* Spix) is a resident species in *varzea* and secondary forests. They catch crickets, cockroaches, spiders, and several butterfly species that perch on branches and trunks. One of us (RC) observed this bird following troops of squirrel monkeys (*Saimiri sciureus* Linnaeus), which dislodge butterflies and many arthropods that are afterwards detected and attacked.

The Laughing Falcon (*Herpetotheres cachinnans* Linnaeus) is able to catch the large *Morpho* butterflies. R. Hill (pers. comm..) observed this bird repeatedly attacking *Morpho* sp. on the wing. According to him the Falcon flew out and flew very swiftly taking the butterfly out of the air. Then it returned to high exposed perch and clipped wings off before consuming the butterfly.

The Plain-brown Woodcreeper (*Dendrocincla fuliginosa* Vieillot) occurs from Honduras to Ecuador, east of the Andes to southern Bolivia, Brazilian Amazonia, and northeastern Brazil (Hilty 2003). This bird is a mixed-species flock follower in the understory of *terra-firme* forest (Willis 1972). It usually perches low in saplings and shrubs before jumping to catch escaping arthropods, including butterflies, which are flushed from vegetation by the passing wave of birds. Sometimes they climb up trees to forage on butterflies and insects hidden in the bark. Given the relatively large number of woodcreepers (51 species; Remsen et al. 2016) and the fact that most are insectivores, we also expect to find other butterfly predators among them.

The Red-eyed Vireo (*Vireo olivaceus* Linnaeus) occurs all over Brazil, and the southern population is an austral migrant to Amazonia (van Perlo 2009). This bird often searches for food at the forest edge, in woodlands, shrubby clearings, and in the canopy of tall trees in cities. Although they feed mostly on larvae, they also attack, with sudden sallies, small Lycaenidae and Riodinidae perched on branches and leaf surfaces. Also in the *Vireo* family, the Rufous-browed Peppershrike (*Cyclarhis gujanensis* Gmelin) is a solitary, territorial, and widely distributed bird occurring from Mexico to Argentina. Its foraging behavior is similar to Red-eyed Vireo, often staying in foliage, but prefers the sub-canopy, concentrating activities mostly in primary forests, and follow mixed-species flocks at the forest border (Hilty 2003).

The Southern House Wren (*Troglodytes musculus* Naumann) is a small resident bird occurring over the Americas to Tierra del Fuego (Hilty 2003). This species is uncommon in natural habitats but is very abundant in urban areas and gardens. This is a very active wren, usually seen foraging from the ground to the canopy on all sorts of arthropods, including small insects and butterflies like Riodinidae and Lycaenidae, which they catch everywhere, including on the ground, shrubs, tree leaf surfaces and trunks.

The Pale-breasted Thrush (*Turdus leucomelas* Vieillot) is also very abundant in cities. It feeds mostly on the ground by hopping to find insects. Early in the morning and late in the afternoon it perches at low heights or in small trees, and sometimes attacks flying butterflies. The Cocoa Thrush (*Turdus fumigatus* Lichtenstein) is an uncommon, resident species that dwells in forest sites near water, occurring as solitary individuals or in pairs. Its range includes Trinidad, Guianas, Venezuela, eastern Colombia, Brazil, and eastern Bolivia (Cintra 2014). This species forages on the ground, and performs a sudden run after organisms and will also flip leaves with its bill, catching its prey by surprise. The Yellow-rumped Cacique (*Cacicus cela* Linnaeus) is a common, gregarious, and widespread bird, occurring solitarily, in pairs or in loose flocks in natural forest and urban areas. This cacique occurs from western Panama to Bolivia, Brazilian Amazonia, the Guianas, and to the east coast of Brazil (Hilty 2003). This bird breeds in colonies with many nests like hanging pouches in the canopy of tall trees, sometimes associated with Crested Oropendola (*Psarocolius decumanus* Pallas) breeding colonies. It forages in groups and away from the colony and brings all sorts of arthropods to its nests, including many lepidopteran larvae and adults. In contrast, the Solitary Black Cacique (*Procacicus solitarius* Vieillot) is a very uncommon, territorial, and solitary bird, and somewhat overlaps its geographical distribution with Yellow-rumped Cacique. It constructs a solitary nest, similar in shape to the Yellow-rumped Cacique, at forest edge in aquatic environments (Cintra 2014). It also feeds on a variety of large arthropods, including butterflies, which it catches by quickly jumping on them just after take-off.

Although relatively small, the list of predators provided here illustrates the variety of insectivorous and omnivorous birds whose species composition and abundance vary in different Neotropical communities, and are likely the major selective agents shaping butterfly defensive traits. We strongly encourage future investigations on bird feeding behavior and the role it has played as a selective agent on butterfly traits.

TABLE 1. Bird species observed to attack butterflies in the Neotropical region. Butterfly families are: Nym = Nymphalidae, Pap = Papilionidae, Pie = Pieridae, Lyc = Lycaenidae, Rio = Riodinidae, Hes = Hesperiidae. Brazilian states: AC = Acre, AM = Amazonas, DF = Distrito Federal, MT = Mato Grosso, PA = Pará, RO = Roraima, SP = São Paulo, TO = Tocantins. The bird taxonomic order followed SACC classification (Remsen et al. 2016). * = moth painted to resemble different mimetic morphs.

Family	**Bird Species**	**Butterflies Attacked**	**Sites / References**
Eurypygidae	*Eurypyga helias* (Sunbittern)	Nym + Pie (several species)	(Novo Airão, AM, 2009; RC)
Charadriidae	*Charadrius collaris* (Collared Plover)	Pie (several species)	(Porto Velho, RO, 1986; RC)
Cuculidae	*Crotophaga ani* (Smooth-billed Ani)	Nym + Pap + Pie (several species) Pie (several species)	Burger & Gochfeld (2001) (Iranduba, AM, 2015; RC)
	Piaya cayana (Squirrel Cuckoo)	*Hyalophora promethea* (Drury)*	Cook et al. (1969)
Momotidae	*Momotus momota* (Amazonian Motmot)	Ithomiini (Nym) (several species) Nym (several species) *Opsiphanes* sp. (Nym)	Pinheiro et al. (2008) (Manaus, AM, 2016; RC) (Gamboa, Panamá, 1994;
	Baryphthengus ruficapillus (Rufous-capped Motmot)	*Phoebis* sp. (Pie)	(Rio Tocantins, TO, 1997; CEGP)
Galbulidae	*Galbula ruficauda* (Rufous-tailed Jacamar)	*Heliconius* sp. (Nym) *Eueides isabella* Stoll (Nym) Nym + Pap + Pie (several species) *Morpho* sp. (Nym)	Benson (1972) Pinheiro & Campos (2013) Chai (1986, 1990) (many sites; RC, CEGP)
	Galbula dea (Paradise Jacamar)	Nym + Pap + Pie (several species)	(Manaus, AM, 2014; RC)
Bucconidae	*Monasa atra* (Black Nunbird)	Nym + Pie (several species)	(Manaus, AM, 2013; RC)
	Monasa nigrifrons (Black-fronted Nunbird)	*Heliopetes* sp. (Hes)	(Carajás, PA, 1995; CEGP)
Falconidae	*Herpetotheres cachinnans* (Laughing Falcon)	*Morpho* sp. (Nym)	(Guanacaste, C. Rica, 2014; RH)
Furnariidae	*Dendrocincla fuliginosa* (Plain-brown Woodcreeper)	*Hyalophora promethea* (Drury)*	Cook et al. (1969)
Tyrannidae	*Hirundinea ferrugínea* (Cliff Flycatcher)	Nym (several species) Nym + Pap (several species)	Pinheiro & Martins (1992) Pinheiro (2003)
	Xolmis cinereus (Grey Monjita)	Pie (several species)	(Brasilia, DF, 1982; RC)
	Colonia colonus (Long-tailed Flycatcher)	*Parides* sp. (Pap)	(Carajás, PA, 1995; CEGP)
	Myiozetetes cayennensis (Rusty-margined Flycatcher)	Nym + Pie + Pap (several species)	(many sites; RC)
	Pitangus sulphuratus (Great Kiskadee)	Nym + Pie + Pap (several species) Nym + Pie (several species) *Hyalophora promethea* (Drury)*	(Carajás, PA, 1995; CEGP) (Manaus, AM; RC) Cook et al. (1969)

