Volume 60, Number 2 Summer 2018

NEWS OF THE LEPIDOPTERISTS' SOCIETY

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The Lepidopterists' Society is a non-profit educational and scientific organization. The object of the Society, which was formed in May 1947 and formally constituted in December 1950, is "to promote internationally the science of lepidopterology in all its branches; to further the scientifically sound and progressive study of Lepidoptera, to issue periodicals and other publications on Lepidoptera; to facilitate the exchange of specimens and ideas by both the professional worker and the amateur in the field; to compile and distribute information to other organizations and individuals for purposes of education and conservation and appreciation of Lepidoptera; and to secure cooperation in all measures" directed towards these aims. (Article II, Constitution of The Lepidopterists' Society.)

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Front Cover:

Tatargina picta, (Erebidae: Arctiinae), Umphang, northwest Thailand, 900m, 12 March 2017, during a trip of **ThaiButterflies.com**. (photo credits: Antonio Giudici; see AntonioGiudici.com for more from his Butterfly Trips)

Digital Collecting:

The moths of South Africa, part 1

David Fischer

12 Byarong Ave, Mangerton, NSW 2500, AUSTRALIA **dfische5@csc.com**

South Africa is a wonderful destination for a moth enthusiast. It has a wealth of wildlife/habitats, excellent infrastructure and is an easy place to visit as an independent traveler. South African national parks are among the world's best. Camps offer a range of accommodation options, restaurants, stores and everything required for a comfortable stay. BnB's are a popular option elsewhere in the country and again, these are among the world's best and most economical. An organized tour or safari is not necessary at all in South Africa.

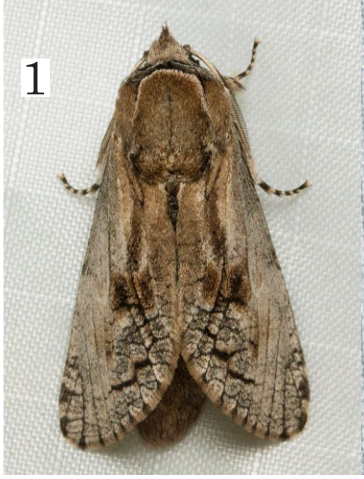
I've had the pleasure of visiting South Africa on three occasions in recent years. Two of the trips included Kruger National Park, a huge park in the northeast of the country. I hired a car at the airport in Johannesburg and then drove for 6 hours to the park. Kruger has many camps and I visited a number of these over week-long stays. I prefer to start at Punda Maria Camp in the far north. The camp is surrounded by sandveld forest including many giant baobab trees. Mothing was good at this camp. When heading south, the habitat slowly changes from dense shrubland to savannahs. I found Mopane and Oliphants Camps to be good for mothing. Lower Sabie in the far south of the park is a must visit camp. There is nothing like eating breakfast while watching wildlife such as elephants, hippopotamus, waterbucks, bushbucks and many others just beyond the camp fence. Mothing was especially good from the deck of my bungalow in Lower Sabie Camp.

The Drakensberg Mountains south of Johannesburg are another spectacular part of the country. These mountains consist of spikes and plateaus that are over 3000m in elevation. They look so distinctive with their cover of grassland rather than forest. I stayed at iKhayalamafu Reserve near Monk's Cowl in the central Drakensberg Mountains. I highly recommend this site both for its natural beauty and as a superb site for mothing.

The Cape area of southern South Africa would have to be one of the most scenic locations on the planet. Plant diversity is extreme and includes many proteas and other flowers in the spring (Sep-Nov). Mothing should be good but my success was limited by poor weather (rain, wind). If I ever have the opportunity again, I would stay in a cabin in Kogelberg National Park. The cabins are surrounded by fynbos and no doubt would be an ideal place for mothing.

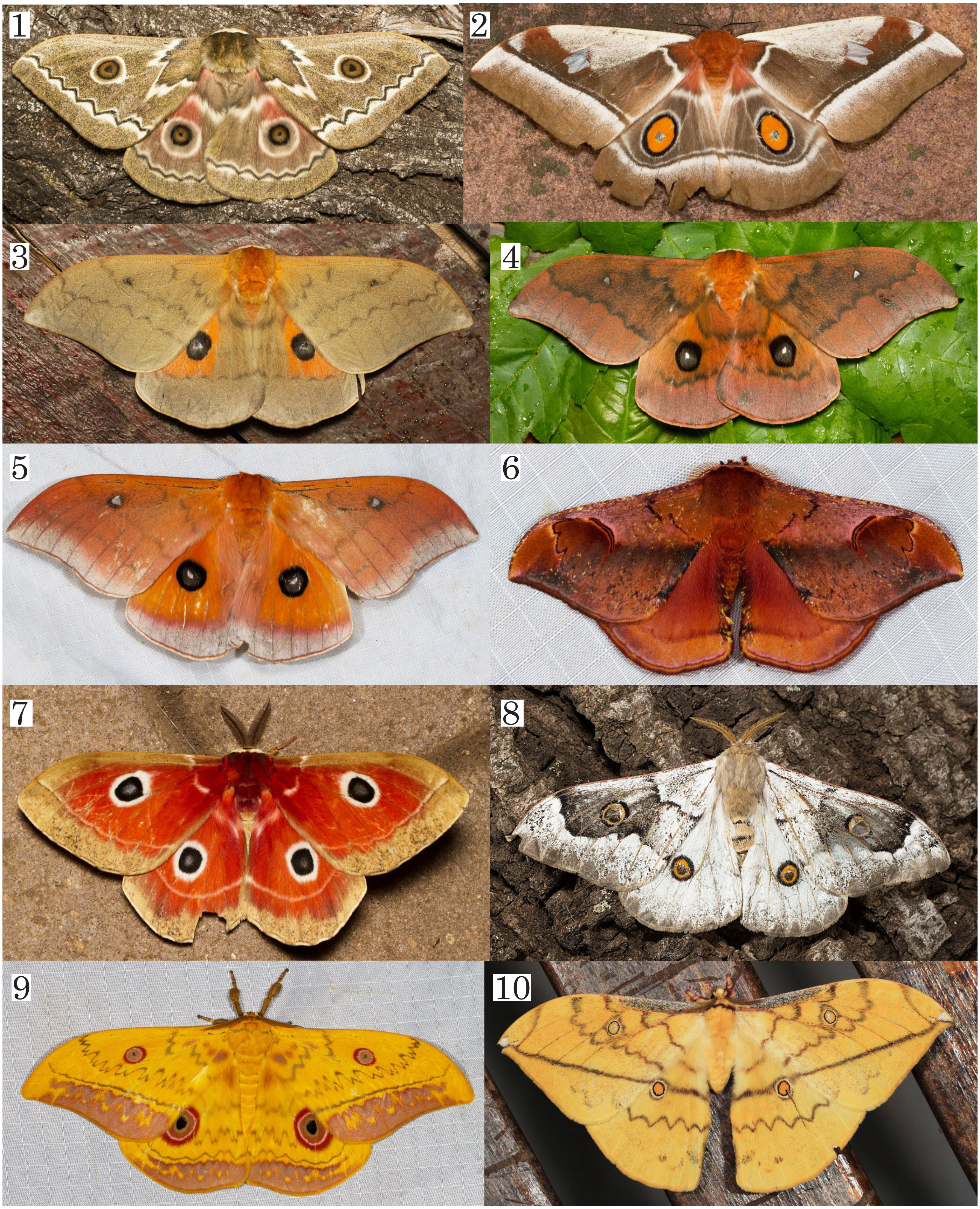
On two visits, I drove north for five hours from the Cape to the Great Karoo National Park. This park is situated in dry, rocky country. Wildlife of the park was mostly different to the other sites that I visited. I stayed at Ko-Ka Tsara Bush Camp on the border of the national park and operated lights all night. Moth diversity was good and included many dry country species that I did not find elsewhere.

The above sites are just a sample of the many superb locations in South Africa. I can't recommend it enough as a top site for a holiday!



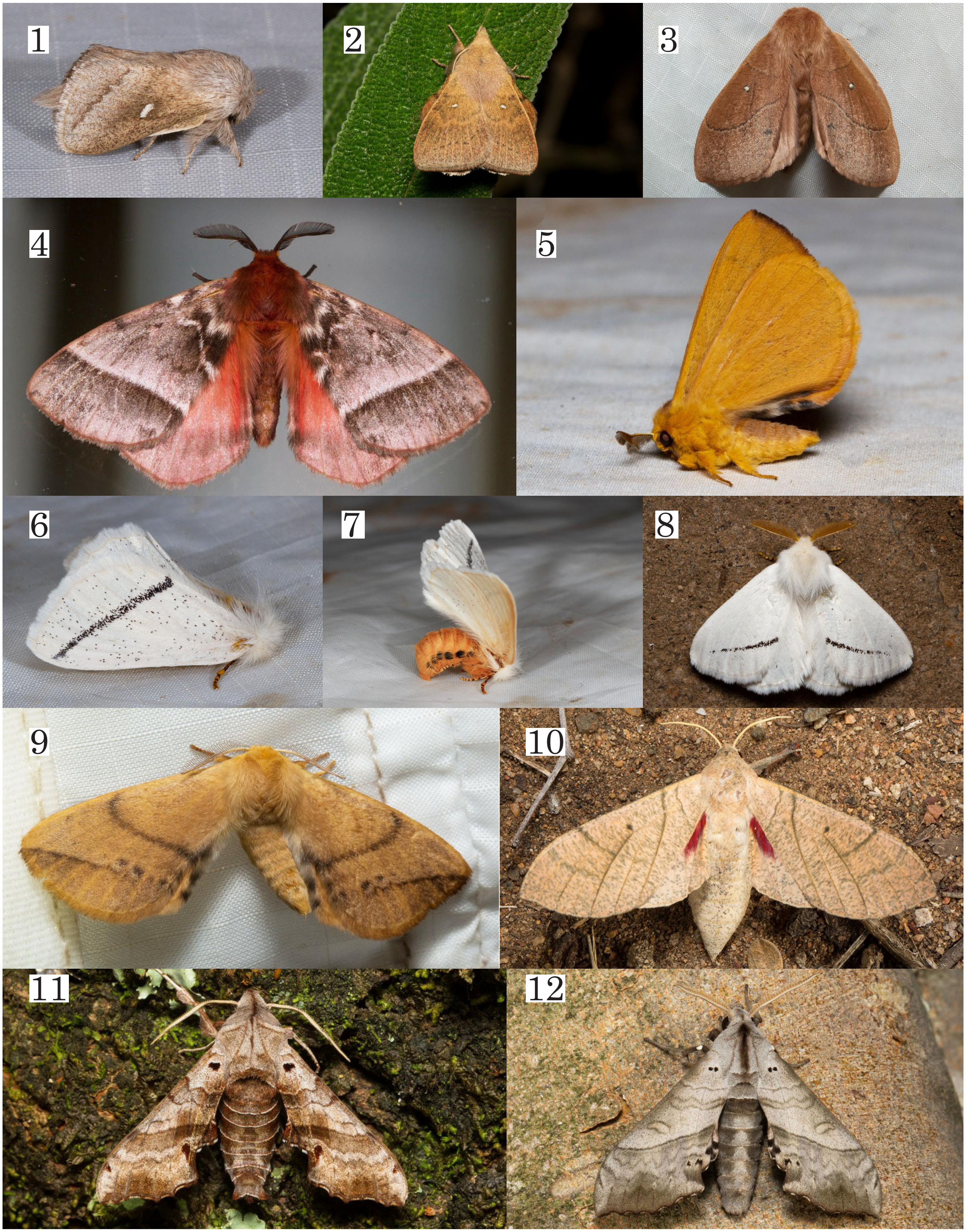
COSSIDAE: 1) *Macrocossus* sp.; 2) *Coryphodema tristis*?; 3) *Phragmataecia irrorata*; 4) *Phragmataecia* sp.; 5) *Macrocossus* sp. Larger threads on the sheets are 5 mm apart.

HABITATS: 1) Drakensberg Mountains, Monk's Cowl area; 2) Drakensberg Mountains, Monk's Cowl area; 3) Kruger National Park, Punda Maria area (north); 4) Kruger National Park, Lower Sabie area (south); 5) Cape region, Cape of Good Hope National Park; 6) Cape region, Kogelberg National Park; 7) Great Karoo National Park; 8) Great Karoo National Park

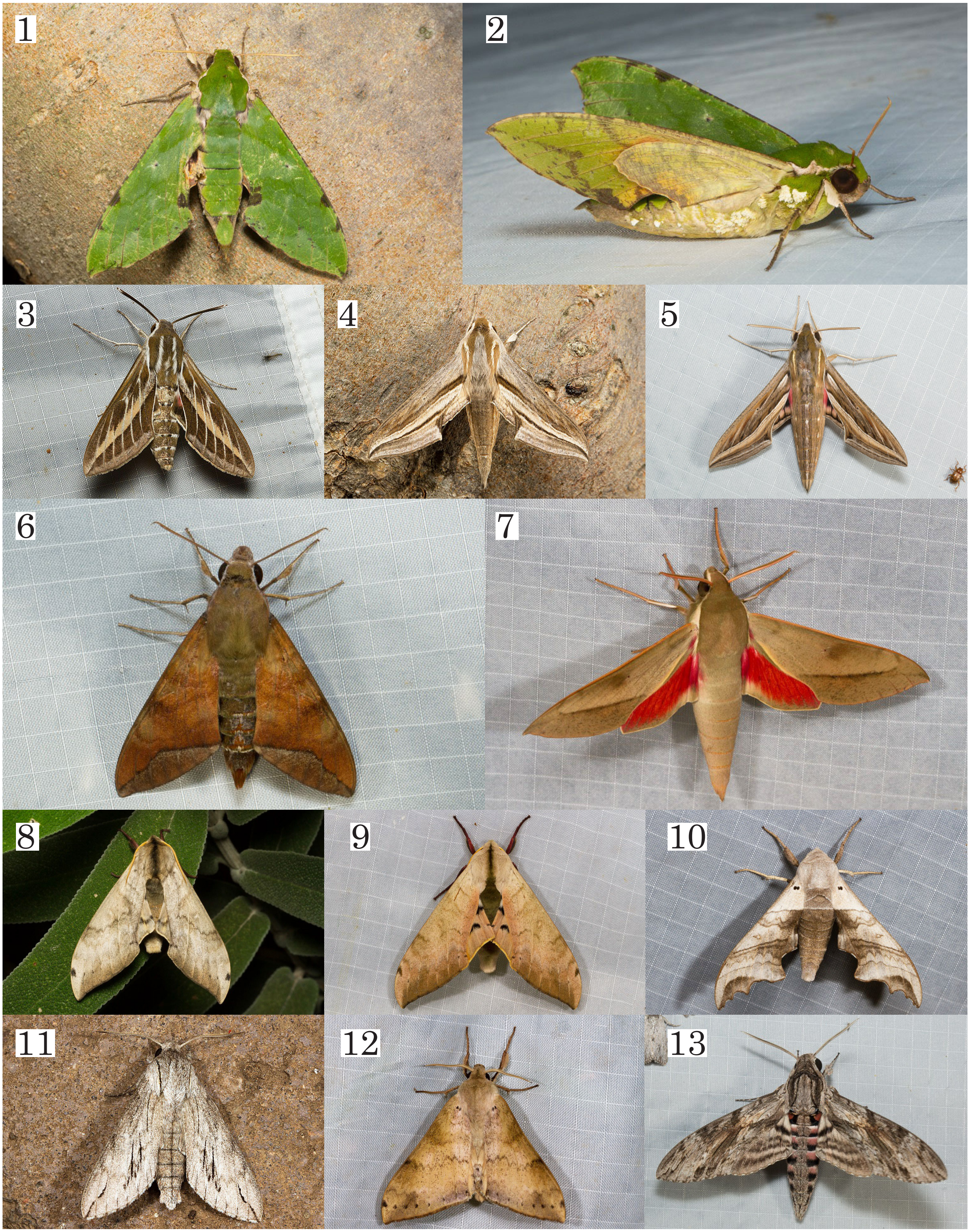


SATURNIIDAE: 1) *Gonimbrasia tyrrhea;* 2) *Bunaea alcinoe*; 3) *Pseudobunaea epithyrena*; 4) *Pseudobunaea epithyrena*; 5) *Pseudobunaea irius*; 6) *Campimoptilum kuntzei*; 7) *Melanocera menippe*; 8) *Usta terpsichore*; 9) *Aurivillius fusca*; 10) *Pselaphelia flavivitta*.

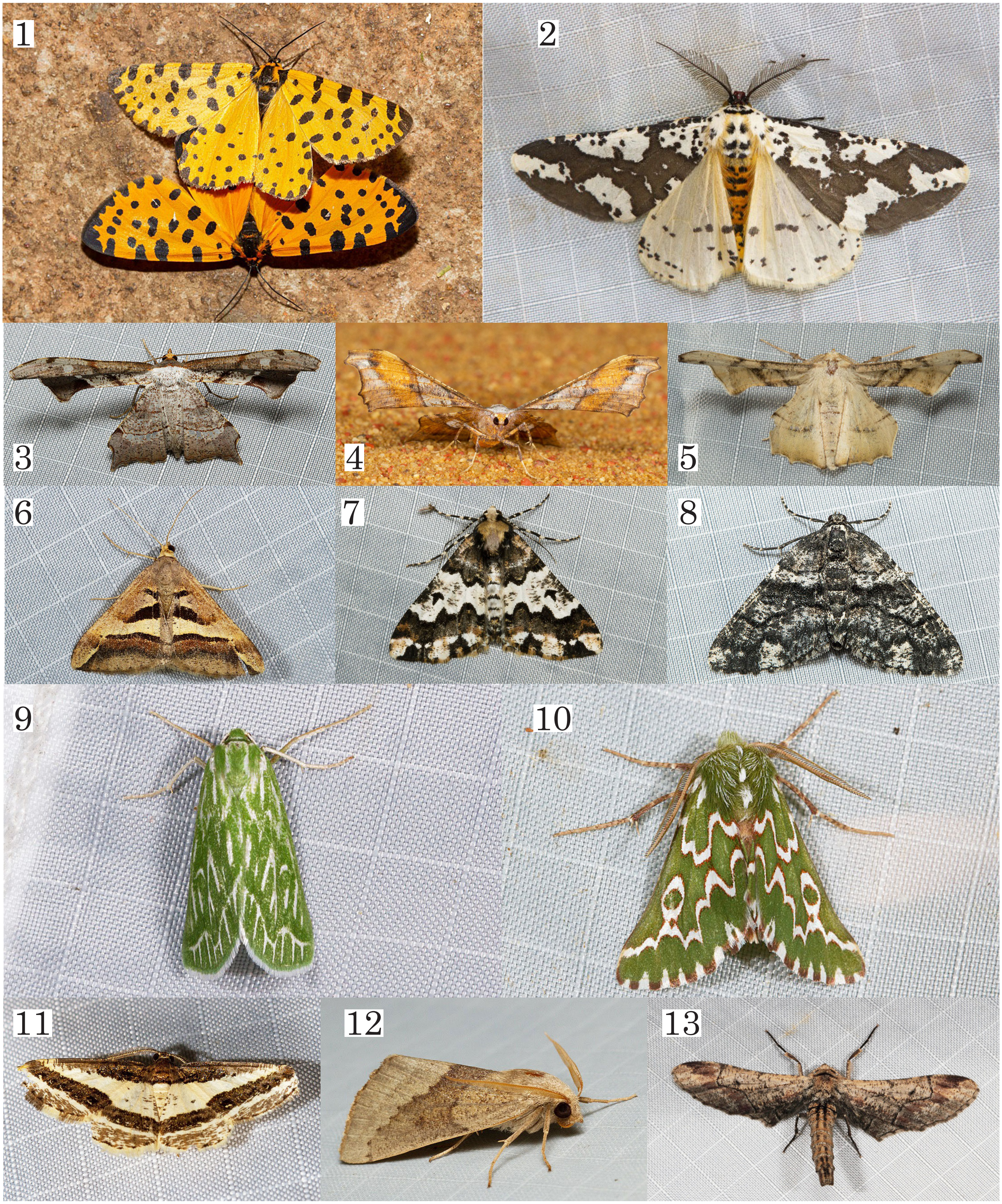
LASIOCAMPIDAE: 1) *Beralade* sp.; 2) *Beralade* sp.; 3) unknown; 4) *Stoermeriana* sp.; 5) *Epicnapteroides* sp.; 6) *Henometa clarki*; 7) *Trichopisthia igneotincta*; 8) unknown; 9) *Philotherma* sp.; 10) *Philotherma* sp; 11) *Streblote jansei*; 12) *Grammodora nigrolineata*. Larger threads on the sheets are 5 mm apart.