Table 1. CONTINUED

Family	Bird Species	Butterflies Attacked	Sites / References
Tyrannidae	*Myiodynastes maculates* (Streaked Flycatcher)	*Heliconius* sp. (Nym)	(Carajás, PA, 1995; CEGP)
	Megarynchus pitangua (Boat-billed Flycatcher)	*Mechanitis polymnia* Linnaeus (Nym) *Heliconius ethilla* Godart (Nym) Nym + Pie (several species) *Hyalophora promethea* (Drury)*	(Brasília, DF, 2000; CEGP) (Campinas, SP, 1984; CEGP) (Manaus, AM, 2004; RC) Cook et al. (1969)
	Tyrannus albogularis (White-throated Kingbird)	Nym (several species)	(Santarém, PA, 1999-2001; RC)
	Tyrannus melancholicus (Tropical Kingbird)	Nym (several species) Nym + Pap + Pie (several species) *Hyalophora promethea* (Drury)*	Pinheiro & Martins (1992) Pinheiro (1996); (many sites; RC) Cook et al. (1969)
	Ochthornis littoralis (Drab Water-Tyrant)	*Marpesia* spp. (Nym)	(Mâncio Lima, AC, 2016; RAAP)
	Myiarchus ferox (Short-crested Flycatcher)	Pie (several species)	(Poconé, MT, 1984; RC)
	Myiarchus sp.	*Temenis laothoe* ssp. (Nym)	(Carajás, PA, 1995; CEGP)
Vireonidae	*Cyclarhis gujanensis* (Rufous-browed Pepper-shrike)	Lyc + Rio (several species) *Hyalophora promethea* (Drury)*	(Santarém, PA, 1999-2001; RC) Cook et al. (1969)
	Vireo olivaceus (Red-eyed Vireo)	Lyc + Rio + Hes (several species)	(Poconé, MT, 1983; RC)
Troglodytidae	*Troglodytes musculus* (Southern House Wren)	Lyc + Rio (several species)	(many sites; RC; CEGP)
Turdidae	*Turdus leucomelas* (Pale-breasted Thrush)	Pie (several species)	(Manaus, AM, 2012; RC)
	Turdus fumigatus (Cocoa Thrush)	*Hyalophora promethea* (Drury)*	Cook et al. (1969)
Thraupidae	*Tachyphonus rufus* (White-lined Tanager)	Nym + Pap (several species) Nym + Pap + Pie (several species) *Hyalophora promethea* (Drury)*	Brower (1984) (Santarém, PA, 2000; RC) Cook et al. (1969)
	Rhamphocelus carbo (Silver-beaked Tanager)	Nym + Pap (several species)	Brower (1984); (many sites; RC)
	Pipraeidea melanonota (Fawn-breasted Tanager)	Ithomiini (Nym) (several species)	Brown & Vasconcellos-Neto (1976)
	Tangara episcopus (Blue-gray Tanager)	Pie (several species)	(Manaus, AM, 2011; RC)
Cardinalidae	*Piranga rubra* (migrant) (Summer Tanager)	Nym (several species)	(Manaus, AM, 2015; RC)
Icteridae	*Cacicus cela* (Yellow-rumped Cacique)	Pie (several species)	(Tefé, AM, 2003; RC)
	Procacicus solitarius (Solitary Black Cacique)	Pie (several species)	(Poconé, MT, 1983; RC)

ACKNOWLEDGEMENTS

We are grateful to Carla M. Penz for information on Amazoian Motmot, Ricardo A. A. Plácido for information on Drab Water-Tyrant, and Ryan Hill for information on Laughing Falcon and many helpful comments on the manuscript.

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Submitted for publication 16 November 2016; revised and accepted 25 January 2017.

Journal of the Lepidopterists' Society
71(2), 2017, 115–116

FIRST REPORT OF THE MANGO FRUIT BORER, *CITRIPESTIS EUTRAPHERA* (MEYRICK) (LEPIDOPTERA: PYRALIDAE) AS A SEEDLING BORER OF CASHEW, *ANACARDIUM OCCIDENTALE* L. (ANACARDIACEAE)

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ABSTRACT.. The invasive mango fruit borer, *Citripestis eutraphera* (Meyrick) (Lepidoptera: Pyralidae, Phycitinae), is reported for the first time as a seedling borer of cashew. Infestation on the seedlings probably indicates opportunistic use of vegetative portions as fruits are seasonal and unavailable during most of the year. Infestation was also observed on the fruits of mango and cashew in the State of Kerala for the first time.

Additional key words: *Anacardium occidentale*, *Citripestis eutraphera*, India, pest, seedling borer

The invasive mango fruit borer, *Citripestis eutraphera* (Meyrick, 1933) (Lepidoptera: Pyralidae, Phycitinae) (Fig. 1), originally described from Java, is a significant pest of the crop in South and South-East Asia and the Northern Territory of Australia (Anderson & Tran-Nguyen, 2012). Meyrick (1930-1936) mentioned that the type specimens were bred from larvae feeding in fruits of *Mangifera*. Kalshoven (1981) provided further information on its life history as a fruit borer of mango, *Mangifera indica* L. in Indonesia. According to him, "the larvae feed mostly on the soft piths of young fruits and also in fruit petioles and in the shoots". He recorded "kebembem" (?*Mangifera odorata* Griffith) as an additional host plant of the pest. It is also known to bore into the fruits of *M. andamanica* King (Bhumannavar, 1991) and cashew, *Anacardium occidentale* L. (Jacob et al. 2004) in the south Andaman Islands. Anderson and TranNguyen (2012) provided diagnosis and biology of *C. eutraphera* following its introduction and establishment in Australia. Jayanthi et al. (2014) reported its invasion and spread in mainland India. It is also known to occur in Bangladesh as a minor pest on mango (Ali et al., 2015). Other host plants of *C. eutraphera* include *Dipterocarpus baudii* Korth., *D. chartaceus* Symington (Dipterocarpaceae), *Mangifera caesia* Jack (Anacardiaceae), and *Parkia javanica* Merr. (Fabaceae) (Robinson et al. 2010).

Larvae of *C. eutraphera* bores into the shoot and fruit stalk of *M. indica* (Kalshoven, 1981). Infestation on the stem of cashew was hitherto unknown. However, heavy infestation of *C. eutraphera* was observed on cashew seedlings and grafts at the District Agricultural Farm, Peringamala, Trivandrum, Kerala (N 08º45'37.3" E 077º02'56.8"; 136 m above sea level) in July–August, 2016. About 80% of the grafts kept enclosed in humid chambers for hardening were killed. Infestation was also observed on seedlings (5–8 leaf stage) grown in polybags and meant to be used as root stock for the production of grafts. Infestation on the fruits of cashew was observed in the succeeding fruiting season in February, 2017.

The infestation, ex situ

Larvae started infestation by boring into the cotyledons of the seedlings (Fig. 1 c, d). Generally only a single cotyledon was infested. When both cotyledons were infested, they were webbed together. From the cotyledons, they bored into the stem at the point of attachment of the cotyledon with the stem (Fig. 1 c). The larva initially tunneled down towards the root and then moved up inside the stem (Fig. 1 e). The larval tunnels contained fecal matter. Larval tunneling inside a stem resulted in wilting and death of the seedling. In the case of grafts, the larvae were mostly confined to the rootstock. In some cases they bored into the scion from the rootstock, crossing through the graft union. In each cotyledon, one or two larvae were observed. However, only a single larva was observed inside the stem of any one seedling. The bore holes were usually covered with frass and excreta (Fig. 1 f). Pupation occurred in a loose cocoon of silk covered with frass and soil on surface near the base of the plant or rarely inside the larval burrow.

The infestation, in situ

In the laboratory, when tender leaves were provided, the larvae webbed together and fed on the leaves and reached maturity. At Peringamala, no infestation was observed on the shoots of grown up cashew trees. Cashew started flowering in December, 2016 and 3.3 to 24.3% infestation was observed on developing fruits of cashew during the first fortnight of February, 2017 (Figs 1 g–k). Larvae bored into the apple at the region of attachment with the nut (Figs 1 g, h) or near the fruit stalk (Figs 1 i, j) and made galleries within the apple. They initially scraped externally and produced frass before entering into the apple. The bore holes were covered with excreta and frass. Larvae often bored holes

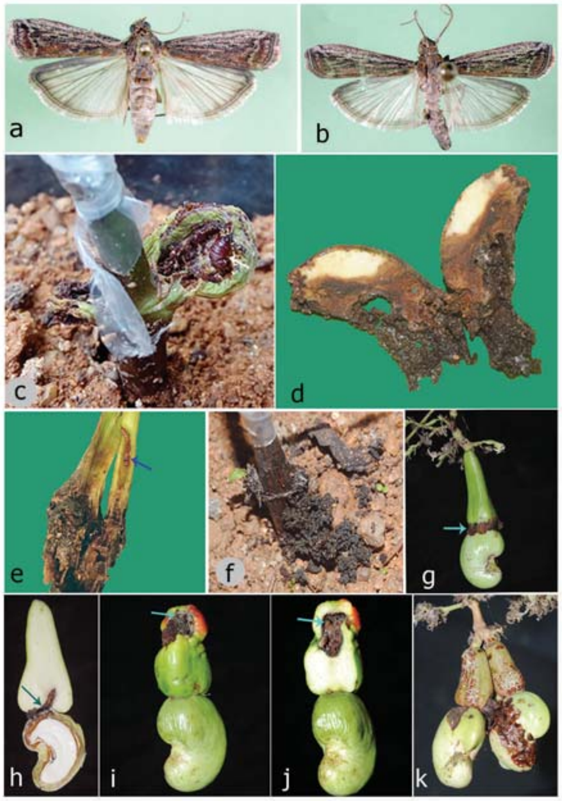

FIG. 1. *Citripestis eutraphera* (Meyrick) (**a**) female moth, (**b**) male moth, (**c**) infested cotyledon, (**d**) cross section through infested cotyledon, (**e**) rootstock with larva inside, (**f**) bore hole at the base of a graft, covered with frass and excreta, seen externally, (**g**) cashew fruit infested at the point of attachment of apple with the nut, (**h**) cross section of fruit infested near the point of attachment of apple with the nut, (**i**) cashew fruit infested near the fruit stalk, (**j**) cross section of infested fruit with larval entry near fruit stalk, (**k**) tender nuts scraped by larvae.

and scraped the surface of tender nuts. However, they did not enter into the nut through the hard shell. Moths were collected at light at the College of Agriculture, Vellayani (N 08° 25' 47.5'' E76° 59' 8.3''; 18 m above sea level) during August, 2016. However, no infestation was observed on cashew fruits or seedlings at Vellayani. Widespread infestation was observed on mango fruits in and around Vellayani beginning on the third week of September, 2016.

DISCUSSION

The only information on *C. eutraphera* as a pest of cashew was provided by Jacob et al. (2004) who recorded it as a major pest of the crop that bores into the apple during March–May in the Andaman and Nicobar Islands. Further information on the nature of damage and symptoms of infestation on cashew are provided here.

All the known host plants of *C. eutraphera* are trees that put forth flowers during a narrow temporal window in a year, so that the susceptible stage of the fruit is not available for survival during most of the year. Observation of *C. eutraphera* as a stem borer of seedlings probably shows the opportunistic use of vegetative parts as the fruits are seasonal and unavailable during most of the year. It is also noteworthy that the larva that initially bores into the cotyledon still retains a semblance of its fruit boring nature. Laval feeding and survival on the tender leaves in the laboratory indicates possible infestation of *C. eutraphera* on the leaves too. Thus *C. eutraphera* is potentially a serious invasive pest of mango and cashew capable of damaging radicle, fruits, stem and leaves. Removal of the cotyledon, though it may affect the vigor of the seedlings, would save the seedlings and grafts from infestation. This is the first report of *C. eutraphera* as a seedling borer of cashew as well as its occurrence in Kerala State.

Voucher specimens of *C. eutraphera* are deposited in the ICAR-National Bureau of Agricultural Insect Resources (ICAR-NBAIR), Bangalore and the Natural History Museum, London.

ACKNOWLEDGEMENTS

We are indebted to Drs M. Shankara Murthy, Department of Entomology, University of Agricultural Sciences, Raichur and David Lees, Natural History Museum, London for confirmation of the identity of C. eutraphera. PKD is supported by the Indian Council of Agricultural Research through the Network Project on Insect Systematics. Ajith P. P., District Agricultural Farm, Peringamala brought the pest incidence to our notice.

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Submitted for publication 20 December 2016; revised and accepted 17 February 2017.

Journal of the Lepidopterists' Society
71(2), 2017, 117–122

DISTRIBUTION, BIOLOGY, AND IDENTIFICATION OF *ARGYRESTHIA PRUNIELLA* IN WASHINGTON STATE

Additional key words: cherry blossom moth, cherry fruit moth, *Argyresthia ephippella*

Argyresthia pruniella (Clerck, 1759) (=*Argyresthia ephippella*) (Lepidoptera: Argyresthiidae) is a minor to moderate pest of cherries that sometimes causes severe damage to cherry crops in parts of Europe (Wimshurst 1928, Carter 1984, Alford 2007, Jaastad 2007). Called the cherry blossom moth or cherry fruit moth, the species is a well-documented herbivore of *Prunus* blossoms and buds (Wimshurst 1928, Jancke 1932, Jasstad 2007). Other recorded hosts include *Pyrus* (Spuler 1910, Lewis and Sohn 2015), *Sorbus* (Réal and Balachowsky 1966, Lewis and Sohn 2015), *Malus* (Alford 1978, 2007), *Lonicera* (Réal and Balachowsky 1966), and *Corylus* (Réal and Balachowsky 1966, Lewis and Sohn 2015), although given the host specialization common within *Argyresthia* some of these records are dubious and likely due to misidentification (J.F. Landry pers. comm.; also see comments in Réal and Balachowsky 1966). The current distribution of *A. pruniella* includes the United Kingdom and most of continental Europe (see country lists in Zhang 1994, Karsholt and Razowski 1996, Lewis and Sohn 2015), Russia (Gershenzon 1989), Asia Minor (Agassiz 1996), and British Columbia, Canada (deWaard et al. 2009). Here we confirm the establishment of *A. pruniella* in the continental United States based on pheromone trapping of adults and larval collections in Washington State. We also give notes on the biology and identification of this pest.

The phenology and morphology of *A. pruniella* has been fairly well studied, with accounts scattered throughout the literature. Eggs are initially pale brown, later turning grey, and are oval, flattened, with raised reticulations, and a circle of small hooks at one end (Carter 1984, Agassiz 1996, Réal and Balachowsky 1966: fig. 93). They are laid in sheltered areas of the host plant, including cracks in the bark, at leaf scars, beneath bud scales, or at the base of shoots and spurs (Jancke 1932, Alford 2007). Most eggs hatch the following spring, although some larvae will emerge in September and overwinter in a silk hibernaculum beneath the empty egg (Carter 1984, Alford 2007).

The larva of *A. pruniella* was described by Werner (1958). He stated that the thoracic L setae form a slanted line on T2 and T3, SD1 is dorsad of the spiracle on A3, the prolegs of A3–6 have 12 crochets in a circle and the tarsal setae are long and bent apically. In the few specimens we examined (n=2), the thoracic setae form a slightly bent diagonal line, there are 12-14 crochets in a circle on the prolegs of A3–6 and there is a single very long tarsal seta that was either broken or not bent apically. The mandible has four teeth, no retinaculum, and only four of six setae are on the prothoracic shield. Werner (1958) noted that a related species also in North America, *A. conjugella*, has six setae on the prothoracic shield, there are 28–34 crochets on the prolegs of A3–6 and the body pinacula

FIG. 1. Outer cocoon, inner cocoon, and pupa of *A. pruniella*, reared from *Prunus avium*.

are pigmented. This partially conflicts with the drawing in Stehr (1987: 407) that showed *A. conjugella* with only 14 crochets on A3–6 and unpigmented body pinacula. Perhaps the best way to separate the two species is to note that *A. pruniella* has four instead of six setae on the prothoracic shield. Both Werner (1958) and Stehr (1987) agreed that the prothoracic shield of *A. conjugella* encloses six setae. Werner (1958: 54) considered the prothoracic shield of *A. pruniella* to be undivided, but our specimens have it split medially, as is typical of most lepidopteran larvae.

Larvae mine the flowering shoots in the early spring (Agassiz 1996, see drawing of damage in Gershenzon 1989: fig. 324) and may be present before bud burst. Later in the season they enter the ovaries of flowers or developing fruit (Jancke 1932, Alford 2007). Each larva can consume 5–7 buds or flowers, resulting in considerable yield loss, especially in unsprayed orchards (Wimshurst 1928, Jaastad 2007). Fully-grown larvae descend to the ground in May to pupate (Agassiz 1996).

The pupa of *A. pruniella* is pale brown with a greenish tint and is surrounded by a double walled cocoon (Agassiz 1996). The inner layer is dense and thick while the outer portion is net-like (Fig. 1). A similar cocoon was shown for a related European species, *A. bonnetella*, by Sterling and Parsons (2012). The pupa of *A. pruniella* was illustrated by Gershenzon (1989) and by Patočka and Turčáni (2005). Agassiz (1996) mentions the presence of spines flanking the anal slit as a recognition feature for *A. pruniella*, but *A. conjugella* and several other European species share this character (Patočka and Turčáni 2005). The differences between *A. pruniella* and *A. conjugella* listed by Patočka and Turčáni (2005) are probably too subtle to be useful for anyone without a large collection and abundant reference material.

Both *A. pruniella* and *A. conjugella* have a long maxilla that extends past the prothoracic legs. This is somewhat unusual compared to other members of the genus, but pupae of *Argyresthia* found on any other host besides cherry in Washington State are probably best identified to only to genus. An important biological difference is that *A. conjugella* overwinters as a pupa, while *A. pruniella* overwinters as eggs or early instar larvae, with pupae present in summer (Agassiz 1996). *Argyresthia pruniella* pupates in the soil, and adults emerge six to seven weeks later (Jancke 1932, Agassiz 1996, Alford 2007).

The adult of *A. pruniella* (Fig. 2) was illustrated in color by several authors including Friese (1969), Agassiz (1996), Parenti (2000) and Sterling and Parsons (2012). In Europe, *A. pruniella* is most similar to *A. bonnetella* but the two species differ in details of the forewing markings (see Agassiz 1996, Sterling and Parsons 2012). The male genitalia of *A. pruniella* were illustrated by Gershenzon (1989). *Argyresthia pruniella* adults typically begin to fly in late June and July when they can be observed resting on foliage and tree trunks in the 'tail up' pose characteristic of Argyresthiidae (Wimshurst 1928, Jancke 1932, see Robinson et al. 1994: fig. 28).

TABLE 1. Number of sites trapped and results for *Argyresthia pruniella* surveys in Washington State, 2012–2013.

	2012		2013	
County	**Sites**	**Positive Sites/ Moths Captured**	**Sites**	**Positive Sites/ Moths Captured**
Whatcom	60	18/171	69	24/816
Skagit	21	0	33	0
Snohomish	10	0	10	0
King	10	0	-	-
Pierce	12	0	-	-
Thurston	10	0	-	-
Clark	1	0	-	-
Skamania	3	0	-	-
San Juan	-	-	21	5/11
Clallam	-	-	9	0
Grant	11	0	12	0
Okanogan	7	0	7	0

FIG. 2. *Argyresthia pruniella*, male. Emerged 15 April 2013 from eggs collected in Blaine, WA on *Prunus avium*.

They fly at dusk and can be beaten from trees or collected with light traps (deWaard et al. 2009, Sterling and Parsons 2012) or pheromone baited traps.

Carter (1984) and Agassiz (1996) stated that *A. pruniella* was introduced to North America, but provided no specimen or collection details. It is not clear if they were referring to undocumented personal communications or if they were simply in error. The claim could stem from Ferguson's (1975) comment that a reared specimen of *A. conjugella* from Nova Scotia could have been a misidentified *A. ephippella*, a junior synonym of *A. pruniella* (J.F. Landry pers. comm.). The first confirmed North American record for *A. pruniella* was from specimens collected in 2007 during a light-trap survey at a park in Vancouver, British Columbia, Canada (deWaard et al. 2009). A small series of *A. pruniella* collected in the 1960s from Nova Scotia, Canada, was later discovered in the United States National Museum collection (USNM) (deWaard et al. 2009); we have been unable to find any other confirmed North American records. Subsequent to publication of the British Columbia records, the Washington State Department of Agriculture (WSDA) implemented pheromone trap surveys throughout Washington and larval surveys in the western part of the state.