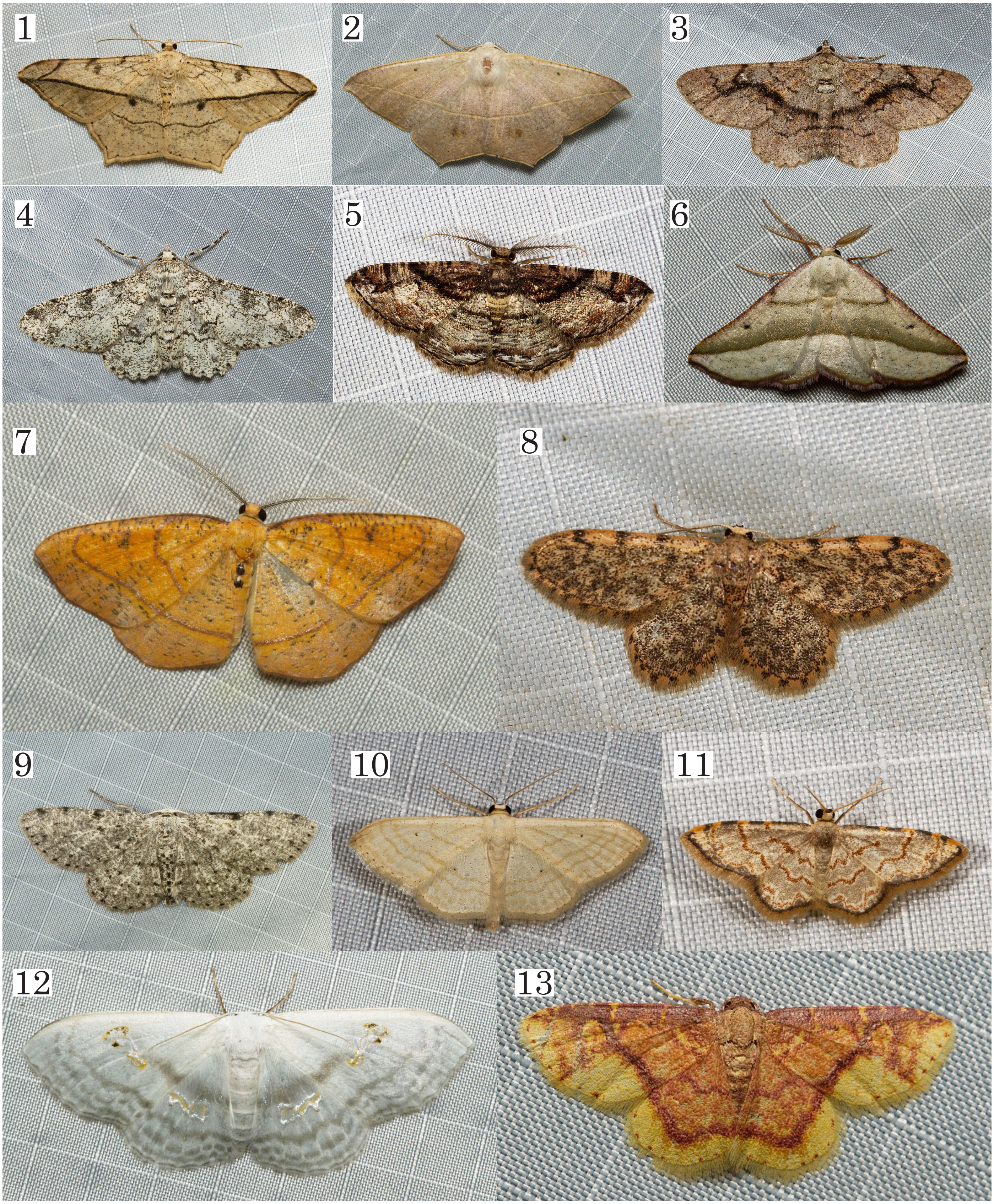
LASIOCAMPIDAE: 1) *Sena prompta*; 2) unknown; 3) unknown. **EUPTEROTIDAE:** 4) *Hemijana* sp.; 5) unknown; 6 & 7) unknown; 8) unknown; 9) *Stenoglene obtusa*. **SPHINGIDAE**: 10) *Neoclanis basialis*; 11) *Rufoclanis numosa*; 12) *Odontosida pusillus*. Larger threads on the sheets are 5 mm apart.



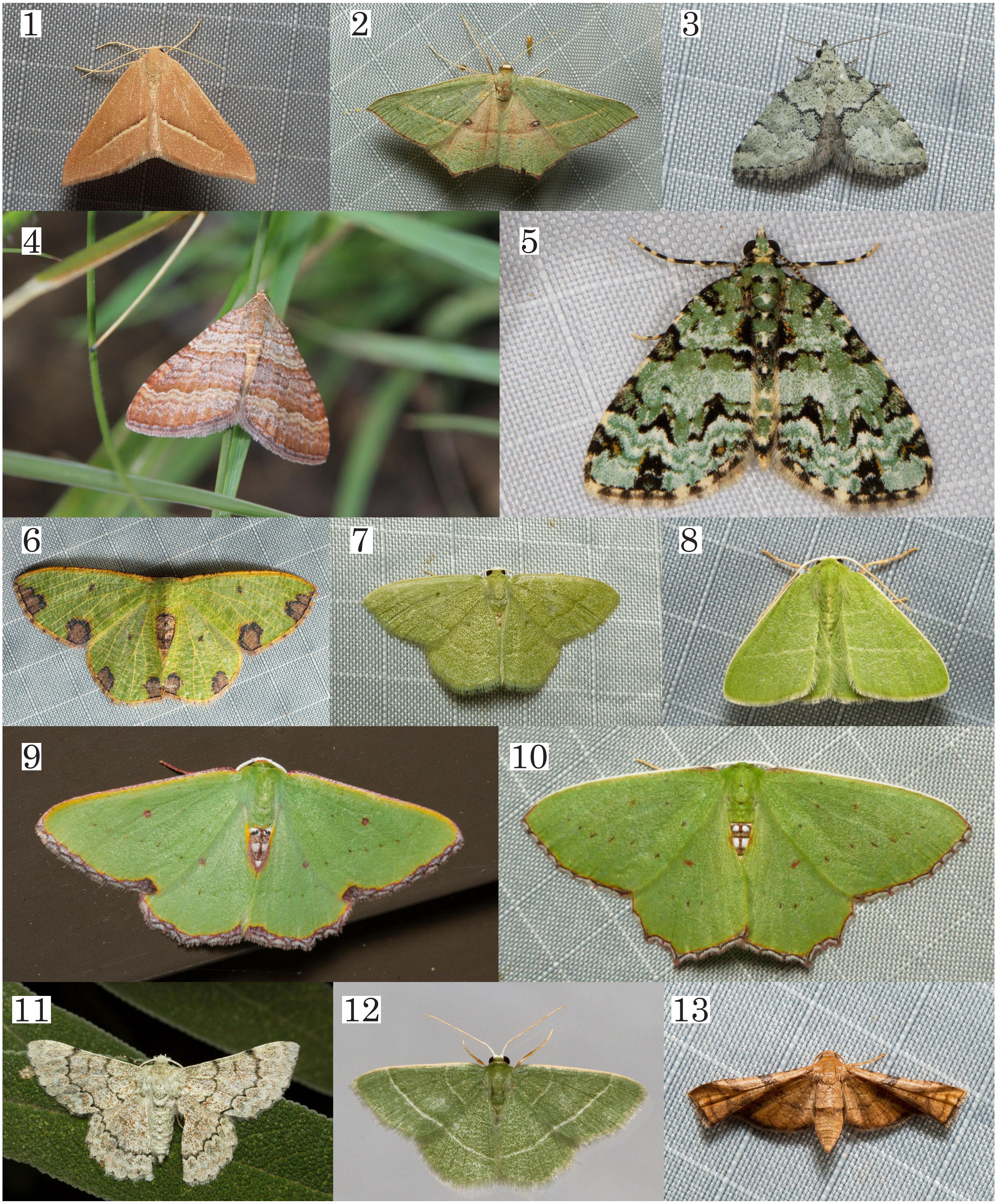
SPHINGIDAE: 1 & 2) *Euchloron megaera*; 3) *Hyles livornica*; 4) *Theretra monteironis*; 5) *Hippotion celerio*; 6) *Nephele comma*; 7) *Theretra capensis*; 8 & 9) *Pseudoclanis postica*; 10) *Polyptychoides grayii*; 11) *Oligographa juniperi*; 12) *Andriasa contraria*; 13) *Agrius convolvuli*.. Larger threads on the sheets are 5 mm apart.



GEOMETRIDAE: 1) *Zerenopsis lepida*; 2) *Rhodophthitus commaculata*; 3) *Psilocladia* sp.; 4) *Xenimpia erosa*; 5) *Coenina dentataria*; 6) *Ligdia pectinicornis*; 7) *Oedicentra albipennis*; 8) *Phthonandria pinguis*; 9) *Dichroma equestralis*; 10) *Drepanogynis bifasciata;* 11) *Ligdia pectinicornis*; 12) *Acrasia accepta*; 13) *Eulycia grisea*. Larger threads on the sheets are 5 mm apart.

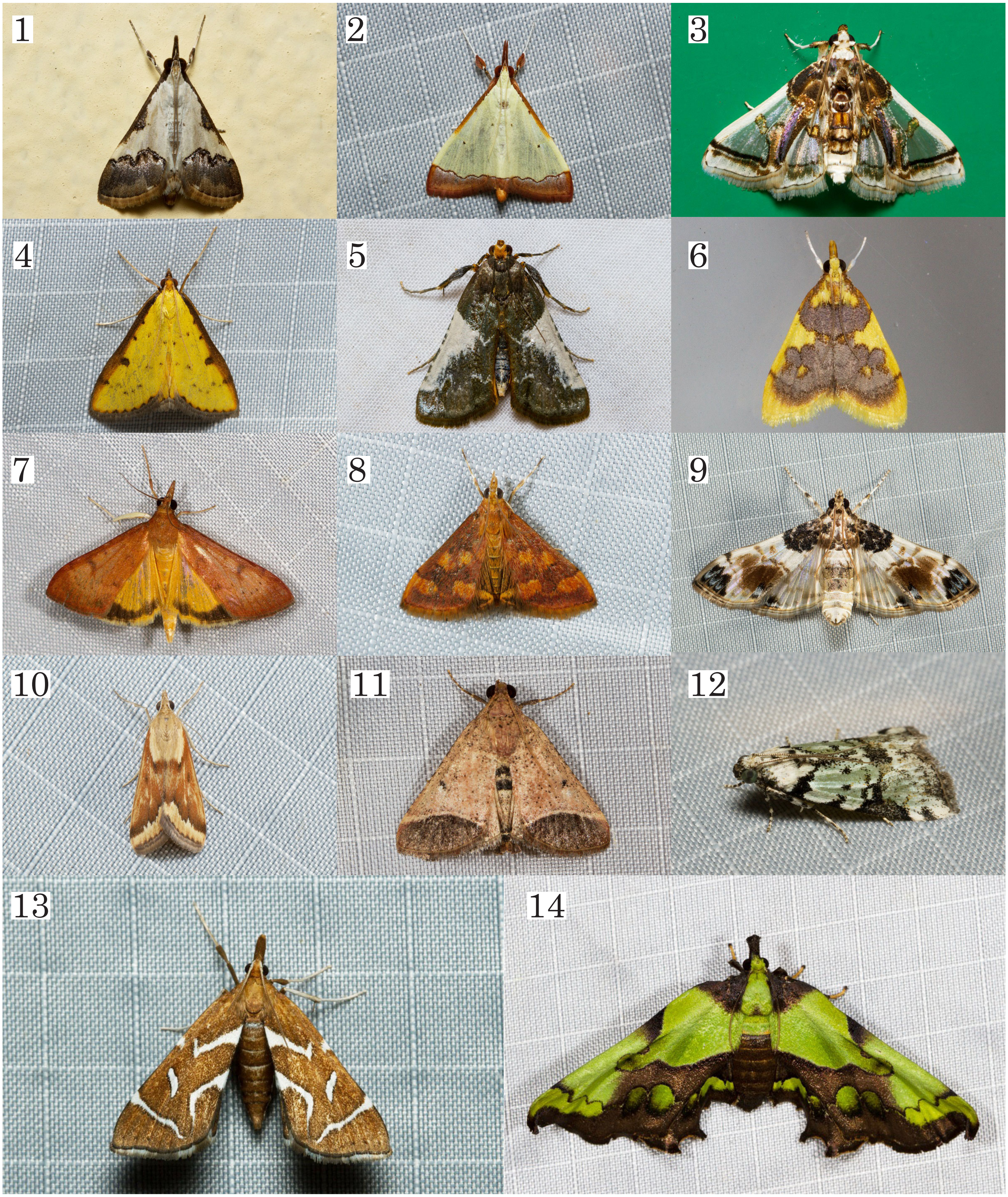


GEOMETRIDAE: 1) *Chiasmia simplicilinea*; 2) *Psilocerea pulverosa*; 3) *Colocleora* sp.; 4) *Cleora* sp.; 5) unknown; 6) unknown; 7) *Oaracta maculata*; 8) *Scopula* sp.; 9) *Scopula* sp.; 10) *Scopula* sp.; 11) *Idaea sublimbaria*; 12) *Problepsis digammata*; 13) *Chrysocraspeda nigribasalis*. Larger threads on the sheets are 5 mm apart.



GEOMETRIDAE: 1) *Chlorerythra* sp.; 2) *Traminda ocellata*; 3) *Piercia bryophilaria*; 4) *Mimoclystia pudicata*; 5) *Piercia bryophilaria*; 6) *Celidomphax rubrimaculata*; 7) *Comibaena* sp.; 8) *Celidomphax quadrimacula*; 9) *Centrochria* sp.; 10) unknown; 11) *Pingasa* sp.; 12) *Microloxia ruficornis*. **THYRIDIDAE**: 13) unknown. Larger threads on the sheets are 5 mm apart.

CRAMBIDAE: 1) *Glyphodes* sp.; 2) *Terastia margaritas*; 3) *Pardomima distortana*; 4) *Sameodes cancellalis*; 5) *Syllepte* sp.; 6) *Crocidolomia* sp.; 7) *Agathodes musivalis*; 8) *Pagyda salvalis*; 9) *Stenochora lancinalis*; 10) *Ghesquierellana hirtusalis*; 11) *Notarcha obrinusalis*; 12) *Notarcha quaternalis*; 13) unknown. Larger threads on the sheets are 5 mm apart.



CRAMBIDAE/PYRALIDAE: 1) *Autocharis* sp. (Crambidae); 2) *Autocharis marginata* (Crambidae); 3) *Syllepte vagans* (Crambidae); 4) Crambidae; 5) unknown (Pyralidae); 6) *Sameodesma xanthocraspia* (Crambidae); 7) *Uresiphita* sp. (Crambidae); 8) *Pyralis* sp., possibly *P. phoenicealis* (Pyralidae); 9) *Alytana* sp. (Crambidae); 10) *Achyra coelatalis* (Crambidae); 11) unknown (Pyralidae); 12) unknown (Pyralidae); 13) unknown (Pyralidae); 14) *Mittonia hampsoni* (Pyralidae). Larger threads on the sheets are 5 mm apart.

Nepytia pellucidaria (Packard) (Lepidoptera: Geometridae) in New York State

Janet R. Mihuc[1] and Timothy L. McCabe[2]

[1]Paul Smith's College, Routes 86 & 30, Pauls Smiths, NY 12970 **jmihuc@paulsmiths.edu**
[2]New York State Museum, 222 Madison Ave., Albany, NY 12230 **timothy.mccabe@nysed.gov**

Keywords: *Pinus,* Adirondack Mountains, larva, Geometridae

The boreal pine looper, *Nepytia pellucidaria* (Packard, 1873), is considered a poorly known and rare species in the northeastern U.S. (Schweitzer et al. 2011). This species was designated the boreal pine looper by Schweitzer et al. (2011) but is also known as the false pine looper (Maier et al. 2011). The species currently carries a NatureServe rank of GU (unrankable) due to lack of information on occurrence and is listed as extirpated in New York (NatureServe 2015). The flight period for adults in northeastern North America is from early August to late September (Handfield 2011, Schweitzer et al. 2011). Adults of this species closely resemble the false hemlock looper, *Nepytia canosaria* (Walker, 1863), a common species in the northeastern U.S. *N. pellucidaria* adults are larger in size and lack the yellow coloration on the head seen in *N. canosaria* (Figure 1). Obvious color differences exist in the larvae of these two species, with *N. pellucidaria* larvae possessing an orange-brown head capsule and orange-brown striping not seen in *N. canosaria* larvae (Maier et al. 2011). Both species feed on conifers but *N. pellucidaria* has a more limited host plant list, being reported to feed only on red pine (*Pinus resinosa* Soland.), pitch pine (*Pinus rigida* Mill.), jack pine (*Pinus banksiana* Lamb.) and white pine (*Pinus strobus* L.) (Maier et al. 2011, Schweitzer et al. 2011). *N. pellucidaria* is a needle feeder and details of its feeding habits are given here.

Recent records of *Nepytia pellucidaria* exist from Canada, and will be detailed below, but records from the northeastern U.S. are historic. Records for New York were from a pitch-pine scrub-oak community known as the Albany Pine Bush. In the New York State Museum (NYSM) there is a male syntype of *N. pellucidaria* that has a Packard label, but the only data is a "Lintner" label in addition to a "1839" label; presumably not a date but a record number from a notebook as was common practice at the time. The only other syntype was a male from Maine and it presumably went to the Museum of Comparative Zoology (Horn & Kahle 1936), but was not in the MCZ's type database. The last historic continental U.S. records of *N. pellucidaria* were from Conway, New Hampshire in 1919 and their rapid decline was coincident with the biological control of brown-tail moth (*Euproctis chrysorrhoea* L.) with an introduced tachinid, *Compsilura concinnata* Meigen (Schweitzer et al. 2011). The last records for the Albany Pine Bush were in 1877. The Gadway Barrens, a jack pine barren within the Adirondack Park in Clinton County, New York, was intensively inventoried for rare Lepidoptera in 2003 (TLM) and no *N. pellucidaria* was observed.

A search of the online databases iNaturalist, Tree of Life and Wikispecies yielded no U.S. records for *Nepytia pellucidaria*. One U.S. record of this species was found in the Butterflies and Moths of North America (BAMONA) database (Lotts and Naberhaus 2015). The record is from Dorchester County, Maryland. The record is dated July 6, 2016, which is earlier than the known flight date for *N. pellucidaria* but is within the known flight period of a similar unnamed species, *Nepytia* species 1, that is known to occur only as far north as Massachusetts (Schweitzer et al. 2011). *Nepytia* species 1 is noticeably smaller than *N. pellucidaria* but there is no size reference in the photograph of the individual on BAMONA. The records of *N. pellucidaria* in the Lepidopterist's Society Season summary database are from Michigan (2012,14), Wisconsin (2014,15) and Georgia (2013) (The Lepidopterist's Society, n.d.). The Georgia specimen is possibly *N. semiclusaria* (Walker, 1863).