Traps were placed for *A. pruniella* in 2011, 2012, and 2013. Eleven sites in Blaine, WA, located on the Washington-British Columbia border, were trapped in late summer 2011. In 2012, 145 sites were trapped in eight western and two eastern Washington counties. In 2013, 161 sites were trapped in five western and two eastern Washington counties (Table 1; Fig. 2). Traps were located in cherry (*Prunus avium*) or other *Prunus* trees in roadside or residential settings. Trap configurations consisted of septa lures loaded with Z11–16Ald in red or white reusable large plastic delta traps (Alphascents) with hot melt pressure-applied adhesive inserts. Traps were first placed in the field during mid-July in 2011, during early June in 2012, and from April to May in 2013. They were checked semi-weekly until late September in all years and then removed. All traps were screened for moths at the WSDA Olympia entomology laboratory. Voucher specimens of *A. pruniella* were deposited in the WSDA Arthropod Collection, USNM collection, and the collection of S. C. Passoa.

In March, April, and May of 2013, twigs were collected from four sites in Blaine, WA where adult moths were detected in the previous survey season. Twigs were examined under the microscope for eggs, larvae, and evidence of damage. All discovered larvae were retained for rearing. Samples were collected from *Prunus avium*, *Malus*, and *Amelanchier*, all rosaceous species that were in bloom during the larval sampling.

Argyresthia pruniella adults were trapped at 30 sites in two western Washington counties during the three years of sampling (Table 1). Seventeen specimens were detected at three sites in the 2011 survey. The 2012 survey resulted in 171 total moths collected across 18 positive sites, all in Whatcom County. The 2013 survey detected 827 moths at 29 sites, five of which were in San Juan County. No moths were detected in eastern Washington in either year (Table 1). Early trap placement in 2013 apparently captured the entire flight period, with the first moths collected after traps had been deployed for more than a month. The end of the flight period is unclear, as a few moths continued to be trapped in each year up to trap removal in mid to late September (Fig. 3); Jancke (1932) recorded adults until late September in Germany.

Several non-target species were also captured, including three species of *Argyresthia*, and *Scoparia* sp. (Crambidae). *Argyresthia pruniella* is most likely to be confused with *A. conjugella* because both species have a similar forewing pattern. They may be distinguished by their head color, ground color of the forewing, and dark spot on the inner margin of the forewing. The head of *A. pruniella* is pure white, the forewing ground color is a dark brown, and the spot dividing the white bar on the inner margin is a contrasting dark brown to blue-black. This differs from *A. conjugella* that has a very faint

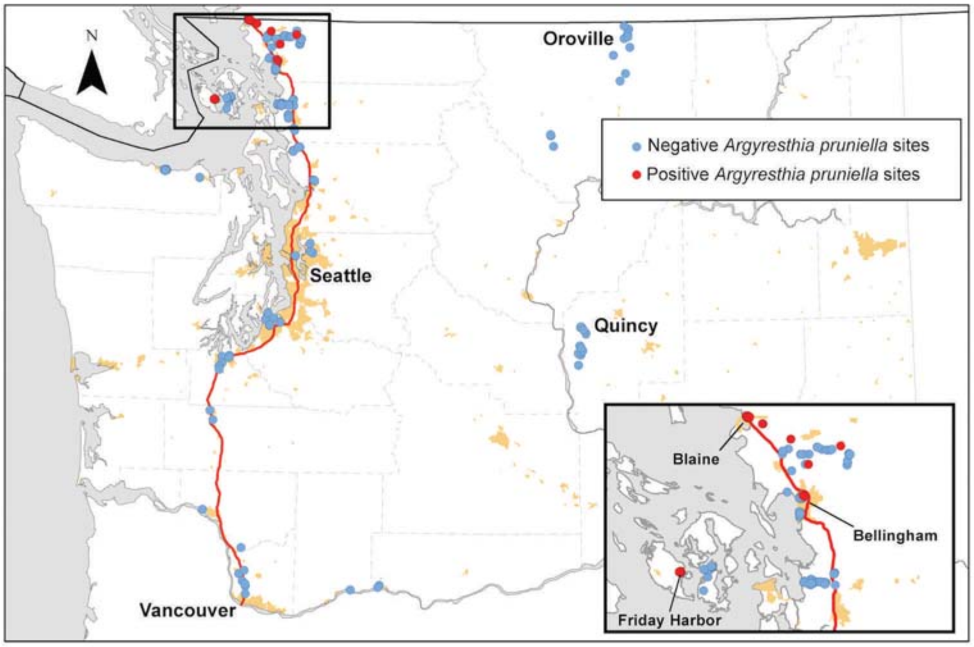

FIG. 3. Positive and negative traps sites for *A. pruniella* in Washington State, 2011–2013.

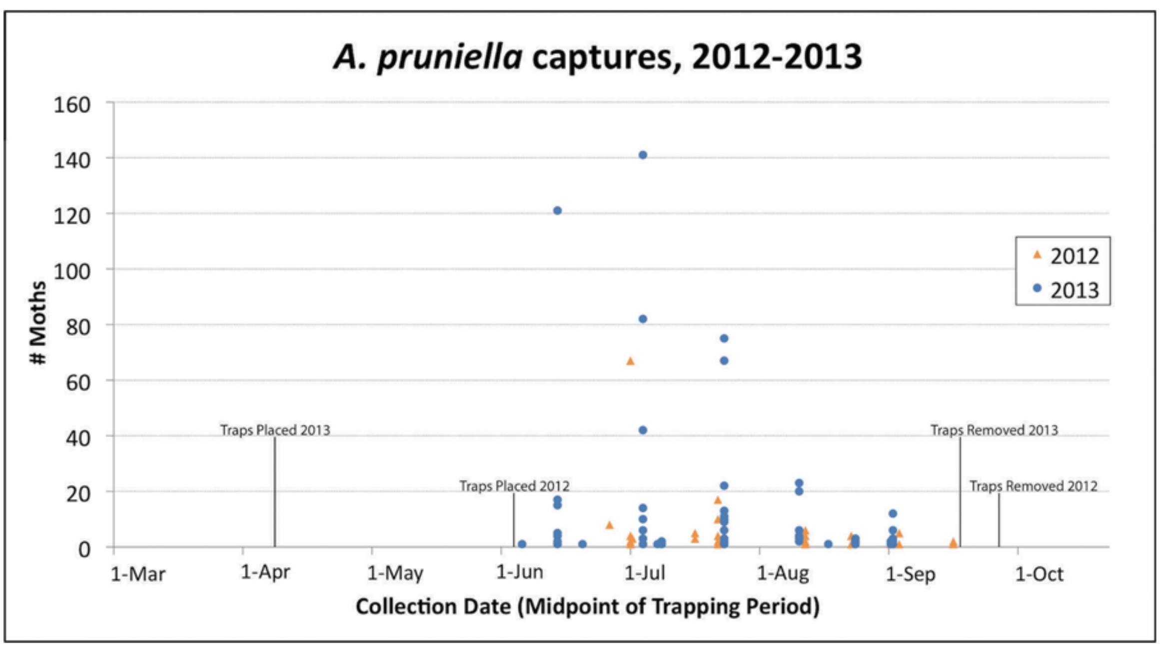

FIG. 4. *Argyresthia pruniella* trap captures, 2012–2013.

orange tint on the white head, a forewing that is gray, and a grayish spot on the inner margin. The male genitalia is also different, and as with many moths, this is the most reliable method of identification. The base of the sclerotized anal tube has three long curved setae in *A. conjugella* that are absent in *A. pruniella* (Gershenzon 1989: 357).

Eggs were detected with difficulty on a few twigs from four *P. avium* trees sampled on 11 March, 2013. No live larvae were found. The eggs were retained, but no larvae eclosed. Larvae of *A. pruniella*, *Spilonota ocellana* (Tortricidae), and *Operophtera brumata* (Geometridae) were readily detected on twigs collected from two *P. avium* trees on 15 April, 2013. We examined 924 individual flowers and observed *A. pruniella* larvae or likely damage from this species in 7% and 2.8% of flowers from the two trees, respectively. Eight more trees were sampled 5 May, 2013; one *Malus*, one *Amelanchier*, and six *P. avium*. No larvae or evidence of larvae were observed feeding on *Amelanchier* (252 flowers examined) or *Malus* (158 flowers examined). Larvae were largely absent from the *P. avium* at this time (4051 flowers examined), with detections made on only a single tree. Many blossom clusters evidenced feeding across multiple flowers in the April and May collections.

More sites were positive and many more moths were collected per site in 2013 than in 2012. Moth capture rate was strikingly higher, with 5.4 moths/trap-day in 2013 and 1.5 moths/trap-day in 2012. This could be partly due to different timing; traps were not deployed in 2012 until early June, potentially missing earlier flight activity. In contrast, traps were placed in late April in 2013. However, the peak capture in 2012 was during the first trapping interval, between early and late June. This time period was also the peak flight in 2013, with the earliest moth captures between 6 and 16 June (Fig. 4). Additionally, seven sites that were trapped in both years were only positive in 2013. It is tempting to view these collection data as evidence for an increasing population, although inter-year variability could also explain these results. This is particularly true given the relatively late start in 2012; the possibility that peak flight occurred before traps were deployed cannot be discounted. However, over 120 more degree-days were accumulated by early June in 2013 than in 2012. These data plus the timing of peak moth capture in both years suggest that adult moth density was indeed greater in 2013 than 2012, due either to increasing populations or a more favorable year for moths.