Figure 1. Specimens of *Nepytia canosaria* (top row) and *Nepytia pellucidaria* (bottom row) collected in Franklin County, New York. *N. canosaria* was collected in September 2016 and the other individuals were collected in September 2017. A metric ruler appears in the photo for reference. Photo credit: J. Mihuc

The Canadian Biodiversity Information Facility lists *N. pellucidaria* on its checklists for Nova Scotia, New Brunswick, Ontario and Quebec (Species Bank 2013). The Lepidopterist's Society Season summary database contains Ontario records of this species from

Algonquin Provincial Park (Renfrew County) in 2005 and 2003, 2004 records from Petroglyphs Provincial Park (Peterborough County) (The Lepidopterist's Society, n.d.). The species was reported in 2000 in Renfrew County, Ontario and in adjacent Algonquin Provincial Park in 2001 and 2002 (Jones and Crolla 2002). Three specimens of *N. pellucidaria* from Renfrew County, Ontario are in the Cornell University Insect Collection (CUIC), with the oldest of these specimens being from 1996. These three specimens were collected in the month of September. Host plants present in Renfrew County include white pine, red pine and jack pine (Jason Dombroskie, personal communication). Handfield (2011) reports this species from southern Quebec only and characterizes its distribution as localized to rare. While no specific observation dates are given, the flight period is listed as August 2-September 24 (Handfield 2011). Schweitzer et al. (2011) report that there are only eight specimens of *N. pellucidaria* in the Canadian National Collection. There are two records of this species in the BAMONA database; one from 2014 in Renfrew County, Ontario and one from 2000 in York County, New Brunswick (Lotts and Naberhaus 2015).

For the past two years, adults of *N. pellucidaria* have been collected near lights (JRM) at three locations in Franklin County, New York, within the Adirondack Park. Individuals have been collected in a UV bucket trap at the Paul Smith's Visitor Interpretive Center (44.448, -74.260) and at a mercury vapor light on the campus of Paul Smith's College (44.434, -74.249). Flight dates were as follows: for 2016, September 8-22, for 2017, September 13-26. One individual was collected Sept. 10, 2016 at a mercury vapor light in Gabriels, New York (44.429, -74.175), 5.95 km from Paul Smith's College. Three *N. pellucidaria* collected at the college in 2017 are shown in Figure 1 along with one *N. canosaria* for comparison. All three collection locations were within or adjacent to mixed forest containing both red pine and white pine. Adult specimens were vouchered at NYSM and CUIC. A singleton female *pellucidaria* collected by TLM at Stormy Pond near the middle of Saranac Lake (Franklin Co., NY) on October 4, 2001 is also present at NYSM. This site is within 15 km of Paul Smith's College.

A gravid female, sent from Paul Smiths to the New York State Museum for rearing, oviposited on September 29, 2016. The ova diapaused. They were overwintered in a manual refrigerator at 45 degrees F until April 14, 2017. The neonates began hatching on May 5 after 21 days at room temperature with ambient light from a window. Hatching was not synchronic; some neonates emerged as much as 10 days later. Neonates were offered white pine, pitch pine and Austrian pine (*Pinus nigra* Arnold). The neonates only fed on the pitch pine and were ultimately reared on it. The developing larvae, including the neonates, typically ignored new growth and showed a preference for last year's needles. Less sap exudes from mature needles. Mature larvae were present by June 26 and cocoon construction amongst the pine needles began soon thereafter. Bred adults emerged on September 23 & 24, 2017 – only two days later than when they were first observed (JRM) in nature at Paul Smith's College.

Figure 2. *Nepytia pellucidaria* larva reared from ova deposited by female collected in Paul Smiths, New York. Photo credit: T. McCabe

Our bred larvae (Figure 2) appear slightly darker than those that have been illustrated (Schweitzer et al. 2011; Maier et al. 2011), having almost no trace of the longitudinal lateral white lines. The bred larvae do possess the "large merged spots on the anal prolegs" mentioned as a typical feature for *N. pellucidaria* in most larvae (Maier et al. 2011); a feature that is absent in larvae of the mid-eastern *Nepytia* sp. illustrated in Wagner et al. 2001. We had no images of larval *N. semiclusaria* for comparison.

Male genitalia were dissected of *Nepytia pellucidaria* (from Paul Smiths), *N. semiclusaria* (a southeastern species – the dissected specimen was from Georgia), and *Nepytia* species 1 from Long Island, N.Y. The male valves of all three were very close. *Nepytia pellucidaria* could be distinguished by a longer clavus projection on the right side (the left projection is atrophied, making the valves appear asymmetric in this genus) and a more extensive subgnathos' spine patch. A *Nepytia semiclusaria* from Georgia (this species' distribution is limited to the Southeast) could not be distinguished by male genitalia from the dissected Long Island specimen. In habitus, fresh *N. pellucidaria* and Long Island *Nepytia* species 1 are gray with the transverse lines black, whereas fresh *N. semiclusaria* are brown with brown lines. Unfortunately, old museum specimens of *N. pellucidaria* and Long Island *Nepytia* sp. fade to brown.

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***Literature Cited** continued on pg. 69*

Larvae and host plants of *Alypiodes bimaculata* (Herrich-Schäffer, [1853]) and *Alypiodes geronimo* (Barnes, 1900) (Noctuidae)

Charles Melton

P.O. Box 592, Hereford, AZ 85615 **cwmelton2@yahoo.com**

Two species of diurnal moths in the genus *Alypiodes* Grote (1883) occur in southeast Arizona. The adults are similarly patterned but can easily be distinguished. Both species are mostly black with yellow-white spots on the forewing. *Alypiodes bimaculata* adults have three yellow-white spots parallel to the leading edge of the forewing. *Alypiodes geronimo* adults are sexually dimorphic. Females have two yellow-white spots on the forewing, one near the leading edge and a second near the tornus. In addition to the two spots on the forewing of the female, males have a third spot located along the leading edge of the forewing.

From my experience, adults of *A. bimaculata* are much more commonly seen in southeast Arizona than *A. geronimo*. *A. bimaculata* adults can at times be abundant during the summer monsoon season puddling in Garden Canyon and Huachuca Canyon on Fort Huachuca. I have yet to see an adult *A. geronimo* in the wild.

Host plant information and larval images for these species are presented on many internet sites including Bruce Walsh's Moths of Southeastern Arizona, **http://nitro.biosci.arizona.edu/zeeb/butterflies/mothlist.html**, Moth Photographer's Group, **mothphotographersgroup.msstate.edu**, BugGuide, **https://bugguide.net/**, iNaturalist, **https://www.inaturalist.org**, Discover Life, **www.discoverlife.org**, and Southwest Moths, **southwestmoths.org/**. Larva and host plant information for *A. bimaculata* are also given in Powell and Opler (2009).

In these sources the host plant for *A. geronimo* is given as *Mirabilis* spp. (L.) (Nyctaginaceae). Early larval instars are shown as light yellow-green speckled with small black spots (pinacula). Later larval instars are shown as white to cream-colored with a transverse black band on most segments. The host plant for *A. bimaculata* is given as *Boerhavia* sp. (L.) (Nyctaginaceae), and the immature is shown as a dark-bodied larva with an orange head and a lateral orange spot on most, if not all, abdominal segments.

On September 21, 2011, a dark-colored larva with an orange head and lateral orange abdominal spots was found feeding on *Boerhavia* sp. in Miller Canyon in the Huachuca Mountains of southeast Arizona. The larva was photographed (Fig. 1), measured, and held for rearing to adult. The larva was placed in a plastic container with cut stems of the host plant inserted in water. Host plant material was replenished as needed.

Figure 1: *Alypiodes geronimo* larva feeding on *Boerhavia* sp. Sept. 21, 2011. Length 28 mm.

Local moth expert Noel McFarland informed me that the larva would require a woody substrate in which to pupate. A piece of dried flower stalk of *Agave palmeri* (Engelm.) (Asparagaceae) was provided. Upon completion of feeding the larva tunneled into it and sealed the entrance.

On July 18, 2012, the adult emerged but instead of the expected *A. bimaculata* it was a male *A. geronimo* (Fig. 2). Photos of the larva and adult were posted at BugGuide.net, **https://bugguide.net/**, and emailed to Bruce Walsh at the University of Arizona. He confirmed the identification of the adult as a male *A. geronimo*. When asked about the larva he replied that the larva did look like *A. bimaculata* and suggested perhaps a hybrid.

Figure 2: *Alypiodes geronimo* adult male. Emerged July 18, 2012. Reared from larva in **Fig. 1**.

After searching for three years for additional larvae without success I decided to rear the other *Alypiodes* larva. From July 14 to July 18, 2017, a total of six yellow larvae speckled with small black spots were found feeding on *Mirabilis longiflora* (L.) (Nyctaginaceae) at various locations in Miller Canyon, Huachuca Mountains, AZ. The larvae were photographed, measured, and individually held for rearing to adult in the same manner as previously described. The following year six adults emerged from late June to Aug. 22, 2017. All adults were *A. bimaculata*. Photos of one of the larvae and the emerged adult are shown in Figs. 3, 4, and 5.

Figure 3: *Alypiodes bimaculata* larva. Found feeding on *Mirabilis longiflora* July 15, 2016. Length 12 mm.

Figure 4: *Alypiodes bimaculata* larva feeding on *Mirabilis longiflora*. Same larva as in **Fig. 3** four days later. July 19, 2016. Length 30 mm. Tunneled into woody substrate July 22, 2016. Adult emerged Aug. 22, 2017.

Conclusion:

Early instar larvae of *A. bimaculata* are yellow, speckled with small black spots. Later instars are white to cream-colored with a transverse black band on most segments. The larval host plant is *Mirabilis longiflora*. Larvae of *A. geronimo* are dark-colored with an orange head and a lateral orange spot on most, if not all, abdominal segments. The larval host plant is *Boerhavia* sp. Host plant results are based on a small number of reared larvae. It is possible that other plants will be found to be suitable hosts. All of the online and book sources that I have seen have the larvae for these two species switched.

Thanks to Noel McFarland for helpful information on rearing the larvae and overall support and encouragement.

Figure 5: *Alypiodes bimaculata* adult. Emerged Aug. 22, 2017. Reared from larva in **Figs. 3 & 4**.

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Nepytia pellucidaria in New York

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Announcements:

The Southern Lepidopterists' Society invites you to join

The Southern Lepidopterists' Society (SLS) was established in 1978 to promote the enjoyment and understanding of butterflies and moths in the southeastern United States. As always, we are seeking to broaden our membership. Regular membership is $30.00. Student and other membership categories are also available. With membership you will receive four issues of the SLS NEWS. Our editor J. Barry Lombardini packs each issue with beautiful color photos and must-read articles. SLS conveniently holds its annual meeting, in Sept. or Oct. (see ad below). The SLS web page (http://southernlepsoc.org/) has more information about our group, how to become a member, archives of SLS NEWS issues, meetings and more.

Please write to me, Marc C. Minno, Membership Coordinator, at **marc.minno@gmail.com** if you have any questions. Dues may be sent to Jeffrey R. Slotten, Treasurer, 5421 NW 68th Lane, Gainesville, FL 32653.

2018 Southern Lepidopterists' Society/ Association for Tropical Lepidoptera Combined Annual Meeting -- John Hyatt and Lance Durden

The 2018 Southern Lepidopterists' Society/Association for Tropical Lepidoptera combined annual meeting will be in the Biological Sciences Building at Georgia Southern University in Statesboro, Georgia on Friday - Sunday, 14-16 September, 2018. There is no home football game that weekend and campus parking will be free after 5 pm on the Friday (14 Sep.) and throughout the weekend. The Biological Sciences Building is new and has modern facilities; the Departmental insect collection will be available for examination during the meeting.

There will be opportunities to set up light sheets in a wooded area of the campus on the Friday night, and James Adams has agreed to lead a field trip to the Ohoopee Dunes area (about 35 miles from Statesboro, and the type locality for *Fernaldella georgiana*) one night. There will be native nectar sources around the building so there should be plenty of local butterflies. We will have a group dinner on Saturday evening after the day's meeting.

So mark the date on your calendar and plan on meeting your lepidopterist friends, and perhaps giving a paper, in Statesboro, Ga. in September.

The June issue of the SLS News will contain more detailed information about the meeting, including campus and parking maps, adjacent hotels, and the usual registration form and call for papers will be provided to SLS and ATL members well prior to the meeting. You can also check out the SLS webpage at http://southernlepsoc.org/.

The Ron Leuschner Memorial Fund for Research

The Lepidopterists' Society has established the Ron Leuschner Memorial Fund for Research on the Lepidoptera. Each year, the Society will fund up to 2 grants for up to $500 each to undergraduate or graduate students depending on merit. Applicants must be members of the Lepidopterists' Society. The applications are due January 15 annually and must include submission of the application form, a brief (500 word maximum) proposal, and a letter of recommendation or support from the student's academic advisor or major professor. Submit all of the above to Shannon Murphy at **Shannon.M.Murphy@du.edu**. Snail mail applications should be sent to Shannon Murphy, Associate Prof., Boettcher West 302, Dept. of Biological Sciences, University of Denver, 2050 E. Iliff Avenue, Denver, Colorado 80208. Successful applicants will be notified by March 15. The review committee consists of members of the Lepidopterists' Society, including the previous year's successful candidates (who are thus not eligible for a new award in the subsequent year's competition). Award recipients will be expected to produce a short report for the committee at the conclusion of their year of funding, which summarizes the positive impact of the award on their research. Recipients must also acknowledge the Fund's support in any publications arising out of the funded work.

Lepidoptera Short Course, Eagle Hill, Steuben, Maine, July 2018

Microlepidoptera: Collection, Preparation, Dissection, Identification, and Natural History -- Jason Dombroskie, July 22-28, 2018

This lab-intensive course will systematically cover all of the families of the microlepidoptera from Micropterigidae to Mimallonidae in the United States and Canada. The focus will be on identification characters for each family and most of the major subfamilies and tribes through talks rich in photos and examination of specimens. Overall natural history will be covered with special focus on ecologically and economically important species. There will be practical training on collecting methods, pinning techniques, and genitalic dissection along with a discussion of larval rearing techniques.

For general information and a complete calendar … **https://www.eaglehill.us/programs/nhs/nhs-calendar.shtml office@eaglehill.us** … 207-546-2821 Ext 4

Lep Soc Statement on Diversity, Inclusion, Harassment, and Safety

This is available at any time, should you need to know at: **https://www.lepsoc.org/content/statement-diversity**

Combined Annual Meeting of The Lepidopterists' Society and Societas Europaea Lepidopterologica

Carleton University, Ottawa, Ontario, Canada; 11-15 July 2018

Please see the ad in the previous issue of the news (60(1): page 36) for details about the meeting, or go to **https://www.lepsoc.org/content/annual-meeting.**

If you have questions, email **lepsoc2018@gmail.com.**

Seventh Annual (Inter)National Moth Week - July 21-29, 2018

This Year's Event Spotlights Geometrid Moths

The seventh annual (Inter)National Moth Week (NMW) is being held July 21-29 around the world. National Moth Week is a global event and during the past six years there have been thousands of participating locations in all 50 states and more than 70 countries. Surveys, moth-watching and educational events have been held throughout Europe, Asia, Africa, South, Central, and North America.

NMW recognizes that late July may not be ideal for mothing everywhere around the world and so encourages events and participation at any other time that will be productive. Simply register those dates and locations on the website (**nationalmothweek.org**) and we will be sure to spotlight them as well.

NMW shines a much-needed spotlight on moths ecological importance as well as their incredible biodiversity. Through partnerships with major online biological data depositories such as BAMONA, Project Noah, BugGuide, Encyclopedia of Life, Discover Life, Biodiversity Bhutan, DiversityIndia, Moth Photographers Group, LepiMap – Atlas of African Lepidoptera, and iNaturalist, National Moth Week encourages participants to record moth distribution, submit data and photographs and to provide information on other aspects of their life cycles and habitats.

NMW 2018 is designated "The Year of the Geometrid (Inchworm) Moth" to encourage participants to look for and learn about these fascinating moths. For more info about NMW and to register a location at any time of the year please visit nationalmothweek.org. To contact us about the event, please reach out to Dave Moskowitz, co-founder of National Moth Week, at **dmoskowitz@ecolsciences.com.**

Season Summary will be delivered with fall issue of the News

The Season Summary will be delivered with the fall issue of the News. Leroy Koehn apologizes but is dealing with important personal issues.

The Association for Tropical Lepidoptera

Please consider joining the ATL, which was founded in 1989 to promote the study and conservation of Lepidoptera worldwide, with focus on tropical fauna. Anyone may join. We publish a color-illustrated scientific journal, Tropical Lepidoptera Research, twice yearly (along with a newsletter), and convene for an annual meeting usually in September. Recent meetings have been joint gatherings with the Southern Lepidopterists Society at the McGuire Center for Lepidoptera & Biodiversity in Gainesville. FL. Dues are $95 per year for regular members in the USA ($80 for new members), and $50 for students. Regular memberships outside the USA are $125 yearly. See the troplep.org website for further information and a sample journal. Send dues to ATL Secretary-Treasurer, PO Box 141210, Gainesville, FL 32614-1210 USA. We hope you will join us in sharing studies on the fascinating world of tropical butterflies and moths.

The Lepidoptera Course, 7-17 August 2018

The 2018 Lepidoptera Course will take place at the Southwestern Research Station (SWRS) in the Chiricahua Mountains of SE Arizona (2 ½ hour drive from Tucson). With its extensive series of Sky-Island mountain ranges, SE Arizona has the highest Lepidoptera diversity in the USA. With low desert scrub oak and mixed oak-pine woodland, lush riparian, juniper, Douglas fir, and mountain meadow habitats all within a 40-minute drive from the station, the SWRS is an ideal location from which to sample this diversity (of both habitats and species).

The focus of the Lep Course is to train graduate students, post-docs, faculty, and serious citizen-scientists in the classification and identification of adult Lepidoptera and their larvae. Topics to be covered include an extensive introduction to adult and larval morphology with a focus on taxonomically important traits, extensive field work on both adults and larvae, collecting and curatorial techniques, genitalic dissection and preparation, larval classification, and general issues in Lepidoptera systematics, ecology, and evolution.

At present, the projected staff include John Brown (Smithsonian), Richard Brown (Mississippi State), Jennifer Bundy (University of Arizona), Chris Grinter (The California Academy of Sciences), Sangmi Lee (Arizona State), Ray Nagle (University of Arizona), and Bruce Walsh (University of Arizona).

Details and an application form can be found online at http://research.amnh.org/swrs/education/lepidoptera-course. Deadline for applications are 1 July 2018. For further inquiries please e-mail Bruce Walsh at jbwalsh@u.arizona.edu, or Michele Lanan at mlanan@amnh.org

***Announcements** continued on pg. 82*

The Nearctic green hairstreaks: how many species?

A taxonomic re-examination of Sheridan's hairstreak (***Callophrys sheridanii***), coastal green or bramble hairstreak (***Callophrys dumetorum***) and western green hairstreak (***Callophrys affinis***) in Washington and Oregon

Glenn A. Gorelick

360 Toyon Road, Sierra Madre, CA 91024 **butterflyguy44@verizon.net**

I have heard these statements arise even after the use of field guides and online resources: "I have trouble telling Sheridan's hairstreak from the western green hairstreak - how do you tell them apart?"; "The bramble hairstreak and the western green hairstreak look the same to me."; "Does Pelham's catalog (2014) list the correct number of species and subspecies, in your view?"

Are there, in fact, three distinct species of *Callophrys* (*s.str.*) in North America?

Varying and often outdated nomenclatural combinations used in many museum collections and the butterfly literature have added to this confusion. With extensive individual variation, it is a very confusing group of hairstreak butterflies so these remain provocative questions. I suppose the answer comes down to how one *defines* a species. There are morphological species, ecological species, and biological species. Since there is more than one definition, there is likely to be more than one opinion. Most contemporary guides agree in the use of wing characteristics such as differences in shape, scale color and distribution and the location, relative shape and completeness of the submedian (submesial) macular band on the wing undersides in identifying these three species of hairstreaks with green undersides. These morphological features are undoubtedly valid criteria for use in species identifications.

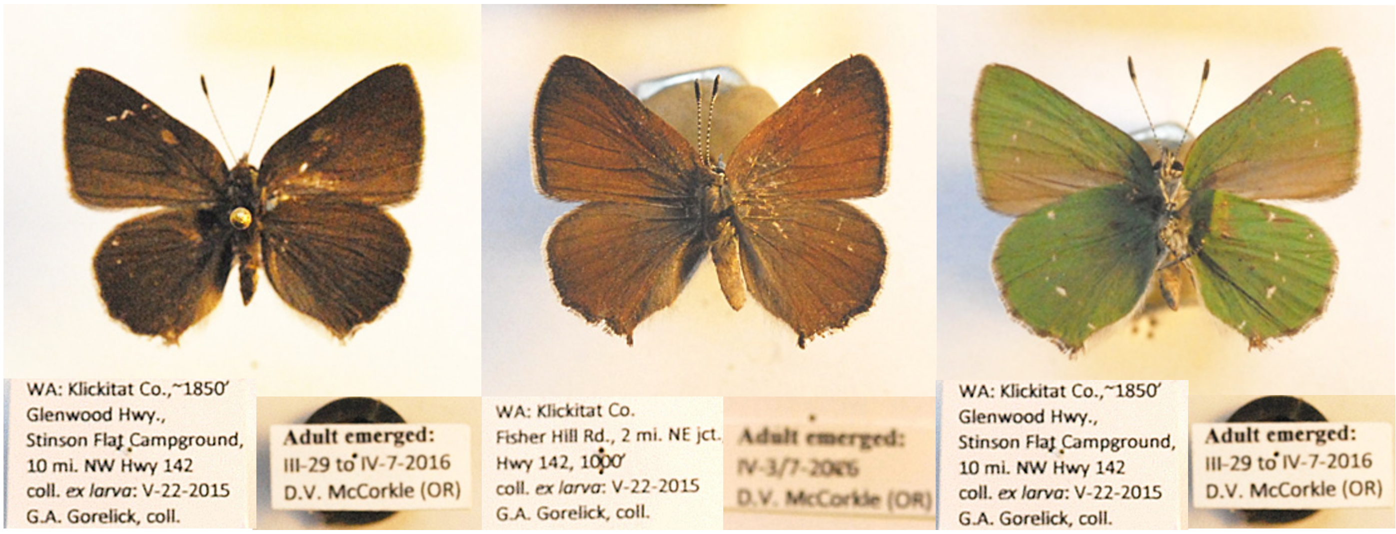
Although the above-listed structural characteristics are relatively definitive, my own questions go further: *Why* do these three species occur only in the localities cited in field guides or collecting reports, often with or very close to each other? Taxonomically-speaking, I suspect that an explanation may lie in their evolutionary history. The scenario that is presented here, accompanied by observational evidence, is concluded with a suggestion to observers and collectors alike that may help to answer such questions.

Literature treatment

Perhaps contributing to persisting questions regarding conspecificity were omissions and misidentifications in earlier publications concerning these three species. For example, the shade of green scale color and distribution on the primary wing undersides prompted me to incorrectly include specimens of nominal *C. dumetorum* and *C. affinis washingtonia* in the type series of *C. dumetorum oregonensis*. These include specimens collected in and labeled from Mason, Chelan, & Okanogan counties in WA; Polk, Clackamas & Yamhill counties in OR; Adams Co., ID (Gorelick, 1968 [1970]). Museums with misidentified paratypes have been sent an additional label (not a replacement label) correcting the identification since *C. dumetorum oregonensis* is restricted to the slopes along the east side of the Cascade range, where it was observed in Yakima, Klickitat, Skamania counties in WA; Wasco, and Jefferson counties in OR, as also defined by Hinchliff (1994, 1996) and Warren (2005). Neither it nor the hostplant, *Lotus nevadensis*, has been collected or positively identified in Deschutes County, however, reported to be within their flight range by James and Nunnellee (2011).

In another publication, also centered almost exclusively on scale color and submesial white maculations, Scott and Justice (1981[1982]) discussed putative intergradation between *C. dumetorum oregonensis* and *C. dumetorum affinis* in the northwestern U.S. and suggested possible intergradation in stages. They concluded that some field-captured individuals looked like *C. dumetorum* yet others more like *C. affinis.* Warren (2005) pointed out that this probable error was created by specimens incorrectly identified at the species level. I also could not corroborate such similarities yet I also found that many similarities do exist in *C. sheridanii* and *C. affinis* adults.

Butterfly publications point out that the most widespread of the *Callophrys* with green undersides (*s.str.)* is the highly variable *C. sheridanii*, found throughout much of western North America and undoubtedly the most commonly-observed *Callophrys* in Washington and Oregon. While Scott (1986), Hinchliff (1994, 1996), Emmel, Emmel and Mattoon (1998) and Guppy & Shepard (2001) treated these as separate species, Pyle (2002) included a possible fourth *Callophrys* (*C. dumetorum* nr. *dumetorum*), also commonly referred to as the coastal green hairstreak. He also revealed parapatry between *C. sheridanii*, *C. dumetorum* and *C. affinis* in the vicinity of Satus Pass (Klickitat Co., WA). Specifically, he suggested that the bluish-green



Figures 1-3: Left to right: *Callophrys dumetorum oregonensis* male upperside; female upperside; male underside. Stinson Flat Campground, 1076' and Fisher Hill Road near jct., Hwy 142, 160' elev., Klickitat Co., WA, leg. G.A. Gorelick

hairstreaks taken at Rickreall Ridge (Polk Co., OR) and the A.J. Andrews Experimental Forest in Lane Co., OR may represent a relictual population that once exhibited a wider range. Warren (2005) discussed these and noted additional similarities to west Cascadian populations aligned with *C. sheridanii*.

Warren (2005) also treated *C. dumetorum, C. sheridanii* and *C. affinis* as separate taxa and discussed occasional sympatry and parapatry in these species. He acknowledged nevertheless lingering questions pertaining to the treatment of some *C. sheridanii* populations.

Scott *et al* (2012), in a summary of the decision rendered by the International Commission on Zoological Nomenclature (I.C.Z.N.), pointed out the restoration of the prior species name "*dumetorum*", rendering the name "*perplexa"* an outdated combination or synonym in their ruling on the names of *Callophrys* butterflies in western North America (I.C.Z.N., 2012). [1]

The biology, distribution and life histories of these three species were described in detail by Warren (2005) and by James and Nunnallee (2011). They emphasized that in *C. dumetorum*, the female's dorsal surface is variably yellowish or tawny, unlike the grey typically seen in *C. affinis* and *C. sheridanii* females (figs. 1-4).

Although Warren (2005) pointed out, as I have also observed, that the tawny to gray dorsal wing color exists in many *C. sheridanii* populations scattered throughout Washington and Oregon, the life histories of these three taxa are morphologically and biologically distinct. Last instar larval differences have been previously described by Gorelick (1971) and Ballmer & Pratt (1988). Detailed instar discussion and accompanying photographs can be found in James and Nunnellee (2011).

Figure 4: *Callophrys affinis washingtonia*: Top: male undersides; female undersides; Bottom: male uppersides; female uppersides. Manastash Ridge Lookout, Hwy I-82, 2800', May 1983, Kittitas Co., WA, leg. J. Hinchliff (photo - Dana Ross)

Discussion

Most recently, I attempted to provide additional information that might explain the reason for often subtle differences in their seasonality factors, flight range and behavior by observing and/or collecting these species in Washington and Oregon during their overlapping flight seasons in May and early June of 2015, 2016, and 2017. The resulting field observations and examination of specimens housed in the museum collections at Washington State University, University of Washington, and Oregon State University prompt me to recommend that the current treatment of *Callophrys dumetorum*, *C. sheridanii* and *C. affinis* remain unchanged… as separate species. Evidence for this recommendation lies in the following six factors that have probably been conducive to their speciation:

First, **Paleogeographic isolating factors:** Significant factors that may have isolated the earliest North American *Callophrys* populations were probably paleogeographical. In Oregon, the Deschutes River Valley and the high desert area of central Oregon between the east slopes of the Cascades and the Blue-Ochoco Mountains continue to serve as barriers to their distribution. The Blue Mountains of northeastern Oregon were glaciated up until 11,000 years ago, suggesting that *Callophrys* had not yet colonized this area. Its western extension, the Ochoco Mountains in central Oregon, were created by volcanic eruptions during the Eocene epoch but never fully glaciated. Nevertheless, periglacial effects (ashfall around 7,700 years ago) resulted in the deposition of clay, a heavy soil type. (U.S.D.A., 2010; Orr & Orr, 2012). Such soil does not favor the colonization of deerweed species nor does it allow for proper drainage for buckwheat species such as *Eriogonum heracleoides* (Wyeth buckwheat) and *E. umbellatum* (sulfur-flowered buckwheat).

Quaternary glaciation in the western Cascades as recently as 18,000 years ago most likely resulted in flooding in the Metolius and Deschutes River basins. In eastern Washington, flats, valleys, and prairies would seem to present themselves as potential barriers between the Simcoe Mountains and the Selkirk Mountains north of Spokane. Nevertheless, disparate populations of *C. affinis* occur in the scablands of Lincoln and Douglas counties, areas with flat plateaus and steep canyon sides. At the end of the last ice age 18,000 to 13,000 years ago, flooding swept across eastern Washington and down the Columbia River Gorge, creating the relatively soil-free, basaltic channeled scablands (Orr & Orr, 2012). This flow resulted in the deposition of sand and silt, conducive to the establishment of *Callophrys* hostplants.

The Oregon high desert, another potential barrier, is a western part of the Great Basin above 4000 ft. (1219 m). Primarily basaltic, its last ice age was between 10,000 and 12,000 years ago and rendered highly unstable habitats. Decomposing lavas prone to mass movement along steep canyon walls thus characterize many locations in Crook, Deschutes, Harney and Malheur counties (U.S.D.A., 2010)). Hinchliff (1994) and Warren (2005) mentioned *Callophrys* colonies in each of these counties.

Second, **climatic factors**: Temperature, humidity and rainfall continue to operate as primary limiting factors to their biological success. They are perhaps afforded a higher degree of thermoregulation than many other butterflies owing to the non-pigmented, structurally-detailed scale architecture on their wing undersides (Ghiradella, 1989; Gorelick, 2005). This adaptation suggests their evolution in a relatively cold climate. For example, in the vicinity of the Camas Prairie Campground in the Mt. Hood National Forest of Wasco County, Oregon, I observed a single female *C. dumetorum* that landed occasionally amongst the tiny rocks with closed wings flattened against the ground in sunny 55 degrees Fahrenheit May weather (Fig. 5).

Figure 5: Maximum sun exposure - female *C. dumetorum oregonensis* oriented laterally on the ground in the vicinity of Camas Prairie Campground, Mt. Hood National Forest, Wasco Co., OR

All three species of *Callophrys* overwinter as pupae. Mean annual temperatures from selected areas in WA were thus included in his review of *C. sheridanii* subspecies by Clench (1963). Hiruma, K., *et al.* (1997) pointed out that *C. sheridanii* pupae in a Kittitas Co., WA population required a temperature of 4 degrees C followed by a warming trend for the adults to emerge. They added that their staggered emergences can last up to 200 days. Unlike the other two species, February and March emergences of *C. sheridanii* in the Pacific Northwest may exhibit many of their behavior patterns including courtship and mating on the ground (J. Pelham, 2017, *pers. comm.*). Both *C. sheridanii* (Fig. 6) and *C. affinis* occur in southern British Columbia, each exhibiting variation in the shape and extensiveness of their hindwing submesial band. *Callophrys dumetorum*, on the other hand, is absent.

Figure 6: *Callophrys sheridanii newcomeri* nectaring, Hog Lake, Spokane Co., WA, March 2016 (photo- John Baumann)

Third, **choice of hostplants:** In searching for *Callophrys* hostplants using herbarium, native plant society records and online postings, I found abundant *Lotus nevadensis* growing in an oak-woodland setting above the Little Spokane River in Riverside State Park and in the vicinity of Stubblefield Lake in the Turnbull National Wildlife Area, both in Spokane Co., WA. The latter locality is a scabland of sandy hummocks, each colonized by stands of *Eriogonum heracleoides*. Evidence of *C. dumetorum*'s occurrence was not found in either locality. Both *Callophrys sheridanii* and *C. affinis*, adapted to overwintering in extremely cold winters and early springs, inhabit these hummocks. The absence of *C. dumetorum* from both northeastern Washington and southern B.C. may suggest a narrower range of temperature tolerance and/or a lack of suitable habitats.

While the subspecific name "*oregonensis*" refers to its occurrence in central and northwest Oregon, I found the largest populations in forest and road clearings along the Klickitat River between 1000 and 2000 ft. (305-610 m) in Klickitat County, WA. Isolated populations of *C. d. oregonensis* inhabiting the eastern slopes colonize areas with *Lotus nevadensis* and *L. crassifolius* in many sites. It also occurs sparingly on its westernmost border along a hiking trail in a disturbed, open mixture of scattered conifers and shrubs at 3200 ft. (975 m) called Penny Ridge, located at the base of Monte Carlo in Skamania County.

On relatively warm, sunny days in Oregon, no more than two were seen in a single day in their oak-woodland communities along the Rowena Crest overlooking the Columbia River (Wasco County), two localities along or near the White River (Wasco County) in the Mt. Hood National Forest, and three such localities in the Deschutes National Forest (Jefferson County).

Figure 7: Female *C. dumetorum oregonensis* perched on flowers of the preferred floral nectar source - *Lomatium triternatum* (nineleaf biscuitroot). Lower Bridge Campground on the Metolius River, Deschutes National Forest, Jefferson Co., OR, May 2015.

As with the above-discussed *Lotus* hostplants, the current range of *C. d. oregonensis* is also largely affected by recent **ecological disturbances** (*secondary succession*). Invasion of weedy plants occurs along the limited boundaries of campgrounds, powerline rights of way, logging and fishing sites, dam construction and demolishment, state parks, clearings for sign postings, and burned areas, each the result of human activity. Without such habitats, they would have to fly for many miles through surrounding forests to find mates, suitable perching shrubs, nectar sources, and hostplant abundance.

Nevada deerweed (*Lotus* (=*Acmispon*) *nevadensis,* Figs. 8-9) is commonly found throughout the western U.S. In Washington, I found it most commonly in southeastern Washington between Monte Carlo (Skamania County) to the west and Goldendale (Klickitat County) to the east.

Figures 8-9: *Lotus (=Acmispon) nevadensis*, Tom McCall Preserve, Rowena Crest, Wasco Co., OR, June 2016 (photo - Roger Steeb); female *C. d. oregonensis* perched on *Lotus* flower- Stinson Flat Campground, Glenwood Hwy, Klickitat Co., WA, May 2015

Unlike most *Eriogonum* hostplant species, it grows best in loose loam soils along roads, streams or at the bottom of slopes. These were exclusively located along or above creek or river tributaries in disturbed areas even with the availability of the big deervetch (*Lotus crassifolius*) that is used by nominal *C. dumetorum* on the west side of the Cascades. Both are birdsfoot trefoil species of legume found commonly associated with both chaparral-type and forest vegetation, in places where sunlight penetrates to the forest floor, enhancing the germination of both food plants and nectar sources. While I never observed *C. dumetorum oregonensis* in association with *Lotus crassifolius* during my study, I can present no evidence that *C. dumetorum oregonensis* uses only *Lotus nevadensis*. Where both plants grow together on the east side of Hood River County (vic. Dee, OR), specimens appear to be *C. d. oregonensis* unlike those resembling the more typically-larger *C. d. dumetorum* adults found on the west side of the county (A. Warren, 2018, *pers. comm.*).

Like *Lotus*, *Eriogonum* species appear abundantly in ecologically-disturbed areas. Firmly established populations of parsnip or Wyeth buckwheat (*Eriogonum heracleoides*) (Fig. 10), also known as creamy buckwheat, occur on the east side of the Cascades in virtually every county in eastern Oregon and eastern Washington, except Skamania and Franklin counties (CPNWH, 2017).

Figure 10: *Eriogonum heracleoides* – Calamity Butte Lookout near summit, 6700', Harney Co., OR, May 2016

I found it to be the preferred hostplant of *C. affinis washingtonia* in both Oregon and Washington but additional buckwheat hostplants are also listed by James and Nunnellee (2011). *Eriogonum heracleoides* is a widespread scrub-steppe plant species that is often found along dry, rocky slopes in association with sagebrush (*Artemisia tridentata*) and antelope bitterbrush (*Purshia tridentata*) and is also used by *C. sheridanii* as a hostplant. Within the flight range of *C. dumetorum oregonensis*, stands of this buckwheat grow abundantly throughout Yakima County but to a relatively lesser degree in Klickitat County, Lakeside Drive - south shore of Conboy Lake, the Bickleton Highway near Cleveland (Cleveland Shrub-Steppe NAP), the Centerville Highway near Harms Road, each only a few miles from *Lotus nevadensis* seen growing along the roads to Trout Lake and the Goldendale Observatory. No evidence of *Callophrys dumetorum*'s occurrence was found in these areas.

Fourth, **behavioral isolation/asynchrony:** These patterns were found to exist between these three hairstreak species. In both WA and OR, males of *C. affinis washingtonia* were seen perched on the above-mentioned sages and in similar communities of sage-scrub vegetation as were males of *C. dumetorum dumetorum* and *C. viridis (=C. sheridanii viridis)* that I studied in California using a marked adult study (Gorelick, 1971). Unlike *C. sheridanii*, they tended to return to the same perches repeatedly. They typically occur on elevated hummocks and montane or ridge summits above 2500 ft. (762 m.) between April and June. Nectar sources include their hostplant where mating occurs. *C. sheridanii* frequents canyon bottoms, emerges as early as late February, and is usually gone by early April. Below 2500 feet, these two species are frequently microallopatric and allochronic. That is, they frequently occur in the same contrasting habitat relationship but separated by weeks or even a month (J. Pelham, 2017, *pers. comm.*).

Unlike *C. d. dumetorum* males in California populations, males of nominal *C. dumetorum* in western OR and western WA do not mate locate on summits although they may do so on high points of the terrain below the summits (Warren, 2005). On the other hand, I never observed *C. d. oregonensis* males seeking elevated terrain for courtship and mating.

Asychrony may have evolved amongst these hairstreaks to reduce competition for hostplants. At the same time, I observed other lycaenids, notably *Strymon melinus*, *Plebejus acmon*, *P. lupini* and *Euphilotes columbiae* ovipositing on the same hostplant stands. I also observed that *C. dumetorum* pupae often do not emerge each year and thus are capable of overwintering for many years, as encountered at the Stinson Flat Campground above the Klickitat River in Klickitat Co., WA. These evolutionary strategies undoubtedly allow them continued biological success in habitats where the temperature range is tolerable.

Fifth, **synchrony** and **sympatry**: In the Pacific Northwest above 2500 ft., it is not unusual for the two to be both sympatric and synchronic although the flight of *C. sheridanii* is usually nearly over when *C. affinis* begins flying (Warren 2005). In the absence of both *C. dumetorum* and *C. affinis*, I found that non-hilltopping *Callophrys sheridanii* may appear instead between May in some years (A. Warren, 2003, *pers. comm.*) and July at elevations above 5000 ft. (1524 m). I have also seen that temporal isolation between *C. affinis* and *C. sheridanii* is not constant and many of their populations are occasionally synchronic, as previously discussed by Warren (2005). Synchronous or asynchronous flight in *C. sheridanii* and *C. affinis* largely depends on seasonal conditions at specific sites. For example, in any given year, *C. affinis* and *C. sheridanii* may be largely synchronic while at the same site in another year they may be asynchronous by up to one or more months (A. Warren, 2018, *pers. comm.)*.

I found such sympatry between *C. sheridanii interrupta* and *C. affinis washingtonia* while collecting in early June 2016 on Pine Mountain (6250 ft. (1905 m) in central Deschutes County, OR. In Fig. 11, the top specimen with virtually no submesial band development appears to be a late season *C. affinis washingtonia*. These two specimens represent the first recorded *Callophrys* captures from Deschutes County.