The quarantine significance of *A. pruniella* is discussed in Ahern (2012). As part of the New Pest Advisory Group process employed when exotic agricultural pests are detected in the United States, the common name "cherry blossom moth" was adopted instead of "cherry fruit moth" since mature fruits are not infested. This distinction is important because the United States exports large quantities of cherries and a common name including "fruit moth" might cause some trading partners to wrongly assume that there is a danger of importing this pest in produce. There are no interception records for *A. pruniella* at United States ports (Jim Young, pers. comm.), which implies that natural spread from British Columbia is the best explanation for this introduction in adjacent Washington State. Further surveys should be conducted to look for further evidence of expanding population size and range, especially in organic cherry orchards that are at the most risk from this pest.

ACKNOWLEDGEMENTS

This work was partially supported by United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) Cooperative Agreement 12-8550-1585-CA and a grant from the Washington State Department of Agriculture Specialty Crop Block Grant program. Megan Asche (WSU) took the photograph of *A. pruniella* in Fig. 2. We thank WSDA employees Rachel Chai, Warren Hellman, Don Kitchen, Andi Kopit, Diane MacLean, and Arlo Pelegrin for field and laboratory assistance. John Brown (USDA, Systematic Entomology Laboratory) identified our initial samples based on morphology. Thanks to Jim Young (USDA, APHIS, PPQ) for checking interception records at the United States ports from 1985 to 2016. We are grateful for Dr. Jean-François Landry sharing many insights regarding this genus, and to an anonymous reviewer whose contributions improved the readability and accuracy of this note.

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Submitted for publication 28 June 2016; revised and accepted 10 November 2016.

Journal of the Lepidopterists' Society
71(2), 2017, 122–125

FIRST RECORD OF *SYNARGIS GORPA* (LEPIDOPTERA: RIODINIDAE) IN THE PAMPEAN GRASSLANDS OF URUGUAY

Additional key words: Atlantic Forest, campos, endangered species, grasslands, Nymphidiini, Pampa, pastizales

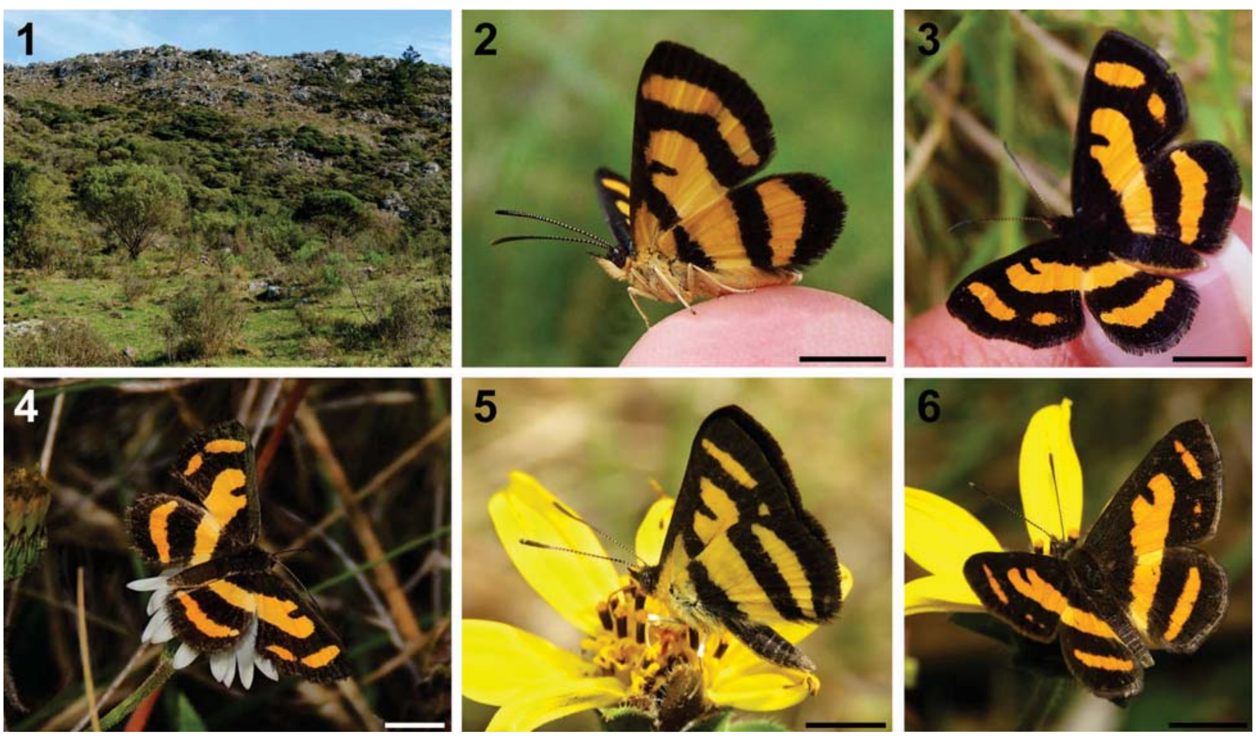
The genus *Synargis* Hübner, [1819] comprises 28 species distributed from Mexico to southern Brazil, Uruguay and Argentina (Callaghan & Lamas 2004, Dolibaina et al. 2013). Hall & Harvey (2002) reviewed the taxonomy of the genus and proposed a first phylogenetic hypothesis. According to these authors, two synapomorphic characters in the eighth sternite define *Synargis*: 1) males with two long, narrow posterior projections with finely serrate tips; and 2) females with well sclerotized lateral margins and weakly sclerotized in the dorsal region. In general, *Synargis* species are associated with tropical lowland rain forest environments and forest edges (Callaghan 1986, DeVries 1997). An exception to this ecological pattern is the '*Synargis axenus* complex', a monophyletic lineage in the '*Synargis regulus*' species group (sensu Hall & Harvey 2002), which contains seven species restricted to open environments such as savannas, shrublands, and grasslands of South America (Fig. 1; Dolibaina et al. 2013).

Recently, Dolibaina et al. (2013) reviewed the taxonomy of the '*S. axenus* complex' and described three new species. One of these new taxa is *Synargis gorpa* Dolibaina, Dias, Mielke & Casagrande, 2013. This rare species is known only from four male specimens from three localities, all of which are high elevation grasslands (900 m or higher) in southern Brazil, from Guarapuava (Paraná), Curitibanos (Santa Catarina), and São Francisco de Paula (Rio Grande do Sul) (Dolibaina et al. 2013). This small butterfly is easily distinguished from other *Synargis* species by the pattern and color of the wings, with bright yellow-orange postmedial and medial bands on a deep black background, and devoid of a marginal band. Here, we provide the first record of S. *gorpa* in Uruguay, and describe and illustrate the previously unknown female. We also provide a map showing the updated geographic distribution of the species, extending its known range by over 700 km.

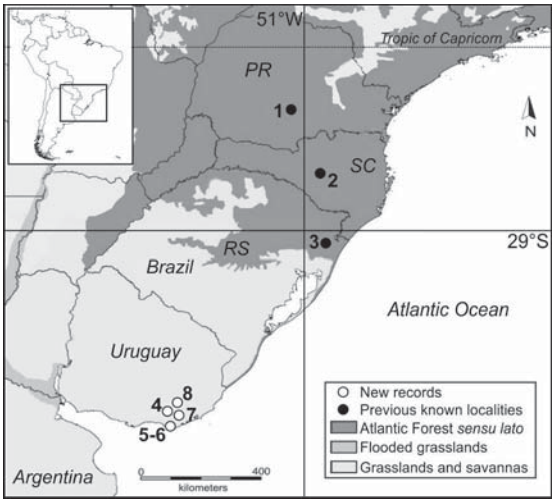
On 17 March 2007 one female of S. *gorpa* (Figs. 2–3) was observed for the first time in the peninsula of Punta Ballena (34°54'26.97"S, 55° 2'33.55"W, 6 m a.s.l.), Maldonado, Uruguay (this specimen was previously cited as *Synargis axenus* (Hewitson, 1876) in Bentancur-Viglione 2009). Additional photographic records were found for four individuals: one female on 7 April 2016 (Fig. 4; 34°25'39.14"S, 55° 7'40.16"W, 221 m a.s.l.), and one male 14 December 2015 (Figs. 5–6; 34°28'4.78"S, 55°19'10.93"W, 290 m a.s.l.) in the vicinity of Minas, Lavalleja, Uruguay; two males on 24 March 2016 in San Carlos (34°45'12.67"S, 54°55'38.31"W, 23 m a.s.l.), and 2 April 2016 in Aiguá (34°15'36.44"S, 54°46'25.06"W, 149 m a.s.l.), Maldonado, Uruguay. Copies of the digital images are deposited in the database of the entomological Collection the Facultad de Ciencias, Universidad de la República (UDELAR), Montevideo, Uruguay (FCE). A review of the Lepidoptera deposited in this collection (FCE-LP), revealed two additional specimens of S. *gorpa* identified as S. *axenus*: URUGUAY, Maldonado, San Francisco, Piriapolis, 8.xii.1972, 1♂, (FCE-LP 246), 9.iii.1974, 1♂, (FCE-LP 245), A. Carmenes leg. The updated range (Fig. 7) of S. *gorpa* was also complemented with data obtained from Dolibaina et al. (2013).

Feeding behavior was observed in the morning (12:40 h) and afternoon (16:00 h) on flowers of *Sommerfeltia spinulosa* (Spreng.) Less. and *Aspilia montevidensis* (Spreng.) Kuntze (Asteraceae); the habitat where this species was found in Uruguay is typical remnants of native subtropical grasslands (Fig. 1). The female wing pattern and color is very similar to males in both dorsal and ventral surfaces, but the wing shape is rounder (Figs. 2–3). The body is dorsally black and laterally and ventrally yellow. The female forewing length is 13 mm (n = 2).