Figure 11: Top: male *Callophrys affinis washingtonia*; Bottom: male *Callophrys sheridanii interrupta* - Pine Mountain, along the road above campground, 6300', Deschutes Co., OR. These two males were taken on the terminal flower buds of what appeared to be the same *Eriogonum heracleoides* stand five years apart!

Such sympatry was also found to exist at the summit of Calamity Butte (Figs. 12-14) at 6700 ft. (2042 m) in Harney Co., OR, where I collected fifteen hilltopping male and two female *C. affinis washingtonia* in early June 2016. Despite a lack of submesial maculations on the hindwings, their wingspan more closely resembled that of typical *C. sheridanii*. Warren (2005) discussed *C. sheridanii*, whose earlier-collected specimens revealed a submesial band on the hindwing undersides resembling that of *C. s. interrupta*. This suggests that *C. sheridanii* most likely occurs in sympatry with *C. affinis washingtonia* at this site as well.

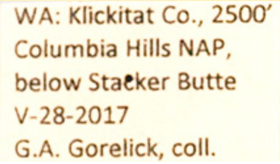
C. sheridanii nr. *neoperplexa* and *C. affinis washingtonia* are sympatric in scabland communities (Fig. 15-17) above 2000 ft. (610 m) in Spokane, Lincoln, and Douglas counties of eastern WA although their flight periods are asynchronous. The former emerges in March and is usually gone by mid-May. The latter usually flies from late April through the first week of June.

Figures 12-14: Road to Calamity Butte Lookout, Harney Co., OR; male *Callophrys affinis washingtonia* on *Eriogonum heracleoides*; male sun exposure on the ground

One male *C. sheridanii newcomeri* and a single male of *C. affinis washingtonia* were taken along the north side of the Columbia River in the Columbia Hills of Klickitat Co., WA only minutes apart on the same roadside *Lomatium triternatum* just below the summit of Stacker Butte (early June 2017; Figs. 18- 21). Their probable hostplants include *E. compositum* and *E. elatum* in the absence of *E. heracleoides*.

WA: Lincoln Co., 2375'
6.4 mi. NE Davenport, Hwy 25
VI-2-2017
G.A. Gorelick, coll.

Figures 15-17: Sage-scrub community (scabland) with dominant *Artemisia tridentata*, vic. Davenport, Lincoln Co., WA; *in copulo* pair of *Callophrys sheridanii* nr. *neoperplexa* on the ground, Hog Lake, Spokane Co., WA, March 2016 (photo -John Baumann); *Callophrys affinis washingtonia* upper sides - **left**: male; **right:** female (data is the same for both male and female)



WA: Klickitat Co., 2500'
Columbia Hills NAP,
below Stacker Butte
V-28-2017
G.A. Gorelick, coll.

Figures 18-21: Road to Stacker Butte summit with *Eriogonum compositum, E. douglasii*; two males (undersides) - left: *C. sheridanii newcomeri*; right: *C. affinis washingtonia* - May 2017 (data label applies to both specimens); Arrowleaf buckwheat (*Eriogonum compositum*)

C. dumetorum oregonensis (in flight during April-May) and *C. sheridanii newcomeri* (typically March-April flight) are sympatric in Wasco Co., OR at Tygh Ridge. In Klickitat Co., WA, sympatry exists along the Klickitat-Appleton Road as well as at Satus Pass on U.S. Hwy 97.

Overlapping ranges and flight periods were also noted in two pre-1955 pinned specimens housed in the James Museum of Entomology collection (Washington State University). *Callophrys affinis washingtonia* and *C. sheridanii newcomeri* were both collected between the months of April and June in the adjacent localities of Black Canyon and the town limits of Pateros, Okanogan Co., WA.

In fact, *C. affinis washingtonia* and *C. sheridanii newcomeri* are essentially sympatric throughout the low elevations of the Okanogan Valley in British Columbia. The former only occurs at relatively lower elevations while the latter may fly from low elevations to alpine habitats and exhibit variable elevational phenotypes (C. Guppy, 2017, *pers. comm.*).

Sixth, **parapatry:** I found relative proximity of *C. dumetorum oregonensis* and *C. affinis washingtonia* in the mountains east of the Cascades in Yakima Co., WA where I found no *Lotus nevadensis*. One such locality was located in the chaparral community east of Fort Simcoe. Another is Umtanum Ridge, situated 66 miles (106 km.) north of Satus Pass in the Simcoe Mountains. Warren (2005) also reported their parapatry in this area.

Figure 22: Male *Callophrys dumetorum oregonensis* on wild strawberry (*Fragaria*), Klickitat Canyon Conservation Area, 6 mi. NE Glenwood, Yakima Co., WA, May 2017 (photo – Carolyn Wright)

Warren (2005) also pointed out examples of such occurrences in the Columbia River Gorge. One such example that I observed was on Hamilton Mountain (Figs. 23-25), Skamania Co., WA (late May 2017), where freshly-emerged males of *C. sheridanii newcomeri* were collected while nectaring on *Lomatium triternatum*. They flew along the trail below the summit at around 2000 ft. (610 m.) in association with *Eriogonum compositum* and *E. umbellatum*. This mountain today composes part of the easternmost portion of the western slopes of the Cascades bordering the Columbia River Gorge, a locality around 36 miles (58 km) west of the *C. dumetorum oregonensis* colony on Penny Ridge.

Figures 23-25: Trail to Hamilton Mountain summit with *Eriogonum compositum* and *E. umbellatum;* two males- *Callophrys sheridanii newcomeri* (wing undersides)

I also observed other parapatric populations of *Callophrys* on the bluffs above the Columbia River. On the Rowena Crest, located 25 miles (40 km.) southwest of the Columbia Hills along the south shore of the Columbia River in Wasco Co., OR, I collected two male *C. dumetorum oregonensis* in late May 2017, two weeks prior to my visit to the Columbia Hills. Its hostplant, *Lotus nevadensis*, was found to be extremely sparse, undoubtedly due to fires and secondary succession. Earlier in the year, *C. sheridanii newcomeri* also occurs on the same bluffs with its hostplant, *E. compositum* (A. Warren, 2018, *pers. comm.*)

Conclusions

Based on their current distribution, it appears to me that the split between *C. sheridanii* and *C. affinis* may well have occurred in what is now northwest Oregon or southwest Washington during the last glacial maxima and invaded what is now Kittitas, Chelan, and Okanogan counties in Washington as well as southern British Columbia. This was probably followed by easterly migrations while developing differences in wing shape and markings during their adaptive radiation. As the previously-discussed glaciers advanced and temperatures dropped, they no doubt drifted downslope from mountain summits while the opposite occurred during the warmer interglacial periods, as did their *Eriogonum* hostplants (Mackay & Thomas, 2017). As climates began to change, these hairstreaks, along with their hostplants, could only remain in suitable habitats (refugia) to which they were pre-adapted. (Stewart and Lister, 2001). Such refugia are seen today as islands of habitat on warmer, south-facing slopes. Several thousand years may have passed before a warming trend allowed these isolated populations to once again move northward or upslope. Such was the probable origin of *C. affinis* (Fig. 26).

While the eventual competition for hostplants may have been a factor that contributed to the differences in their flight periods, seasonal fluctuations in temperature and rainfall in their northern flight ranges appear to have selected for their single annual generation and thus may explain the occasional synchrony of their flight periods.

With regards to the dispersal of *C. dumetorum* (Fig. 27) in the Pacific Northwest, fossil evidence showing the close resemblance between the subtropical Eocene forests of eastern Oregon and those of its west coast suggest that the Cascade Mountains were not yet in existence. Rocks from the Pliocene, however, indicate that this topographic-climatic barrier arose well before further differentiation in *C. dumetorum* populations had taken place. The two subspecies of *C. dumetorum* may have also diverged in what is now the Cascade Range in Oregon and spread northward. By then, advancing clusters of *Lotus* probably began to colonize the canyon bottoms of Oregon and Washington and their spread was undoubtedly well underway by the Holocene when humans were present. The resulting plant community that contained these pioneer *Lotus* species was affected by grazing, burning wood, and hunting (Larson, 1980).

In summary, *C. sheridanii* (Fig. 28) appears to have five relatively-distinct subspecies in the Pacific Northwest. On the east side of the Cascades, there appear to be three subspecies: (1) *newcomeri* - segregates that extend from lowland or desert regions of central and eastern WA; (2) *interrupta* – segregates found in the Great Basin and also on peaks and buttes in lowland desert regions of central and eastern OR; (3) nr. *neoperplexa* – populations that occur at lower elevations in the Columbia Basin of eastern WA. On the west side: (4) *pseudodumetorum*- populations that occur along the west slope of the Cascades and Siskiyou Mountains, with an isolated population in the Oregon Coast Range, and (5) *lemberti* – populations in southern OR to northwestern CA and the high elevations of the Siskiyou and Sierra Nevada Mountains and the southern Cascades.

Climatic pressures, competition and natural selection thus undoubtedly led to continual radiation throughout western North America and resulted in the many locally-adapted *Lotus*, *Ceanothus* and *Eriogonum*-feeding populations that exist today. These three species are now well known to exhibit sympatry or parapatry throughout their flight range.[2] East-west intergrades appear to exist between some populations of *C. sheridanii* in the Pacific Northwest yet **I found no conclusive evidence of such blends between *C. sheridanii* and *C. affinis* or between *C. affinis* and *C. dumetorum*.** Many of their intra-population scale characteristics on the wing undersides appear to be variably ecotypic, no doubt due to genes. Subspecies that do not interbreed despite possessing identical genitalia may be in the process of behaviorally separating into species and are thus likely by some to be called *incipient species* (McMillan *et al*, 1997); (Vila *et al*, 2005). Subspecies in ecotypic populations may not lead to the formation of incipient species, however. Distinguishing between traditional species and incipient species is very difficult so I now conclude that *C. sheridanii*, *C. affinis*, and *C. dumetorum* are incipient species.

One must assume that the habitats now frequented by *Callophrys* throughout the Pacific Northwest (e.g., scabland hummocks, Fig. 29) probably did not exist between 11 and 13,000 years ago.

Figures 26-28: Left: Male *C. affinis washingtonia* on *Cercocarpus* leaf, Hog Lake, Lincoln Co., WA, May 2016 (photo – Jeanne Dammarell). **Middle**: Male *Callophrys dumetorum dumetorum* on lemonadeberry (*Rhus integrifolia*), Irvine, Orange Co., CA, March 2016 (photo – Kim Moore). **Right:** *Callophrys sheridanii* is undoubtedly the most widespread and exhibits the most complex population structure of the three green hairstreaks in the Pacific Northwest. Pictured above is a male *Callophrys sheridanii* nr. *neoperplexa* on the ground at Stubblefield Lake, Turnbull National Wildlife Refuge, Spokane Co., WA, March 2016 (photo – John Baumann).

FIG. 29: Dominant scab sagebrush (*Artemisia rigida*) and scattered *Eriogonum heracleoides* at Stubblefield Lake, Turnbull National Wildlife Refuge, near Cheney, WA (Spokane Co.)

Owing to their taxonomically-confusing nature, I maintain that these three incipient species arose by parallel evolution from a single common ancestor as evidenced by the lack of genitalic differences. In the absence of fossil evidence, however, molecular data and future DNA studies will undoubtedly reveal the still-needed evidence required to clarify their evolutionary history. But to identify the "greenies", one needs to ascertain their habitat's dominant plant community, probable hostplants, locality elevation and adult behavior before adding collector and identification labels to specimens. So I believe that R.M. Pyle was correct in his field guide recommendation that one must *watch them* in the field *before* collecting them. Along with a field guide, be sure to bring your field notebook, camera, altimeter, map or GPS, and plenty of time and patience.

Footnotes:

1. The subspecies name *perplexa* was first rendered synonymous with nominal *dumetorum* by Gorelick (1971) but resurrected as a species by Emmel, Emmel, and Mattoon, 1998.
2. *Callophrys sheridanii viridis* and *C. dumetorum dumetorum* are sympatric at the Marina sand dunes, Monterey Co., CA. Close parapatry is exhibited by *Callophrys sheridanii sacramento* and *C. affinis albipalpus* in the Sacramento Mountains of Lincoln and Otero counties in New Mexico. Warren (2005) suggested that, as seen in western Oregon, *Callophrys sheridanii pseudodumetorum* occurs in sympatry or close parapatry with *C. dumetorum dumetorum* at Ruth Reservoir, Trinity Co., CA.

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Figure 30: Newly-emerged *Callophrys affinis washingtonia*, Twin Lakes, Lincoln Co., WA, April 2016 (photo – Jeanne Dammarell)

Thanks also go to Paul Hammond who reviewed the manuscript and provided some taxonomic input and to Jonathan Pelham, whose thoughts regarding their sympatry in Washington were also appreciated.

Close-up photos of adults were graciously provided by Carolyn Wright, Kim Moore, John Baumann, Jeanne Dammarell and Dana Ross. Pinned specimens were photographed using the camera flash apparatus and software assistance supplied by Steven Kutcher.

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I.C.Z.N. paratype specimen labeling standards were provided by Chris Marshall, O.S.A.C.

All specimens of *C. affinis washingtonia* and *C. dumetorum oregonensis* collected during my study were deposited in the following nine American museum collections, including those institutions cited in my 1968 [1970] publication: James Museum of Entomology, Washington State University, Pullman, WA; Burke Museum, University of Washington, Seattle, WA; Oregon State Arthropod Collection (OSAC), Oregon State University, Corvallis, OR; Nevada State Museum of Natural History, Carson City, NV; U.S. National Museum, Smithsonian Institute, Washington, D.C.; California Academy of Sciences, San Francisco, CA; Essig Museum of Entomology, University of California, Berkeley, CA; Natural History Museum of Los Angeles County, Los Angeles, CA; C.P. Gillette Museum of Arthropod Diversity, Colorado State University, Ft. Collins, CO.

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Announcements

Continued from p. 71

Society of Kentucky Lepidopterists

The Society of Kentucky Lepidopterists is open to anyone with an interest in the Lepidoptera of the great state of Kentucky. Annual dues are $15.00 for the hard copy of the News; $12.00 for electronic copies only.

The summer field trip will likely be to McCreary County in southern KY, weekend of June 14-17. Contact Loran Gibson, 859-384-0083 or **1stkymothman@gmail.com,** to learn more. The annual meeting is held each year in November, at the University of Kentucky, Lexington. Dates for 2018 are Nov. 9-10.

To join the Society of Kentucky Lepidopterists, send dues to: Les Ferge, 7119 Hubbard Ave., Middleton, WI 53562.

PayPal is the easy way to send money to the Society

For those wishing to send/donate money to the Society; purchase Society publications, t-shirts, and back issues; or to pay late fees, PayPal is a convenient way to do so. The process is simple: sign on to www.PayPal.com, and navigate to "Send Money", and use this recipient e-mail address: **kerichers@wuesd.org**; follow the instructions to complete the transaction, and be sure to enter information in the box provided to explain why the money is being sent to the Society. Thanks!

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Membership Updates

Chris Grinter

Includes ALL CHANGES received by 8 May 2018. Direct corrections and additions to Chris Grinter, **cgrinter@gmail.com.**

New Members: *Members who have recently joined the Society, e-mail addresses in parentheses. All U.S.A. unless noted otherwise. (red. by req. = redacted by request)*

Andrew H. Aldercotte: [address redacted by request] (andrew@aldercotte.com)
Elizabeth Avis: [address redacted by request] (libbyavis@shaw.ca)
Mike V.A. Burrell: [address redacted by request] (mike.burrell.on@gmail.com)
Janis K. Bush: One UTSA Circle, Dept. of Environmental Science and Ecology, San Antonio, TX 78249 (janis.bush@utsa.edu)
Laura E. Carter: [address redacted by request] (laura@dctx.com)
Ashley Mae Chepulis: 23 Echo Ave Apt 1, Gloucester, MA 01930 (Ashley.chepulis@gmail.com)
Julia B. Colby: 800 W Wells St., Milwaukee, WI 53233 (colby@mpm.edu)
Amanda L. Dookie: [address redacted by request] (amandadookie@gmail.com)
Erica Fischer: [address redacted by request] (fisch259@msu.edu)
Don Henne: Faculty of Natural Resources Management, 955 Oliver Rd., Thunder Bay, Ontario P7B 5E1 CANADA (dhenne@lakeheadu.ca)
Katherine Hernandez: [address redacted by request] (kahe3611@colorado.edu)
Michael Hofmann: 4442 S Beech Way, Morrison, CO 80465 (pinkmouse84043@yahoo.com)
Colin Jones: 300 Water St., 2nd Floor N, NHIC, OMNRF, Peterborough, Ontario K9J 3C7 CANADA (colin.jones@ontario.ca)
Benjamin Mous: [address redacted by request] (benmous@q.com)
Thomson Paris: 1573 SE Burning Lane, Port St. Lucie, FL 34952 (thomsonparis@ufl.edu)
Nantasak Pinkaew: Department of Entomology, Faculty of Agriculture at Kamphaengsaen, Kasetsart University Kamphaeng Saen, Nakhon Pathom 73140 THAILAND
Robert Reed: 215 Tower Rd., E145 Corson Hall, Ithaca, NY 14853 (robertreed@cornell.edu)
Jesus Arturo Ochoa Santana: Carrera 24 #48-62, Barranquilla, Atlantico 080012 COLOMBIA (ochoa.13@hotmail.com)
David H. Specht: 4320 SE 45th Ave., Portland, OR 97206 (dvdcspec@comcast.net)
Karen Taylor: [address redacted by request] (sac.8.mo@gmail.com)
Chris Tenney: 700 Briggs Ave. Space 14, Pacific Grove, CA 93950 (tenneyx2@mac.com)
Benjamin T. Wright: 677 Craghead St., Danville, VA 24541 (bwright@smv.org)
Chanchal Yadav: 312 Fergus Crescent, Ottawa, ON K2J 5S4 CANADA (chanchalyadav@cmail.carleton.ca)

Address Changes: *All U.S.A. unless otherwise noted.*

John R. Beck: 6534 McCarty Rd., Saginaw, MI 48603 (John.beck2@va.gov)
Diane M. Debinski: 310 Lewis Hall, Montana State University, Bozeman, MT 59717 (diane.debinski@montana.edu)
Alexander Grkovich: 4 Valley Circle, Peabody, MA 01960 (agrkovich2003@yahoo.com)
Brittany Harry: 840 Danish Drive, Fayetteville, NC 28303 (bdh0030@auburn.edu)
Richard A. Henderson Sr.: 2609 Welsford Way, Louisville, KY 40242 (mothcollector@twc.com)
Daniel Rubinoff: 310 Gilmore Hall, Entomology Section, University of Hawaii, 3050 Maile Way, Honolulu, HI 96822 (Rubinoff@hawaii.edu)

Marketplace (Books, etc.)

Continued from p. 89

Butterflies of Venezuela by Andrew Neild. Condition: NEW, in original packaging. Volume 1 -- Nymphalidae Limenitidinae, Apaturinae, Charaxinae -- $100 plus shipping from Washington DC. Volume II -- Nymphalidae Acraeinae, Libytheinae, Nymphalinae -- $145 plus shipping. Both volumes together $230. One copy available. Please write to Bob Robbins at **marulosada33@gmail.com**. 602

Research

Wanted: An adult specimen, either sex, of *Lophocampa roseata* for chemical analysis of the red wing pigment. Observations, photos, specimens of larvae and adults of the Spotted Tussock Moth, *Lophocampa maculata*, and *Lophocampa roseata* from all areas of North America, recent or old data. Records from Alaska and northern Canada, the desert SW, southern Appalachians and Pacific Coast are especially needed to define range. Records of early or late season observations are particularly valuable. All larval and adult photographs are useful, especially if they show unusual patterns of coloration. Specimens are desired for future genetic analysis. Contact Ken Strothkamp, Portland State University (**kstrot2@pdx.edu**). 604

WANTED: Specimens needed of *Carmenta ithacae* for DNA analysis and museum specimens (image attached). Will cover postage and will compensate collector ten dollars per specimen for up to 12 individuals. Please contact: William Taft at **billandgussie@earthlink.net** for more information or any questions. 604

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Papilio (Heraclides) caiguanabus Poey (Papilionidae): a new U.S. record from the Florida Keys, with notes on its name and food plant

John V. Calhoun[1,2] and Susan F. Kolterman[3]

[1]977 Wicks Drive, Palm Harbor, FL 34684 **bretcal1@verizon.net**
[2]Research Associate, McGuire Ctr. for Lep Research and Biodiversity, FL Museum of Natural History, Gainesville, FL
[3]30 Poinciana Drive, Key Largo, FL 33037 **sforrest6@bellsouth.net**

"Big News broke in the butterfly world this week." That is how an article in the *Miami Herald* newspaper began on 22 June 2017, three days after the junior author (SFK) photographed an unusual butterfly on Key Largo, Monroe County, Florida (Staletovich 2017). On 19 June 2017, while hiking along the Grove Trail at the northern edge of John Pennekamp Coral Reef State Park, SFK encountered what she thought was a slightly battered *Battus polydamas* (L.) as it visited the flowers of wild coffee (*Psychotria nervosa* Sw.). This trail winds through a tropical hardwood hammock, then opens onto an old grove of scattered, small citrus trees. Two photos of the butterfly were taken as it perched on a nearby vine. While examining the photos later that day, SFK noticed that the butterfly had a hindwing tail, unlike *B. polydamas*. She immediately sent one of the images (Fig. 1) to South Florida naturalist Roger L. Hammer, who suggested that it was *Papilio caiguanabus* Poey, a Cuban species popularly known as Poey's black swallowtail or Poey's swallowtail. Soon after, the image was forwarded to the senior author (JVC), who confirmed that it was indeed a male *P. caiguanabus*. Several people accompanied SFK to the same area the following day, but the butterfly was not relocated.

Figure 1. *Papilio caiguanabus*, male, 19.vi.2017, Key Largo, Monroe Co., FL (S. F. Kolterman).

Papilio caiguanabus is endemic to Cuba and Isla de la Juventud (Isle of Youth; formerly Isle of Pines). It occurs locally in xeric habitats throughout Cuba, from sea level to about 1000 ft., possibly more frequently on the eastern side of the island. It is uncommon to rare, though it can be locally common at times (Bates 1935, Riley 1975, Collins & Morris 1985, Alayo & Hernández 1987, Smith et al. 1994, Tyler et al. 1994, Hernández 2004, Lewis 2010). The general scarcity of *P. caiguanabus* in Cuba makes its appearance in Florida all the more unexpected. The butterfly on Key Largo possibly arrived a short time before it was observed, having been carried northward on southerly storm winds, which may account for its condition. Alternatively, it arrived in good condition and was present for some time (Staletovich 2017). There is no evidence that a local population is established on Key Largo.

The name. The original publication date of the name *P. caiguanabus* has been reported in the literature as 1851, 1852, or 1854. This confusion is understandable. The volume that includes the description of this butterfly was not published all at once, but was issued in parts from November 1851 to June 1854 (Norman 1938, Romero 2014). Although its title page is dated 1851, an inconspicuous notation in the volume indicates that the pages on which the written description of *P. caiguanabus* appears were published "en Junio de 1854" (in June of 1854). In addition, a hand-colored, lithographed plate, portraying butterflies identified as "Papilio *Caiguanabus Poey*" (Fig. 2), was published in the same volume in "Octubre 1852" (October 1852). Poey referred to this plate in his written description of 1854. Because the figures on the plate are named, they represent an indication (i.e. description) of this nominal taxon. The correct publication date of *P. caiguanabus* is therefore October 1852, despite that the written description of the species appeared almost two years later. No publication date is directly associated with the plate, thus the year is given in brackets following the name (i.e. *Papilio caiguanabus* Poey, [1852]), in reference to Poey ([1852]). Some authors (e.g. Lewis et al. 2014) place *caiguanabus* within the genus *Heraclides*. For the purposes of this article, we take a conservative approach and use *Papilio*, though Shiraiwa et al. (2014) offer a compelling argument for recognizing *Heraclides* as a genus, rather than as a subgenus of *Papilio*.

The name of this species is rather unusual. In the original description of *P. caiguanabus*, Poey (1854) remarked "Lleva un nombre indio" ("It has an Indian name"). About 75 miles west of Havana, Cuba, in the Pinar del Rio Province, the name Caiguanabo has been associated with a least four geographical features: a cave system, a mountain range, a river, and a settlement. This is an aboriginal word, meaning

Figure 2. Plate 15 of Poey [1852], which represents the "original description" of *P. caiguanabus*.

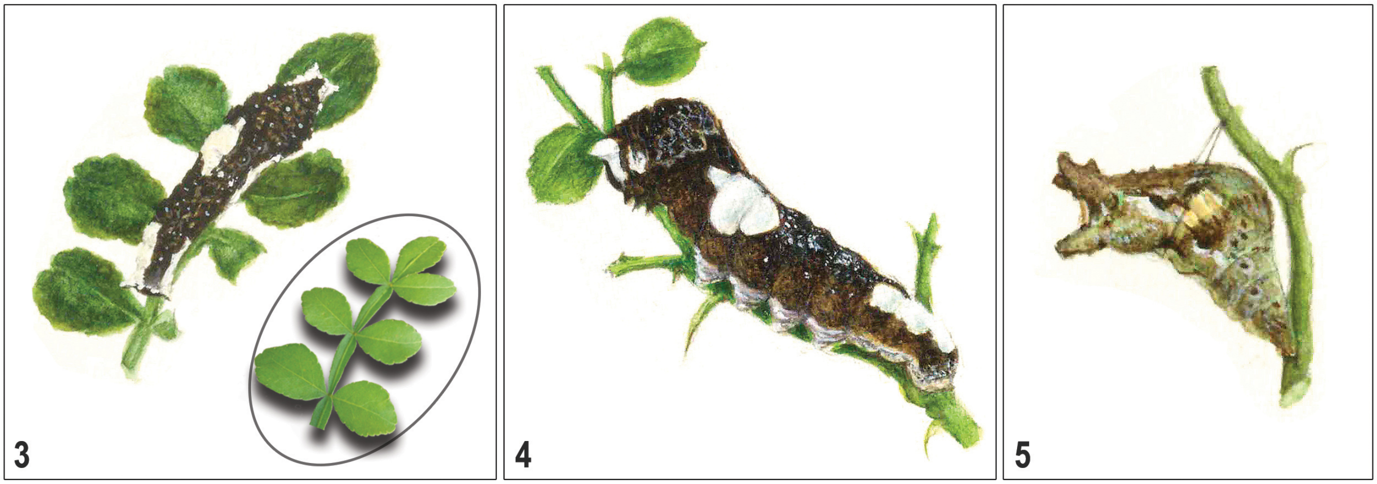
a large property or plantation (Bachiller 1883). The Cuban zoologist Felipe Poey (1799-1891) evidently borrowed this name for his new butterfly. Based on the pronunciation of Caiguanabo (see Heilprin & Heilprin 1922), the butterfly's name should be pronounced "ki-gwa-na'-boos."

Food plant. Riley (1975) reported that *P. caiguanabus* feeds on *"Securinega acidothannus."* Properly spelled *acidothamnus*, this name is now treated as a synonym of *Flueggea acidoton* (L.) G.L.Webster (simpleleaf bushweed) of the family Euphorbiaceae. This alleged food plant was repeated in the literature without further investigation into its source. As noted by Collins and Morris (1985), this would represent an unlikely host for a butterfly of the subgenus *Heraclides*, whose members typically feed on plants of the citrus family, Rutaceae. Tyler et al. (1994) suggested that the report of *F. acidoton* (as *S. acidothamnus*) probably refers to a pupation site or a misidentified species of *Zanthoxylum* (Rutaceae), as adults of *P. caiguanabus* have been seen in areas where *Zanthoxylum* grows in abundance.

Riley (1975) cited "Miss M. E. Fountaine, unpublished drawings and notes" as the source of the reported food plant of *P. caiguanabus*. Margaret E. Fountaine (1862-1940) was an adventurous English lepidopterist who travelled the world from 1892 to 1940, collecting and rearing butterflies, and illustrating their early stages (Cater 1980, Scott-Stokes 2006, Waring 2014). Four volumes of her original watercolor drawings were bequeathed to The Natural History Museum, London (NHMUK). Norman D. Riley (1890-1979), former keeper of entomology at the museum, met Fountaine in 1913 and later organized the acquisition of her drawings during the 1940s (Harvey, et al. 1996). Fountaine's 862 drawings are arranged in chronological order by locality. Multiple larvae and pupae are portrayed on each page, and brief notes are written next to each figure. Larvae are typically shown resting or feeding on leaves of their supposed food plants. Fountaine often confined live female butterflies and fed them sugar water until they laid eggs. If she did not know the food plant, she would introduce a selection of potentially suitable plants to the resulting larvae (Fountaine 1911). Her writings indicate that she solicited the help of others to identify the plants. After her death in 1940, Fountaine's twelve-volume diary was bequeathed to the Norwich Castle Museum, Norwich, England (NCM). It was contained in a locked trunk with orders that it not be opened until 1978 (Cater 1980).

Fountaine first visited Cuba from October 1910 to early 1911, surviving the devastating 1910 Cuba hurricane while traveling onboard the steamship *Olivette* from Tampa to Havana (Cater 1980; Fountain diary, NCM). She returned to Cuba two decades later, arriving during the autumn of 1931 and departing in early March 1932. She journeyed alone during the latter trip (at 69 years of age), starting out aboard a largely empty "big Boat of the Ward Line" from New York to Havana. Soon after, she endured a bumpy 5.5 hour flight to Santiago de Cuba, being the only woman among several Cuban men; her courage bolstered by a swig of brandy. A week later, Fountaine made her way eastward (presumably by rail) to the village of Guantánamo, where she lingered for several months (Cater 1987, Scott-Stokes 2006; Fountaine diary, NCM). She later recalled, "I dreaded the thought of going alone to Cuba. I had not one friend or acquaintance on the Island, and I felt I had neither the physical strength, or the moral courage to face what was before me" (Fountaine diary, NCM). Despite her anxiety, Fountaine fearlessly explored the Cuban countryside in search of butterflies. She also reared many species, some for the first time.

Fountaine's butterfly collection of over 23,000 specimens also was bequeathed to NCM. Based on her surviving specimens, she first encountered *P. caiguanabus* in October 1931, in the vicinity of Guantánamo. She collected three adults (two males, one female) in October and November. Her collection also contains six specimens of *C. caiguanabus* that she reared in November 1931 from eggs (two males, one female) and larvae (one male, two females). The adults emerged June-September 1932. Because Fountaine left



Figures 3-5. Drawings of the early stages of *P. caiguanabus*, Guantánamo, Cuba, by M. E. Fountaine (© The Natural History Museum, London). **3,** young larva on *Zanthoxylum* cf. *fagara*, 12.xi.1931. Inset is a leaf of *Zanthoxylum fagara* for comparison. **4,** mature larva on *Zanthoxylum* cf. *fagara*, 19.xi.1931. **5,** pupa, 22.xi.1931.

Cuba on 8 March 1932, the butterflies presumably emerged at her home in London. Unfortunately, Fountaine's diary does not mention rearing *P. caiguanabus*. In Cuba, adults of this species reportedly begin to emerge at the onset of the wet season, which generally arrives in May (Tyler et al. 1994), though they have been recorded earlier in the year (Fernández-Hernández 2007).

In an attempt to confirm the food plant of *P. caiguanabus* reported by Riley (1975), JVC obtained an image of Fountaine's illustration at NHMUK. Three figures of the larva and pupa are included on sheet 74, within the third volume of her drawings (Figs. 3-5). They represent the only known record of the early stages of this species. The figures clearly portray a member of the subgenus *Heraclides*, and the larvae resemble those of *Papilio* (*Heraclides*) *andraemon* Hübner, which Fountaine reared on orange (*Citrus* sp.) at Guantánamo, and illustrated on the same sheet of drawings. The pupa of *P. caiguanabus* appears to be differently colored than that of *P. andraemon*.

Fountaine's notes for her figures of *P. caiguanabus* read:

"271. Young Larva of Papilio Caiguanabus, on leaves of Securinega Acidothannus [sic]. Guantánamo (Oriente) Cuba, West Indies. Nov:12:1931" (Fig. 3).

"271^{a}. Full grown Larva of Papilio Caiguanabus, on a stalk of Securinega Acidothannus [sic]. Guantánamo (Oriente) Cuba, West Indies. Nov:19:1931" (Fig. 4).

"271^{b}. Pupa of Papilio Caiguanabus. Guantánamo (Oriente) Cuba, West Indies. Nov:22:1931" (Fig. 5).

Fountaine's misspelling of the plant name explains why the same mistake was made by Riley (1975), who merely reiterated Fountaine's notes. It is unknown who identified the plant for Fountaine, but it was possibly the Cuban zoologist Charles T. Ramsden (1876-1951), whom she first met at Santiago de Cuba. They later spent time at his home in Guantánamo and collected butterflies together in that area (Fountaine diary, NCM). Fountaine was also accompanied in the field by the amateur entomologist Mercedes O. Cubría (1803-1980), who "seemed to have a real passion for these wild forest insects" (Fountaine diary, NCM) (Fig. 6). Cubría is best known for becoming the first Cuban-American woman to reach the rank of lieutenant colonel in the United States Army, earning the Bronze Star and Legion of Merit Awards during her long military career (Mendoza 2004).

Fragments of the food plant of *P. caiguanabus* are visible in Fountaine's illustrations (Figs. 3-5), and they do not agree with *F. acidoton*. To determine the species, Fountaine's figures were shared with three experienced botanists: Pedro

Figure 6. Margaret E. Fountaine (right) and Mercedes O. Cubría collecting butterflies on horseback near Guantánamo, Cuba, 1931/32 (Fountaine diary, courtesy Norwich Castle Museum).

Acevedo-Rodríguez (National Museum of Natural History, Smithsonian Institution) Alan R. Franck (University of South Florida Herbarium), and Mark A. Garland (United States Department of Agriculture). All identified the plant as a species of *Zanthoxylum*, most likely *Z. fagara* (L.) Sarg. (wild lime, lime prickly-ash). The small, obovate leaflets with crenate margins, marginate leaf rachis (barely visible below the larva in Fig. 3) and hooked thorns (see Figs. 4 and 5) are consistent with that species. *Zanthoxylum fagara* is widespread in the Neotropics and ranges northward to Texas and Florida (Tropicos 2018). *Papilio caiguanabus* could conceivably become established in extreme southern Florida (at least temporarily) if a stray gravid female were to encounter *Z. fargara* or another acceptable species of Rutaceae. Three other swallowtails in Florida (all within the same subgenus) are known to feed on this plant: *P. andraemon* (Hübner), *P. aristodemus* Esper, and *Papilio cresphontes* Cramer (Minno et al. 2005).

Finally, Lauranzón et al. (2013) listed "*Laetia* sp." as a food plant of *P. caiguanabus* without explanation. This is an unlikely host, as this genus is a member of the family Salicaceae, which includes willows, poplars, and aspens. Among approximately 570 worldwide species of Papilionidae, only two or three are known to withstand the toxic effects of these plants, and they belong to North American members of the subgenus (or genus) *Pterourus* (Lehnert & Scriber 2012). It is hoped that lepidopterists in Cuba will soon confirm *Zanthoxylum* as the host of *P. caiguanabus* and publish a more detailed life history.

Acknowledgements

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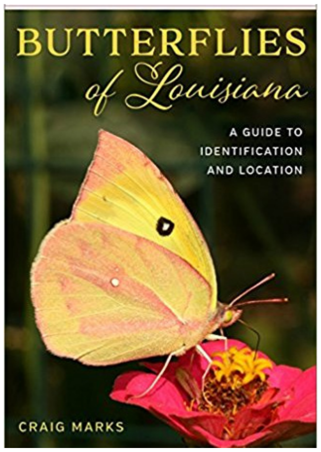

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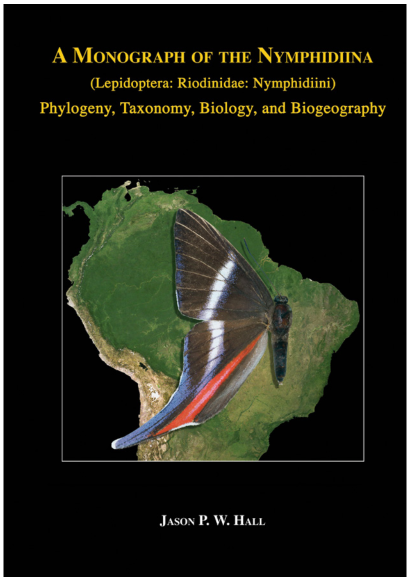

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Marketplace continued on pg. 83

Research on the evolutionary age and origin of ghost moths (Hepialidae)

John R. Grehan[1] and Carlos Mielke[2]

[1]Research Associate, Section of Invertebrate Zoology, Carnegie Museum of Natural History, 4400 Forbes Ave.,
Pittsburgh, PA 15213 **Calabar.John@gmail.com**
[2]Caixa Postal, 1206, 84145-000 Carambeí, Paraná, Brazil **Cmielke1@uol.com.br**

Exploring the age and geographic origin of biological groups is an essential part of evolutionary biology. These concerns have been the subject of intense exploration, debate and controversy for more than a century and a half (Craw, 1982; Craw *et al*., 1999). A key challenge has been how to reliably determine the evolutionary age of taxa and understand how sister taxa often occupy different places (allopatry). The fossil record would seem to be an obvious source for dating, but it is sporadic and most clades lack a fossil record altogether. In addition, there is no empirical way to know if, and by how much, the phylogenetic age may precede the oldest fossil of a group. In recent decades a solution appeared to be found, as degree of molecular divergence was thought to provide a measure of evolutionary time. Fossils were used to date particular nodes and then extrapolate dates for those nodes where fossils are absent. This method has become widely used as a means to verify the ages of taxa that can falsify earlier origins.

Leaving aside the question of whether different groups share a common molecular clock, the problem with this approach is the use of fossils to calibrate divergence. Since fossils only provide a minimum record of phylogenetic age, then so too do the extrapolated molecular divergence dates (Ho & Phillips, 2009). The setting of 'priors' to impose a confidence level for how much older the group is likely to be than its oldest fossil does not overcome this problem, since there is no empirical means by which to set the age limits or their probability.

Another method is to use island ages as calibration points, but this relies on the island being accurately dated and assumes that the endemic taxa are no older than the islands. This assumption is contradicted by molecular divergence studies that show cases of endemic taxa being older than the islands they occupy. These methodological constraints are usually overlooked when molecular dates are used to preclude earlier origins of clades and the role of earlier historical events (Heads, 2005a, b).

With growing awareness of the problem of minimum ages inherent in fossil and island calibrated divergence estimates, some molecular theorists have begun to recognize the validity of tectonic correlations to date phylogenetic nodes (Ho *et al*. 2017, Landis *et al*. 2017). This approach uses the age of tectonic formations separating allopatric taxa to date the age of clade divergence. In this approach, a divergence estimate represents an actual date (or its approximation) rather than a minimum date, as generated by fossil calibrations. While this approach is fairly new in molecular clock applications, correlating tectonics with distributions to provide phylogenetic ages has been used in biogeography since the 1960s (Craw *et al*., 1999).

Recent global and regional applications of tectonic-biogeographic correlation have shown a cohesive pattern of spatial correspondence between the distributions of allopatric taxa and tectonic structures. Tectonic activity on the latter often dates back to Mesozoic time (Heads 2012, 2014, 2017). Many different taxa share particular patterns of distribution with respect to ocean basins, the most extensive tectonic features of the planet. Other correlations involve clade boundaries with belts of compression, and reverse faulting. These correlations have important implications for understanding both the evolution of life and the ecological relationships of organisms and their environments.