A better knowledge on the ecology and geographical distribution of *S. gorpa* is fundamental to understanding the biogeography and evolution of the '*S. axenus* complex' and its transition from forests to open habitats. According to the morphology-based phylogeny proposed by Dolibaina et al. (2013), *S. gorpa* is the sister group of other species in the complex, with a wing pattern that is intermediate between other species in the '*S. regulus*' species group, which are associated with forested habitats. In this sense, the new records for Uruguay are potentially important for the biogeographic reconstruction because they show that the species may occur in grasslands at lower altitudes further south in the Pampa biome (known as campos in Brazil and pastizales in Uruguay). Until then, this species was



Figs. 1–6. Habitat and adults of *Synargis gorpa*. **1,** General aspect of the rocky grasslands in "Sierra de los Indios" near Minas, Lavalleja, Uruguay. **2–3,** female in latero-ventral and dorsal view, respectively; **4,** female feeding on flower of *Sommerfeltia spinulosa* (Asteraceae); **5–6,** male feeding on flower of *Aspilia montevidensis* (Asteraceae) in latero-ventral and dorsal view, respectively. Scale bars = 0.5 mm. Photos (1–4) by F. Pérez-Piedrabuena, and (5–6) by G. Casás.



FIGS. 7. Map showing the eight known localities for *Synargis gorpa* in southern Brazil and Uruguay. The solid black circles represent the three previously known localities for S. *gorpa* (see Dolibaina et al. 2013), and open circles represent the five new localities in Uruguay. **1.** Guarapuava, Paraná (PR); **2.** Curitibanos, Santa Catarina (SC); **3.** São Francisco de Paula, Rio Grande do Sul (RS); **4.** Minas, Lavalleja (LA); **5.** San Francisco, Maldonado (MA); **6.** Punta Ballena (MA); **7.** San Carlos (MA); **8.** Aiguá (MA).

known only from high elevation grassland mosaics associated with Araucaria forests in the Atlantic forest sensu lato. In Uruguay, two additional species are known in the 'S. *axenus* complex', *Synargis bifasciata* (Mengel, 1902) and *Synargis ochrophlegma* (Stichel, 1911) (Dolibaina et al. 2013; M.G. Bentancur-Viglione, unpublished data). In the Maldonado region S. *gorpa* and *S. bifasciata* are found in sympatry.

The discovery of *S. gorpa* in Uruguay was made via photos posted on an image hosting website (Flickr), grouping images via "mariposas del uruguay" (see https://www.flickr.com/groups/1693756@N23/, last accessed [September 27, 2016]). This kind of initiative taken by nature enthusiasts, including both biologists and non-biologists, has grown in South America and has become a valuable source of new records (see Kaminski et al. 2015). Such 'Citizen Science' should be encouraged as a means of engaging people to know their local biodiversity and at the same time provide valuable information on the distribution and monitoring of Neotropical species.

The collection dates suggest that *S. gorpa* is bivoltine, with a spring (November–December) and a late summer generation (March–April). Collection specimen data plus our new records suggest that this pattern is consistent over years. In Uruguay, distribution records are concentrated in the southwest, from mountainous sites in "Sierra de los Indios", "Sierra Carapé" and "Cerro de las Ánimas" near Minas, to sea level on the Maldonado coast. Despite these new distribution records, this riodinid species is still known only from few individuals and localities, being rare and potentially endangered with its occurrence restricted to natural grasslands. These South American open grasslands have historically been neglected from a conservation point of view in terms of recognition of their diversity and endemism (see Overbeck et al. 2007). Consequently, several endemic species in these ecosystems are threatened (Dolibaina et al. 2011; Siewert et al. 2014) or possibly extinct (e.g., Penz et al. 2011). Thus, we hope this brief report will encourage further studies on the ecology and evolution of this recently discovered grassland butterfly.

ACKNOWLEDGEMENTS

We thank Gustavo Casás for making public the images of S. *gorpa* in the hosting website "mariposas del uruguay" and for his kind permission to use them in this paper, and to Eduardo P. Barbosa, Carla M. Penz and Keith R. Willmott for critically reading the manuscript. MGB received a doctoral fellowship of Agencia Nacional de Investigación e Innovación (Uruguay). LAK was financially supported by PNPD-CAPES (Brazil).

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Submitted for publication 8 August 2016; revised and accepted 3 October 2016.

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Journal of the Lepidopterists' Society
71(2), 2017, 125–129

BUTTERFLY SURVEYS ARE IMPACTED BY TIME OF DAY

Additional key words: Decorah, Iowa, unified butterfly recorder, time of day, diurnal variation

Butterfly surveys are commonly used to monitor the abundance and diversity of butterfly communities (Douwes 1975, Pollard 1977, Thomas 1983). Butterflies are ectothermic poikilotherms whose internal temperature is largely determined by environmental temperatures (Douwes 1975) and solar radiation (Clench 1966). Because of this, butterfly behavior can be shaped by environmental conditions at the sites sampled. These conditions may include habitat structure (Dover and Settele 2009), time of day (Pollard and Yates 1993, Pellet et al. 2012), time of year and phenology (Pollard 1977, Thomas 1983, Pollard and Yates 1993), and environmental temperatures (Wickman 1985, Masters et al. 1988, Saastamoinen and Hanski 2008). Additionally, butterfly behavior is affected by a combination of habitat structure and evolutionary history. Different butterfly species may be active at different times throughout the day depending on what resources are available, how those are arranged, and strategies they have evolved to use to find resources while minimizing predation (Schultz and Crone 2001, Dover and Settele 2009, Pellet et al. 2012). Differences in behavior can then lead to changes in the probability of detecting the presence of a given butterfly species (Pellet et al. 2012). It follows that surveys of butterfly communities may produce different results depending on the time of day sampling occurs based on temporal variation of the environmental factors that impact butterfly behavior.

Few studies have examined how time of day affects the results of butterfly community surveys (Pollard 1977, Wikström et al. 2009). Pollard (1977) recommends carrying out surveys between 1045 and 1545 h, and Pollard and Yates (1993) consider the impact of time of day to be negligible compared to variation in time of year. Wikström et al. (2009), however, emphasizes that these conclusions are based on limited data or data that cannot adequately account for time of day in the analysis. Time of year may be responsible for a large amount of variation in sampling results, yet rare species or species that are only active during a particular time of day may be missed if attention is not paid to the time of day sampling occurs (Wikström et al. 2009, Pellet et al. 2012). Furthermore, none of these analyses have been done in the United States (Wikström et al. 2009) and it is necessary to carry out these studies under local conditions, as the environmental effects of time of day will depend on the latitude of the study site. The goal of this study was to compare the results of butterfly surveys performed at different times throughout the day to quantify how time of day may affect the results of butterfly surveys in Iowa.

Butterfly communities were surveyed in six planted tallgrass prairies in Northeast Iowa on either July 21, 23,

Table 1. Size, location, and transect lengths of planted tallgrass prairies in Northeast Iowa surveyed for butterflies during the summer of 2015.

Prairie Name	Area (ha)	Lat (°N)	Long (°W)	Transect Length (m)
Decorah Community	15.6	43.302	91.803	2108
Gateway	15.6	43.318	91.812	1674
Anderson	10.9	43.315	91.799	1588
Jewell	7.9	43.319	91.823	1260
Aikman	1.5	43.324	91.81	1368
Van Peenan	3.7	43.318	91.776	2253

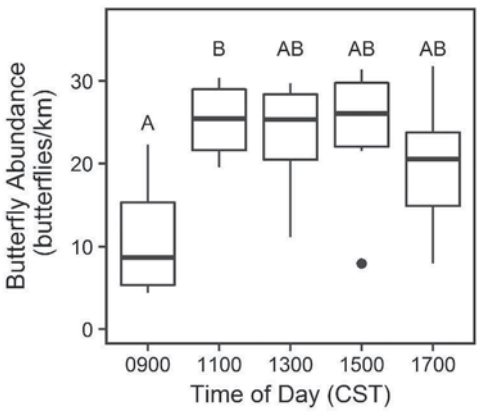

FIG. 1. Median and range of butterfly abundance (butterflies/km) observed during each survey time period (n=6). Survey times that do not share a letter are significantly different from each other (Tukey HSD; p < 0.05).

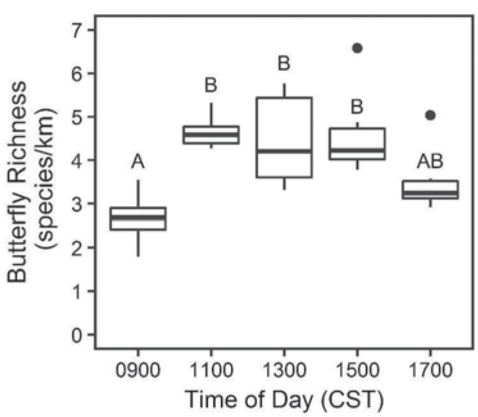

FIG. 2. Median and range of species richness (species/km) observed during each survey time period. Survey times that do not share a letter are significantly different from each other (Tukey HSD; p < 0.05).