The use of oldest fossil age and island age to calibrate time trees has often led to view that most of modern life is young (post-Gondwana breakup) and the result of chance, long distance dispersal across continents and oceans. This dispersal model views the ability to disperse over long distances as both the mechanism of range expansion and the source of evolutionary divergence (Craw *et. al*., 1999; Heads 2012). The idea that molecular divergence dates are younger than the ocean basins means that trans-oceanic chance dispersal must be invoked to explain the origin of allopatry. This leads to a contradictory situation in which, on the one hand, taxa are supposed to be highly mobile (including apparently poor dispersers), while on the other hand such events have to be so rare (usually unique) so as to not overwhelm the geographic isolation necessary for divergence.

The tectonic correlation method does not create a contradiction between dispersal ability and the need for geographic isolation. Instead it leads to a model of evolution in which the mobility of organisms usually operates as a means of ecological survival that may also result in range expansion, but not divergence. It is the imposition of isolating mechanisms (whether ecological or geological) upon the distribution range that can lead to divergence (called vicariance). This results in allopatric taxa originating locally rather than having dispersed from elsewhere. In this model, overlapping or sympatric distributions are evidence of dispersal whereas allopatric distributions are evidence of vicariance (Craw *et al*., 1999; Heads, 2012).

A recent global and regional application of tectonic correlation methods was based on a wide range of groups with well resolved phylogenies and distribution records (Heads 2012, 2014, 2017). This analysis provided substantial evidence for vicariance as the principal mechanism in the evolution of modern life. In view of these findings we decided to examine the applicability of tectonic correlation to the evolution and distribution of ghost moths – the Exoporia, in which the Hepialidae or true ghost moths comprise the vast majority of species.

Ghost moths are more or less globally distributed and have a relatively basal position in lepidopteran phylogeny, and so they provide a potentially interesting group for biogeographic study. Unfortunately, the phylogeny of ghost moths is still poorly understood, and it is not yet possible to generate the same kind of phylogenetic comparisons presented in Heads' (2012, 2014, 2017) work. What was possible, however, was a preliminary analysis of the Southwest Pacific region, for which as several monographic and other taxonomic treatments are available (e.g. Gibbs, 1990; Dugdale, 1994; Simonsen, 2015, 2018). These works identified reliable monophyletic units (genera and species) along with detailed distribution records. This biological information was compared with many detailed tectonic maps and reconstructions to identify tectonic correlations for ghost moth genera and species in the Southwest Pacific.

Our analysis, recently published in *Zootaxa* (Grehan & Mielke, 2018), found that the distributions of many ghost moth species closely matched tectonic structures of Mesozoic or Cenozoic age. From these findings we suggested that the ghost moth fauna of the region represented a substantially intact Mesozoic fragment of an East Gondwana biota. We pointed out that not only had individual species survived from that time, but that many of their distributions had retained at least part of their original boundaries.

Australian ghost moths were found to have distributional boundaries coinciding with two principal tectonic formations – the Whitsunday Volcanic Province (WVP) (including the biogeographic region known as the McPherson-Macleay Overlap (MMO) at its southern margin), and the Otway-Bass-Gippsland Basin system (OBGB) between Tasmania and the mainland. The MMO is one of the most prominent biogeographic centers in Australia (Heads, 2014) and it lies on the Clarence-Moreton basin, active in Jurassic and Cretaceous time. For ghost moths the MMO is the northern range limit for 84% of Australian species. The WVP represents a vast region of magmatism in East Gondwana that was active at 195-132 Ma. The OBGB lies across southeastern Australia and Bass Strait (separating Tasmania from the mainland). It is a region of Mesozoic to lower Cenozoic basins that formed as a failed branch of the southern ocean rift that developed prior to the separation of Australia and Antarctica (Heads, 2014).

The historical impact of these Mesozoic structures may be illustrated by the example of the sister species group *Abantiades aphenges* (Turner, 1904) and *A. fulvomarginatus* (Tindale, 1932) (Simonsen, 2018). These have an allopatric distribution disjunct between eastern and western Australia (Fig. 1) that might be seen as the result of dispersal from one or other of the two localities. However, a vicariance origin is consistent with the 'boxing in' of *A. aphenges* between the WVP and OBGB. This suggests a tectonic origin of the species, and the break between it and the Western Australian species. The southern boundary of *A. aphenges* at the OBGB rather than further south at the edge of Bass Strait suggests that the species range did not expand beyond the former basin. Seven other ghost moth species have a similar distributional boundary while a further nine species extend only to the northern edge of Bass Strait.

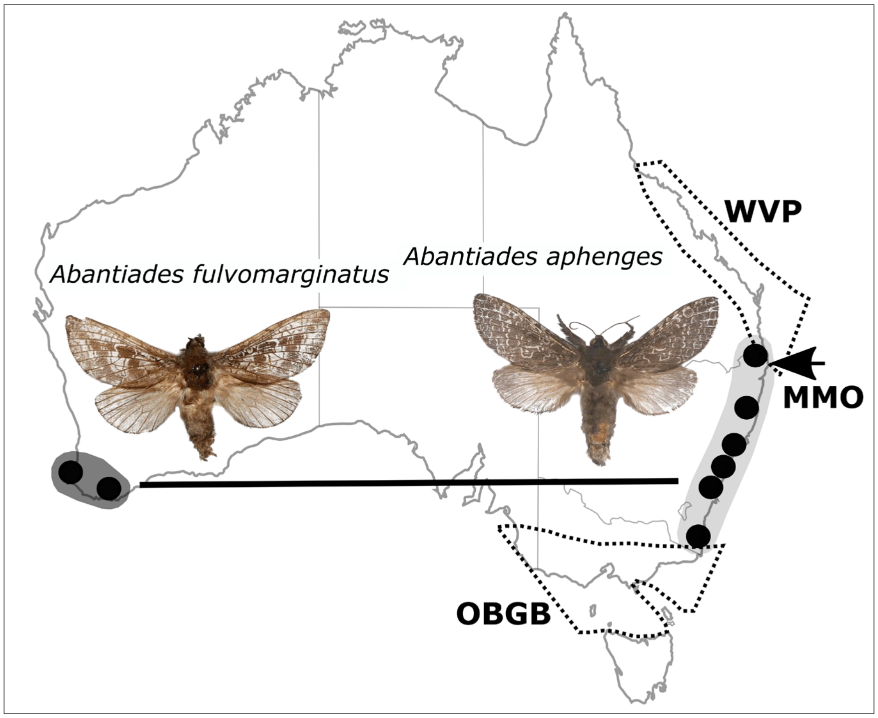

Figure 1. Sister species disjunction involving a western *A. fulvomarginatus* and an eastern *A. aphenges* boxed in by the Otway-Bass-Gippsland Basin system (OBGB) and southern boundary of the Whitsunday Volcanic Province (WVP) at the McPherson-Macleay Overlap (MMO), arrow. Modified from Grehan & Mielke (2018). Species photos: Len Willan & CSIRO Ecosystem Sciences.

In New Zealand the most prominent tectonic features are the Alpine fault and the associated Southern Alps. Strike-slip (horizontal) movement along the fault began about 23 million years ago and has resulted in a 470 km displacement of geological belts that crossed the fault. A similar displacement is observed in at least 225 taxa, including terrestrial and

Figure 2. Example of a distributional disjunction correlated with the Alpine Fault in New Zealand separating populations of *Wiseana jocosa*. Modified from Grehan & Mielke (2018). Photo: Landcare, New Zealand.

marine forms (Heads, 2017). This historical influence is seen in about 11 ghost moth species and is illustrated here by the disjunct distribution of *Wiseana jocosa* (Meyrick, 1912) with a northern range west of the fault and a southern range east of the fault (Fig. 2). The boundaries of the distribution correspond with the Alpine Fault and not with the Southern Alps. This tectonic correlation suggests that the ancestral range of *W. jocosa* existed prior to initial movement of the fault 23 million years ago, and that species level differentiation has apparently not yet occurred in that time. In other taxa (including the ghost moth genus *Dioxycanus*) species differences are found (Heads, 1990; Heads & Craw 2004).

The influence of tectonics on evolutionary differentiation is not confined to horizontal displacement. As tectonic movements thrust land up or down, they will also transport the resident plants and animals to higher or lower elevations. If a lowland species has the biological qualities that allow survival at higher elevations, or the ability to evolve them, they will persist, while those that do not will become extinct. Where organisms survive tectonic uplift the resulting topographic isolation may lead to differentiation (Fig. 3a) (Heads, 2012, 2014, 2017). This process is illustrated here by the disjunct allopatric distribution of *Aenetus montanus* Tindale, 1953 at about 1500 m in eastern Australia and its sister species *A. ombraloma* (Lower, 1902) at a lower 300-1000 m elevation range in Tasmania (Fig. 3b). A vicariance origin for this pattern would involve a widespread ancestral distribution across what is now Tasmania and southeastern Australia that was disrupted by uplift of the Blue Mountains (beginning about 90 Ma). This resulted in divergence between upland and lowland populations.

Altogether, our study examined tectonic correlations for about 17 species in New Zealand and 23 species in Australia. We also considered some wider regional distribution characteristics for the splendid ghost moths (*Aenetus*) distributed across Australia, New Guinea, New Zealand, and parts of Indonesia, and the potential relationships between the Australasian oxycanine moths and genera in eastern Asia. Finally, we also considered the role of

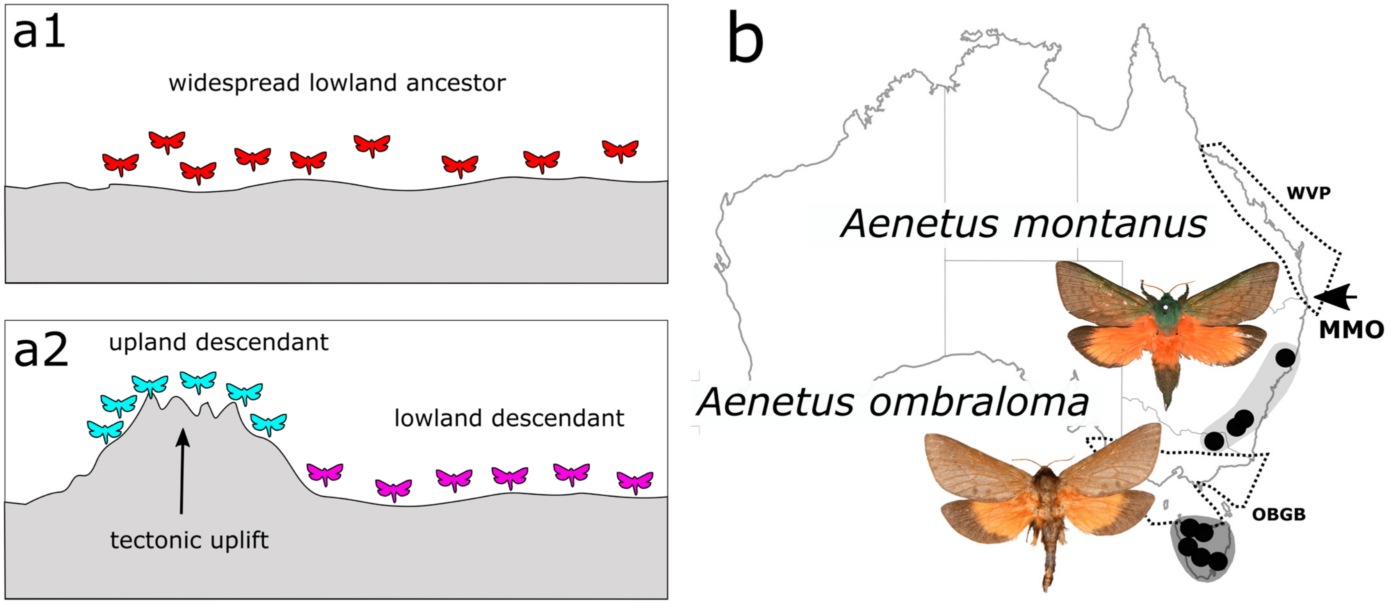

Figure 3. Divergence by tectonic uplift: (a) concept of divergence by tectonic uplift involving original lowland ancestor (a1) subjected to uplift resulting in geographic isolation and differentiation (a2); (b) allopatric distribution of high elevation *Aenetus montanus* and lower elevation sister species *A. ombraloma*.

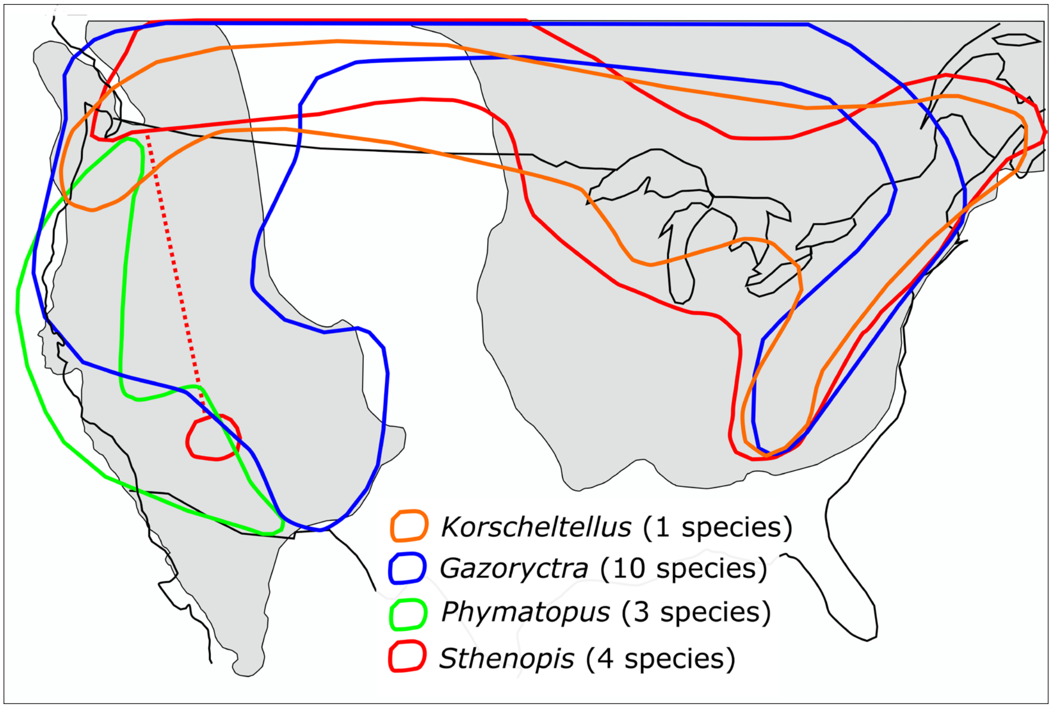

Figure 4. Generalized map of Cretaceous inland seas with superimposed outline distribution ranges of northern North American ghost moth genera showing absence of taxa in submerged regions (northernmost geography not included). Individual species distributions and northern range limits are not shown (cf. Grehan & Mielke 2018).

tectonic history in the origin of the endemic Southwest Pacific islands genus *Phassodes* (Solomon Islands, Fiji, and Samoa). Through these examples our findings support the argument presented by Heads (2012, 2014, 2017) that most regionally distributed animals and plants, including those that occupy oceanic islands, have their origins in vicariance events dating back to different landscapes in the Mesozoic. This view is not in conflict with fossil-calibrated molecular divergence dates as such estimates do not preclude or falsify earlier origins.

Future studies on the ghost moths of other regions are also likely to be historically informative. For example, the distribution range of the southern African ghost moth fauna lies to the south and east of a former Cretaceous inland sea (now the Congo basin) (cf. Heads, 2012). In northern North America there is an interesting absence of endemism and a relative lack of species representation in regions that were submerged by inland seas during the Cretaceous (Fig. 4). Regardless of where one may stand on these and other historical models, our study of the Southwest Pacific establishes that there are tectonic correlations with ghost moth distributions that are consistent with Mesozoic vicariance, and that such evidence should be considered in future studies of Exoporian biogeography.

Acknowledgements

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Conservation Matters: Contributions from the Conservation Committee

Anthropogenic threats to high-altitude parnassian diversity

Fabien L. Condamine[1] and Felix A.H. Sperling[2]

[1]CNRS, UMR 5554 Institut des Sciences de l'Evolution (Université de Montpellier), Place Eugène Bataillon, 34095
Montpellier, France **fabien.condamine@gmail.com, *corresponding author***
[2]Department of Biological Sciences, University of Alberta, Edmonton T6G 2E9, Alberta, Canada

Introduction

Global mean annual temperatures increased by ~0.85° C between 1880 and 2012 and are likely to rise by an additional 1° C to 4° C by 2100 (Stocker *et al.* 2013). Anthropogenic climate warming is driving the geographic distributions of most species toward higher latitudes and elevations (Parmesan 2006). Climate-driven local extinctions are already widespread, and recent results show that such extirpations have occurred in hundreds of species, including 47% of 976 plant, insect, vertebrate and marine invertebrate species surveyed (Wiens 2016).

For insects, numerous studies have shown the impact of climate and habitat change. Perhaps the most alarming recent one was on flying insect diversity, with collecting traps deployed over 27 years in 63 nature protection areas in Germany (Hallman *et al.* 2017). They found a seasonal decline of 76% and mid-summer decline of 82% in flying insect biomass due to unknown large-scale changes whose influence extended into protected areas. Climate change has more clearly been implicated in both latitudinal and elevational shifts in Lepidoptera species distributions. A pioneering study on 35 non-migratory European butterflies showed that 63% of the species shifted their ranges to the north by 35–240 km in the 1900's, and only 3% shifted to the south (Parmesan *et al.* 1999). Such range shifts carry risk; a recent study of Canadian butterflies has demonstrated significant "climate debt," with an increased gap between required and realized range shifts for species with smaller ranges (Lewthwaite *et al.* 2018). In the tropics, a study of geometrid moths at Mount Kinabalu, Malaysia, found that in 42 years the leading margins of their distributions shifted uphill faster than the trailing margins retreated, with many species increasing their elevational extents (Chen *et al.* 2011). However, this did not result in increases in range area because the area of land available declines with increasing elevation. Accordingly, extinction risk may increase long before species reach a summit, even when undisturbed habitats are available. This is a particular concern for high-altitude adapted insects, like the parnassians or Apollo butterflies (genus *Parnassius*).

Current diversity and evolution of parnassians

Parnassians are well-known butterflies representing at least 60 species with a northern circumpolar and mountain distribution. They occur in almost all mountain ranges of the Northern Hemisphere from the Rocky Mountains to the Himalayas. Except for a few widespread species like *Parnassius apollo* (**Fig. 1**), most current *Parnassius* diversity is restricted to mountain valleys or the highest places of the world, with many microendemic species. High-altitude species often live at 4000m, occurring even at Everest Base Camp (e.g. *Parnassius epaphus*).