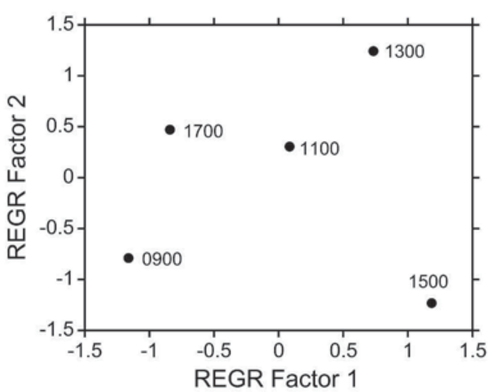

FIG. 3. Principal components analysis (PCA) comparing overall butterfly assemblages among the five time of the day surveys.

or August 4, 2015 (Table 1). Each prairie was surveyed five times on one of these dates with surveys occurring at 0900, 1100, 1300, 1500, or 1700 h CST. All surveys were conducted when the appropriate weather conditions for maximum butterfly activity were met: cloud cover less than 90%, wind less than 20 km/h, and temperature between 19–30 °C. Butterfly communities were surveyed by a single observer using a modified Pollard walk technique (Pollard 1977) following an established transect that meandered through different areas of the prairie. Butterflies within 10 m of the surveyor were identified to species by sight if they were common and easily identifiable, or they were netted and released for species that were not easily identified in-flight. All identifications were done referring to Schlict et al. (2007) and sightings recorded with the Unified Butterfly Recorder (UBR) app (www.reimangardens.com/collections/insects/unified-butterfly-recorder-app/) on an Android tablet which records survey track and eographic coordinates of each butterfly sighting. A summary list of all butterflies surveyed can be found in Table 2.

Because survey transect length differed among prairies, butterfly sightings were standardized by transect length to butterfly abundance (butterflies/km) and species richness (species/km). A one-way ANOVA was used to detect differences among the time of day, and Tukey's post-hoc comparisons were used to compare butterfly abundance and species richness between the different survey times. There were significant differences among survey times for both butterfly abundance ($F = 6.704$, df = 4,25, $p = 0.001$; Fig. 1) and species richness ($F = 3.691$, df = 4,25, $p = 0.017$; Fig. 2).

Principal components analysis (PCA) comparing butterfly assemblages among the five times of the day surveys were conducted revealed butterfly assemblages at 1100, 1300, and 1500 h were fairly similar, while 0900 and 1700 h had the most unique butterfly assemblages (Figure 3). Component 1 explained 39.2% of the variation and was most highly correlated with *Celastrina neglecta* (0.972), *Colias philodice* (0.960) and *Ancyloxypha numitor* (0.952). Component 2 explained an additional 29.7% of the variation and was most highly correlated with *Boloria bellona* (0.975) and *Wallengrenia egeremet* (0.975).

Spearman rank order correlations were used to examine relationships between temperature and butterfly abundance and species richness. Temperature was significantly correlated with butterfly abundance ($r = 0.499$, $n = 30$, $p = 0.005$; Fig. 4) and nearly significantly correlated with species richness ($r = 0.347$, $n = 30$, $p = 0.06$; Fig. 5). As temperature increased, both butterfly abundance and species richness increased. A linear

TABLE 2. List and counts of all butterflies observed at six sites combined in late July and early August 2015 during surveys at five different times of the day.

Scientific Name	Common Name	0900	1100	1300	1500	1700	Total
Epargyreus clarus	Silver-Spotted Skipper	0	1	0	0	0	1
Erynnis baptisiae	Wild Indigo Duskywing	0	6	5	4	5	20
Pholisora catullus	Common Sootywing	0	0	1	0	0	1
Ancyloxypha numitor	Least Skipper	0	1	1	2	0	4
Polites peckius	Peck's Skipper	0	0	0	1	0	1
Wallengrenia egeremet	Northern Broken-dash	0	1	2	0	1	4
Papilio glaucus	Eastern Tiger Swallowtail	1	10	2	3	10	26
Papilio cresphontes	Giant Swallowtail	0	0	0	2	0	2
Pieris rapae	Cabbage White	20	38	40	38	22	158
Colias philodice	Clouded Sulphur	3	7	14	16	6	46
Colias eurytheme	Orange Sulphur	0	2	5	3	1	11
Everes comyntas	Eastern Tailed-Blue	0	3	2	4	1	10
Celastrina neglecta	Summer Azure	11	14	14	17	11	67
Danaus plexippus	Monarch	54	92	83	102	113	444
Speyeria cybele	Great Spangled Fritillary	5	19	23	8	12	67
Boloria bellona	Meadow Fritillary	0	1	2	0	1	4
Phyciodes tharos	Pearl Crescent	1	4	10	8	0	23
Polygonia interrogationis	Question Mark	0	0	1	0	0	1
Polygonia comma	Eastern Comma	1	2	3	2	0	8
Vanessa atalanta	Red Admiral	12	27	17	19	19	94
Limenitis arthemis astyanax	Red-Spotted Purple	0	0	0	0	1	1
Limenitis archippus	Viceroy	2	2	1	2	1	8
Asterocampa celtis	Hackberry Emperor	0	0	0	1	0	1
Asterocampa clyton	Tawny Emperor	0	0	0	1	0	1
Satyrodes eurydice	Eyed Brown	1	0	0	0	0	1
Cercyonis pegala	Common Wood Nymph	8	7	8	11	5	39
Number of Butterflies		119	237	234	244	209	1043
Species Richness		12	18	19	19	15	26

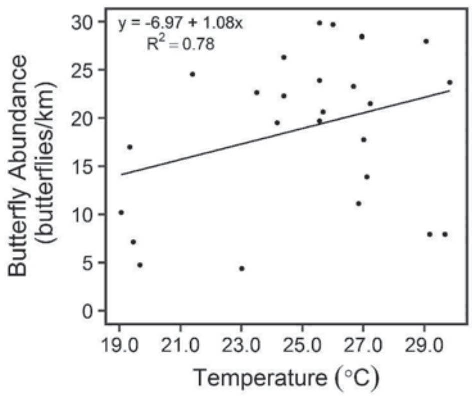

FIG. 4. Scatterplot of temperature (°C) and butterfly abundance (butterflies/km) observed during surveys.

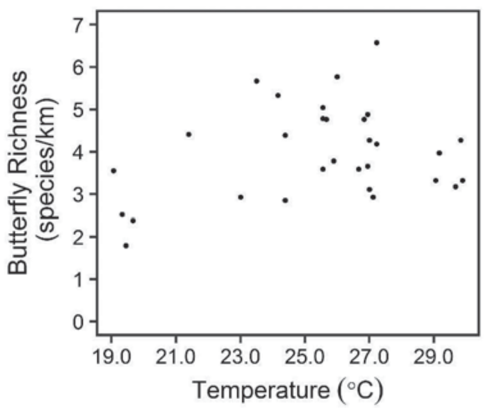

FIG. 5. Scatterplot of temperature (°C) and species richness (species/km) observed during surveys.

regression also showed that temperature could be used as a predictor for butterfly abundance (y = -6.97 + 1.08x, β = 0.395, p = 0.031, R2 = 0.156; Fig. 4).

Our data suggest that surveying butterfly communities at 0900 h morning or 1700 h in the afternoon may not provide an accurate description of the butterfly assemblages at a site. In particular, significantly fewer butterflies and lower species richness at 0900 h indicate that butterfly activity is reduced, likely due to cooler temperatures in the morning. Reduction in activity reduces the probability of detection; species that perch throughout the day may hide during the hottest parts of the day, whereas species that are highly territorial may be active throughout the entire day regardless of temperature (Pellet et al. 2012). In our study, *Papilio glaucus* peaked at 1100 h and then again at 1700 h, suggesting it may prefer to rest during the hottest parts of the day. Pieris rapae was most active between 1100 h – 1500 h and was seen less at 0900 h and 1700 h. It may prefer to fly during the warmest part of the day, or when the sun is highest in the sky. Other species with noticeable peaks at different times of day included *Vanessa atalanta* at 1100 h, *Phyciodes tharos* at 1300 h, and *Colias philodice* and *Cercyonis pegala* at 1500 h. The exact reason these peaks occurred during these times may be an artifact of the small sample size and time, or unique behavioral characteristics of these species.

As mentioned above, the probability of butterfly detection is going to change with multiple environmental variables and species phenology, so further research is necessary to tease apart the relative contributions of these factors (Wickman 1985, Heinrich 1986, Masters et al. 1988, Van Dyck and Matthysen 1998, Saastamoinen and Hanski 2008, Dover and Settele 2009, Cormont et al. 2010, Pellet et al. 2012). Our sites did differ somewhat in their topography, aspect, and surrounding vegetation, however exploring the effect this may have had on our results is beyond the scope of these surveys. Regardless, it is clear the specific behavior of individual butterfly species at different times of day must be considered when carrying out butterfly community surveys. Time of day should be an important consideration when performing butterfly surveys as it appears time of day affects butterfly abundance and species richness due to the fact that different butterfly species exhibit diverse behaviors at different times of day depending on their evolutionary history.

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Submitted for publication 6 July 2016; revised and accepted 20 February 2017.

Journal of the Lepidopterists' Society
71(2), 2017, 129–131

NATURAL NON-*VIOLA* HOSTPLANT OF A SIERRAN *SPEYERIA* (NYMPHALIDAE, HELICONIINAE) AND AN ASSOCIATED PARASITOID (DIPTERA, TACHINIDAE)

Additional key words: *Argynnis, Bistorta bistortoides, Madremyia saundersii, mormonia*, Polygonaceae

Larvae of the North American genus *Speyeria* Scudder (some would argue *Argynnis* Fabricius, see Dunford 2009, de Moya 2016) are said to be very secretive, nocturnal feeders that subsist solely on *Viola* Linnaeus (Violaceae) (Scott 1986, Brock & Kaufman 2003, James & Nunnallee 2011, ad infinitum). Although a number of authors have, for example, either surmised (Bird et al. 1995[1]), suggested (Durden 1965[2]), proposed (James 2012[3]), or observed (Christopher Durden pers. comm. 27 July 2005[4]) that other plant families could be/are used, no conclusive proof has ever been presented. Herewith I belatedly report finding five probable *Speyeria mormonia mormonia* Boisduval caterpillars feeding exclusively on *Bistorta bistortoides* Pursh (Polygonaceae) in a California arctic-alpine meadow, with all larvae reared to pupation and four parasitoid flies obtained. Thus, to the list of "*Argynnis* s.l." that eat both Violaceae and Polygonaceae—currently only *Argynnis aglaja* Linnaeus (Fric et al. 2005, plus new Fukuda et al. 1983, Chou 1994, but see Nishida 1993*)—previously overlooked *Argynnis adippe* Denis & Schiffermüller (Fukuda et al. 1983), *Argynnis xipe* Grum-Grshimailo (Lee 2005 fide Kim 1965), and now *S. mormonia* (this study) can be added. It will be interesting to note how these and future revelations of taxonomically unrelated foodplants affect our total-evidence understanding of the Argynnini and the phylogenetic placement of its genera.

On 4 July 1990, while on knees and elbows looking for *Colias behrii* W.H. Edwards (Pieridae) caterpillars to photograph at 3150 meters (10,335 feet) next to Middle Gaylor Lake, Tuolumne County, California, I encountered a last-instar *Speyeria* actively feeding on *B. bistortoides* (identified, verified, and accessioned at Jepson Herbarium, Berkeley, California, JEPS 84842 dated 28 July 1990). It crawled into the ground debris moments later, but was watched and then extricated; a careful check revealed no additional larvae. The time was about 12 noon PDT with a clear sky and pleasant temperature— a thorough examination of the vicinity disclosed zero violets. Seeing no other *B. bistortoides* nearby I left the area, only to return shortly to the same clump where yet another caterpillar in its penultimate stadium was discovered hiding among the tangled undergrowth.

Ten days later on 14 July 1990 I went back to the aforesaid alpine lakeshore for the sole purpose of finding more *Speyeria* preadults. Several hours of searching showed *B. bistortoides* to be abundant there, at least in places. However, leaves with only minor eaten damage were seen during this subsequent visit, inspection of which revealed no larvae. Just as a storm passed overhead in the early afternoon that would drop rain, hail, and the temperature, a patch with extensive fresh leaf incisions was finally found, which yielded a mature caterpillar resting on the bare ground next to the plant. Two weeks later on 28 July 1990 I again returned, this time circling the entire lake and checking every *B. bistortoides* for signs of recent feeding damage. In the seven hours so spent merely three such clumps were located, though many others exhibited older, scarred notches. From these promising plants, and with the aid of an iced tea spoon, two last-instar *Speyeria* were uncovered as they lay concealed at the base of two separate patches. Notably, the only other plant-eating insect encountered on all of the above *B. bistortoides*

FIG. 1. Probable *Speyeria m. mormonia* (final instar from 3150 meters, Middle Gaylor Lake, Tuolumne Co., CA; 6 July 1990, ~16 mm in length, five days before pupation) on *Bistorta bistortoides*, a confirmed new hostplant record.

FIG. 2. *Speyeria m. mormonia* (final instar ex confined females from 2945 meters, Sonora Pass, Alpine Co., CA; 16 February 2003, 28 mm in length, several days before pupation) reared on *Viola sororia* Carl Ludwig Willdenow.

was a single sawfly (Hymenoptera) larva, plus still NO violets visible anywhere around Middle Gaylor Lake.

Thus, a total of five *Speyeria* caterpillars were found on four different *B. bistortoides* that were separated by considerable distances, the two closest clumps being roughly 24 meters (79 feet) apart and all on the same/east side of the lake. A couple of these plants were carefully uprooted and brought to my lab in Antioch where larval development continued (Fig. 1). In lieu of comprehensive testing, one of the caterpillars was simply confined for several hours on a small potted *Viola ocellata* Torrey & A. Gray, a shade-loving violet of the California Coast Ranges, upon which it extensively and repeatedly fed. All five *Speyeria* pupated successfully, one doing so in the soil, but none survived to adulthood due to misfortune (one) or tachinids (four), the latter a remarkable outcome given the highly furtive habits of these larvae. Of the four pupae confirmed to be parasitized, the ensuing dipteran(s) of one could not be located, while the remaining three chrysalises yielded a total of six maggots—three emerging from one pupa†—and ultimately four adult flies, two males and two females, which were identified by Dr. Paul Arnaud (California Academy of Sciences, San Francisco, California, and donated thereto) as *Madremyia saundersii* Williston, a native tachinid with a wide range of primarily lepidopterous prey, including *Speyeria cybele* Fabricius (Arnaud 1978). One of the maggots emerged about five days after its host pupated, spending nine days as a pupa itself before producing a male, while the two female flies took approximately 12 days to eclose under equivalent ambient indoor, versus natural arctic-alpine, conditions.

Although none of the above immature *Speyeria* resulted in an adult butterfly, the circumstantial determination of *S. mormonia* is nevertheless compelling for this otherwise well-studied taxon. A print from a larval slide was shown to caterpillar expert Thomas Allen ("with that dorsal stripe it looks very much like a *Speyeria*", pers. comm. 13 March 1999) and *Speyeria* authority Dr. David James ("it certainly looks like *mormonia*", pers. comm. 10 July 2015), and though Sierran butterfly expert Kenneth Davenport replied to my inquiry that "both *egleis* and *mormonia* should be there [lakeshore in question]" (pers. comm. 24 September 2014), photos of final-instar *Speyeria egleis* Behr in publications by James (2008) and James & Nunnallee (2011) illustrate a more uniformly patterned, darker, and larger larva. Additionally, albeit mindful of possible geographic, altitudinal, and/or individual variations, excellent matches for the subject California caterpillars—note distinctive combination of prominent middorsal pale stripe and whitish, relatively short scoli—can be seen in Miller & Hammond (2007, *S. m. erinna* W.H. Edwards, Oregon), James & Nunnallee (2011, *S. m. washingtonia* Barnes & McDunnough, Washington), Berwyn (2012, *S. m. eurynome* W.H. Edwards, Colorado), plus my own Kodachrome image of a last-stadium *S. m. mormonia* from neighboring Alpine County, California (Fig. 2). Furthermore, Guppy & Shepard (2001) state that "the larval habitat of the Mormon Fritillary occurs at higher elevations than that of other *Speyeria* species", with Brock & Kaufman (2003) agreeing that *S. mormonia* is "often the only member of the greater fritillary group found at or above treeline", while Dunford (2009) concludes that "*Speyeria mormonia* is the most likely member of *Speyeria* to occur in high mountain habitats."

Having reviewed much of the relevant literature while preparing this paper, it is perhaps not completely surprising that *S. mormonia*, a widespread and abundant Western boreal butterfly that appears remarkably well adapted to many different mid-to-high-elevation habitats, would eventually be documented to naturally utilize a hostplant other than *Viola*. Whether this represents a recent colonization (derived character) by just *S. mormonia* in North America or a wholly overlooked usage (ancestral character) shared with ecologically similar Nearctic congeners needs to be investigated by future workers.

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Submitted for publication 16 January 2017; revised and accepted 27 January 2017.

FOOTNOTES

[1] *Speyeria mormonia*, Alberta: alpine larva but no violets.
[2] *Speyeria* sp., Wyoming; *Artemisia* (Asteraceae): dry-country larvae but no violets.
[3] *Speyeria mormonia*, Oregon; *Bistorta bistortoides* (Polygonaceae): captive oviposition, absence of violets.
[4] *Speyeria zerene*; *Spiraea* (Rosaceae): larva developed to normal adult male.

* Translation: *Polygonum suffultum* of the Polygonaceae has been mentioned as a foodplant for a long time; however, there are very few cases in which it has been observed to be actually eaten in the wild.

† Of the resulting three fly puparia, only one runt male eclosed whose wings did not expand.

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71(2), 2017, 132

CORRECT SPELLING OF *ALBUNA BEUTENMUELLERI* SKINNER, 1903 (SESIIDAE)

Additional key words: Incorrect original spelling, German umlaut, authorship.

Recently, Taft, Cognato & Opler (2016) resurrected the clearwing moth taxon *Albuna beutenmuelleri* Skinner 1903 from synonymy with *Albuna pyramidalis* (Walker 1856). In their publication they used the species name *beutenmulleri* (following Duckworth & Eichlin 1973), which is an incorrect subsequent spelling. The species name is spelled *beutenmülleri* in the original description, apparently named after the famous American entomologist William Beutenmüller (1864–1934, originating from Germany). Ä, ö, and ü are German umlauts, and according to Article 32.5.2.1 of the International Code of Zoological Nomenclature (ICZN, 1999: 40), "in a name published before 1985 and based upon a German word, the umlaut sign is deleted from a vowel and the letter "e" is to be inserted after that vowel. If there is any doubt that the name is based upon a German word, it is to be so treated." In 'Examples', the code points out: ... *mülleri* (published before 1985) is corrected to *muelleri*.

So the incorrect original spelling *Albuna beutenmülleri* must be corrected to *Albuna beutenmuelleri*, as correctly cited already in Heppner & Duckworth (1981) and Pühringer & Kallies (2004, 2016).

ACKNOWLEDGEMENTS

I thank Axel Kallies (Melbourne, Australia) for pointing to the publication, and Bill Taft (East Lansing, Michigan, USA) for supplying a pdf of his paper.

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Submitted for publication 2 January 2017; revised and accepted 20 February 2017.

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