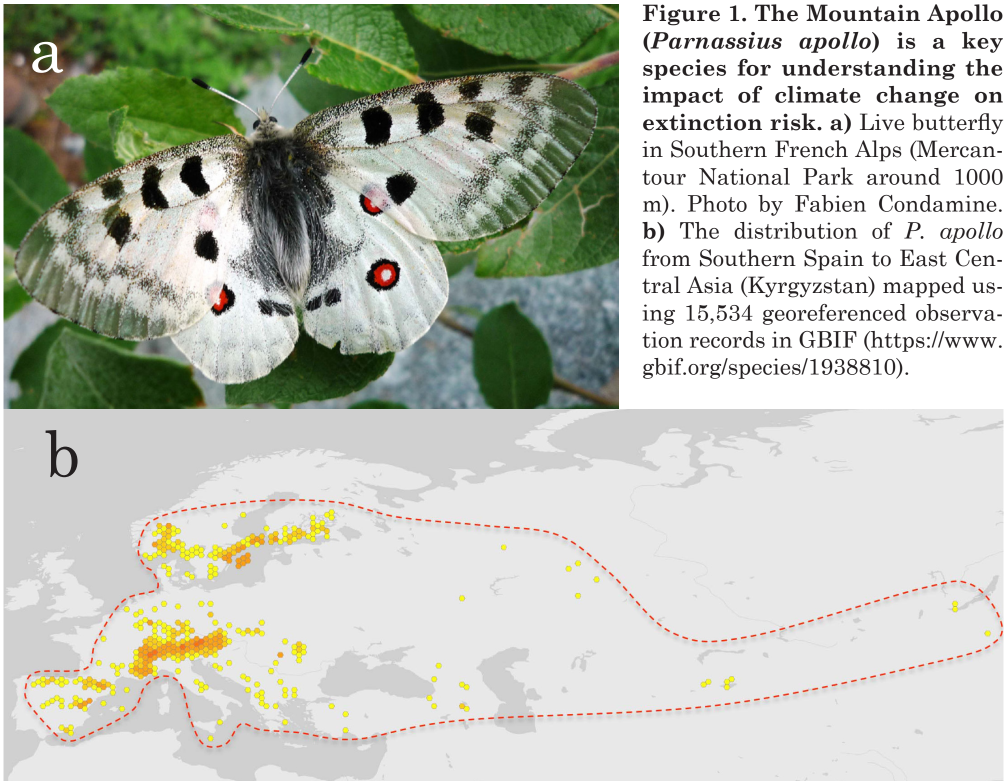

Figure 1. The Mountain Apollo (*Parnassius apollo*) is a key species for understanding the impact of climate change on extinction risk. a) Live butterfly in Southern French Alps (Mercantour National Park around 1000 m). Photo by Fabien Condamine. **b)** The distribution of *P. apollo* from Southern Spain to East Central Asia (Kyrgyzstan) mapped using 15,534 georeferenced observation records in GBIF (https://www.gbif.org/species/1938810).

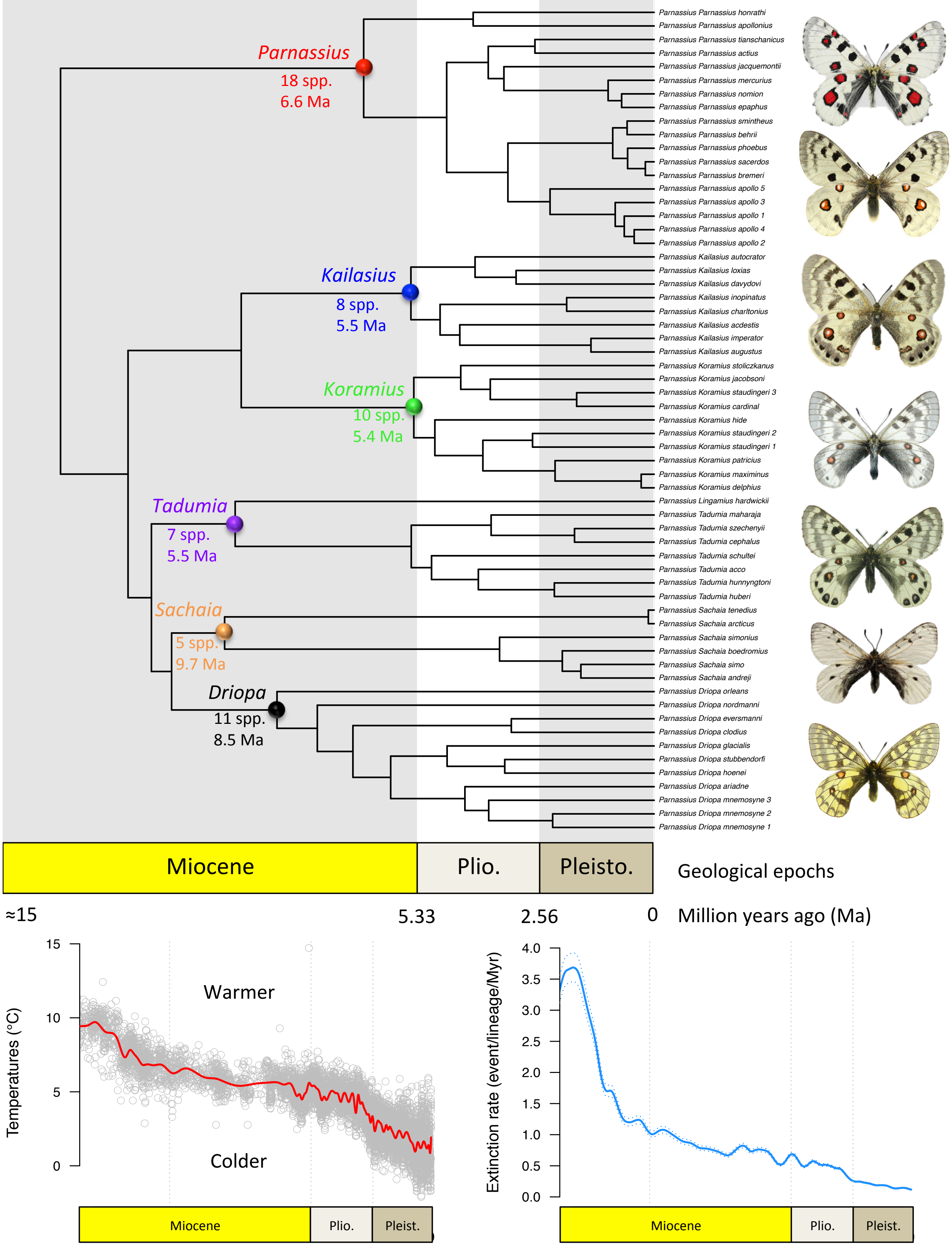

Figure 2. The evolutionary history of *Parnassius* indicates the genus originated 15 million years ago in Central Asian mountains. The phylogeny is based on both molecular and morphological data (adapted from Condamine *et al.* 2018). The dated phylogeny allows its biogeographic history to be inferred from current distributions, and the diversification rates to be estimated. In this case, we inferred a peak in extinction rates linked to the warmest time in the Miocene.

A comprehensive revised parnassian phylogeny indicates a mid-Miocene origin in Central Asian mountains and the Tibetan Plateau (**Fig. 2**, Condamine *et al.* 2018). Our data suggest that parnassians colonized mountains during a warming event 15 Ma which suggests that *Parnassius* was already a mountain-adapted group that escaped warm climate of this period. The genus subsequently diversified into six subgenera that constitute independent mountain radiations. Some subgenera are isolated mountain radiations in a local area (e.g. subgenera *Kailasius* and *Tadumia* in the Himalayas), while others colonized multiple mountain areas (e.g. subgenera *Driopa* and *Parnassius*). Although allopatric speciation has been an important mechanism in the diversification of *Parnassius*, a diversity equilibrium has been reached and sympatric overlap between species is now common within subgenera, suggesting ecological constraints on the creation of new species (Condamine 2018).

Many *Parnassius* species are isolated in mountain patches and at high risk of extinction from environmental change (Todisco *et al.* 2010, 2012; **Fig. 3**). As mountain specialists they can likely track their climatic niches by climbing up mountains until they can go no higher (Wilson *et al.* 2005; Settele *et al.* 2008). Given that a substantial part of their current species diversity already occurs at high altitude, parnassians are especially likely to be threatened by climate change. Using a phylogeny of parnassians, diversification models indicate that they have been historically sensitive to global warming, with their extinction rate increasing with warmer temperatures (**Fig. 2**). Projecting this evolutionary trend to future climate implies that parnassian species will have a high probability of going extinct as the world becomes warmer, and a cascade effect can be expected when their ecological interactions get reshuffled with host-plant species dropping out.

Status and threats to parnassian diversity

Parnassians are conspicuous mountain insects that are both attractive to collectors and easy to monitor as adults. Decreased population sizes can be detected and allow assessment of extinction risk for species. Based on numerous studies, four major anthropogenic threats to *Parnassius* species can be identified (**Fig. 4**).

First, global climate change will directly affect species distributions, with the elevational distribution of *Parnassius* species shifting upward on mountains. However, mountain ranges are finite geographical and ecological areas with constraints on movement, and even the highest mountains constitute ecological and evolutionary limits for parnassians (Condamine 2018). There is evidence for an upshift of 200m for the distribution of *Parnassius apollo* in central Spain (Wilson *et al.* 2005). Multiple studies on the Rocky Mountain parnassian (*Parnassius smintheus*) based on two decades of observations and experimental data show the effect of climate change on overwintering survival, larval development, date of emergence and adult activity, with both low and high extreme temperatures in November causing the most population change (Roland and Mat-

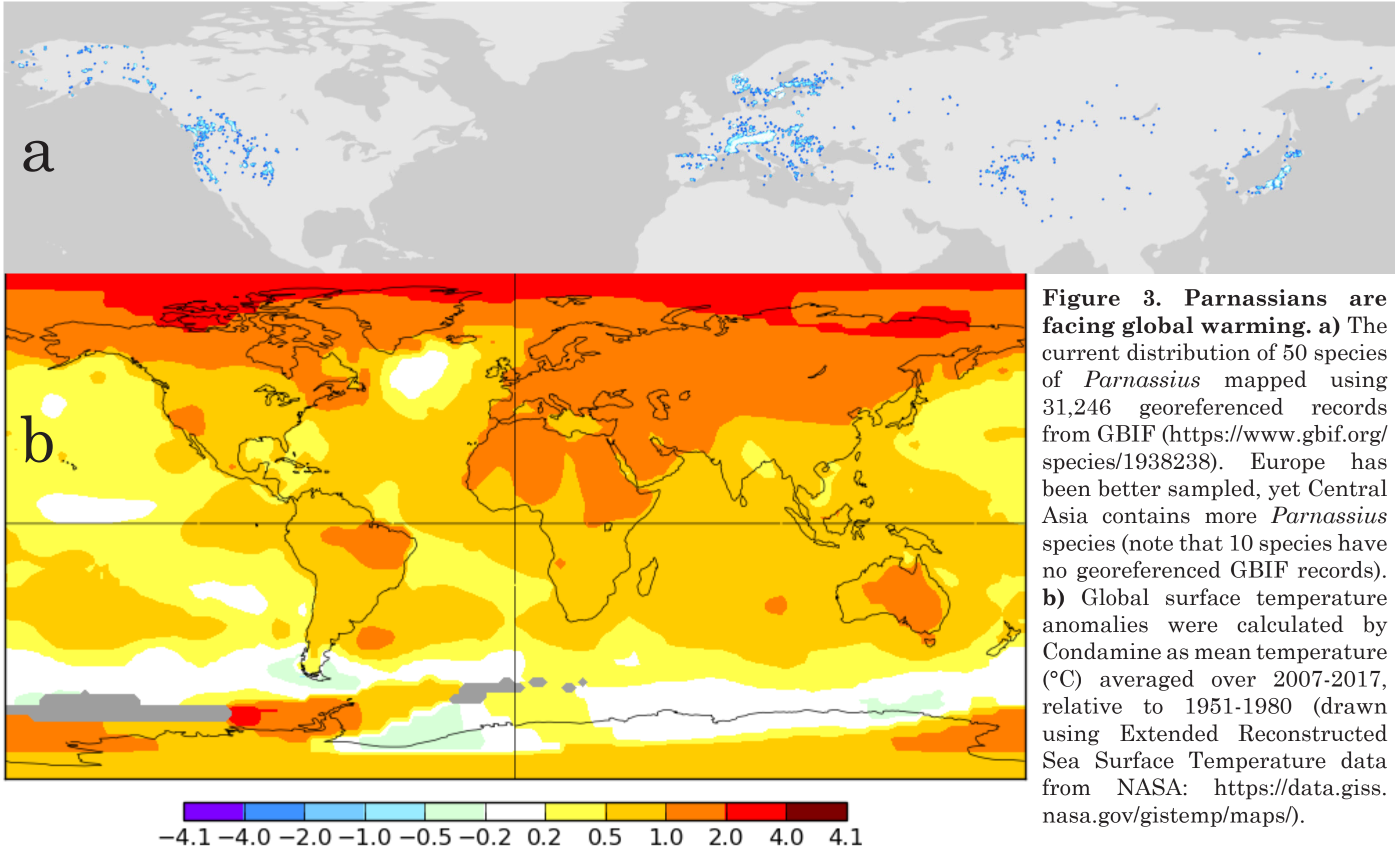

Figure 3. Parnassians are facing global warming. a) The current distribution of 50 species of *Parnassius* mapped using 31,246 georeferenced records from GBIF (https://www.gbif.org/species/1938238). Europe has been better sampled, yet Central Asia contains more *Parnassius* species (note that 10 species have no georeferenced GBIF records). **b)** Global surface temperature anomalies were calculated by Condamine as mean temperature (°C) averaged over 2007-2017, relative to 1951-1980 (drawn using Extended Reconstructed Sea Surface Temperature data from NASA: https://data.giss.nasa.gov/gistemp/maps/).

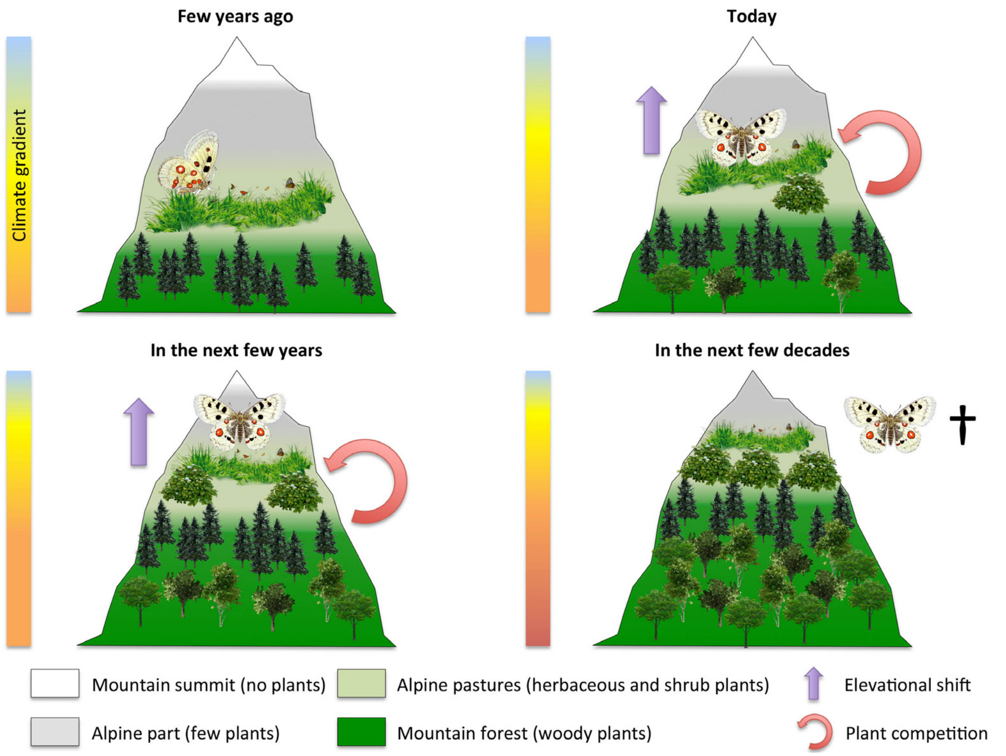

Figure 4. Schematic of current threats on parnassians. Combined abiotic and biotic factors affect *Parnassius* survival, and climate warming induces elevational shifts for both *Parnassius* and vegetation (purple arrow). Reshuffling of vegetation initiates novel biotic interactions with host plants potentially becoming less available to the butterflies (red arrow). The combination of climate warming and vegetation change also leads to a drastic size reduction of living area for both *Parnassius* and their host plants, which are caught between mountain summits and colonization barriers of unsuitable ecological conditions, eventually leading to butterfly extinction.

ter 2016). Much *Parnassius* species diversity is located in areas where climate warming has been the most severe (+2°C in average over the last 10 years, **Fig. 3**), leading to an increased extinction risk for high-elevation parnassians.

Second, global climate change is leading to shifts in vegetation habitat structure and the biotic interactions of *Parnassius* host plants. Plant species are massively and rapidly moving toward mountain summits, with the rate of increase in plant species richness accelerating on European mountain summits and strikingly synchronized with accelerated global warming (Steinbauer *et al.* 2018). This is reshuffling plant communities and changing biotic interactions between insects and plants. A groundbreaking study in the European Alps argues that accounting for novel competitive interactions may be essential to predicting species' responses to climate change accurately (Alexander *et al.* 2015). They show that species range dynamics depend not only on their ability to track climate, but also the migration of their competitors and the extent to which novel and current competitors exert differing effects (i.e. asymmetry in the importance of changing competitor identity at leading versus trailing range edges).

Third, high-mountain pastures can be damaged by cattle and other livestock. A recent study documents the impact of cattle grazing on butterflies in Tien Shan, a vast mountainous territory in Central Asia. This region contains a substantial proportion of all *Parnassius* species, and 13 of the 17 species are endemic (Condamine *et al.* 2018). Korb (2015) shows evidence that two high-altitude species, *Parnassius delphius* feeding on *Corydalis* and *Parnassius actius* feeding on *Rhodiola*, are declining over time because of grazing pressures. Korb reported that areas with *Corydalis* and *Rhodiola* were reduced by at least half between 1999 and 2008. Although cattle do not eat these *Parnassius* food plants, many plants were trampled and overwintering plant parts suffered hoof damage.

Finally, over-collecting may threaten parnassians. Demand for specimens is clear. For example, on April 22, 2018, on eBay we found that *Parnassius* had higher numbers of specimens for sale than any other swallowtail genera except *Papilio*: 644 entries for *Parnassius*, 1051 for the 200 species of *Papilio*, and 332 for the 100 species of *Graphium*. This only means that *Parnassius* are prized by collectors, and it does not by itself demonstrate an effect due to collecting. Such collecting is hard to document, although Sperling has anecdotally noticed a precipitous decline over 20 years in a population of *Parnassius eversmannii* on Pink Mountain (British Columbia), which has been subjected to substantial collecting pressures with little obvious change in the composition of vegetation on this mountaintop.

Parnassius apollo, with all its subspecies endemic to mountain areas distributed throughout the Palearctic (**Fig. 1**, Nakonieczny *et al.* 2007), may provide an analog for other *Parnassius* species. Since the first half of the twentieth century, *P. apollo* populations have declined and became rare or extinct in several European countries (Collins and Morris 1985; Descimon *et al.* 2006; Nakonieczny *et al.* 2007). The main causes for this decline seem to be anthropic, such as shepherding, pollution, tourism, collecting or habitat loss (Nakonieczny *et al.* 2007). Other causes for the decline could be related to the fact that the species is very sensitive to habitat alteration and climate change. *Parnassius apollo* populations are particularly small and isolated in the south of Europe, where their distribution is restricted to mountain ranges (Todisco *et al.* 2010). In Spain, each of the 23 described subspecies of *P. apollo* is endemic to a different mountain range. Historical data indicates that the altitudinal range of essentially all Spanish subspecies of *P. apollo* has been moving upslope in response to climate change, resulting in smaller and more isolated populations (Wilson *et al.* 2005).

Although some collectors have made efforts to possess every subspecies and population, the impacts of collecting on the observed declines are less clear. Nonetheless, overcollecting is considered to have contributed to the rarity of this species today in Finland, Italy, and Spain (Collins and Morris 1985), and *Parnassius apollo* was the first invertebrate to be listed in CITES and IUCN lists as a vulnerable species (IUCN 2018). It is also listed in the European Red Data Book as a species with a high climate change risk (Settele *et al.* 2008). Accordingly, laws exist in many countries to restrict collecting, and to monitor imports and exports of specimens. However, these laws may also discourage monitoring of populations by amateurs, reducing understanding of local population dynamics and the amount of occurrence data that can be used to inform conservation actions. Further, these laws do not address the main threats, which are climate change and habitat alteration.

Protecting the environment will help to safeguard species

A growing number and variety of anthropogenic threats affect all parnassians worldwide. Many parnassian species and subspecies will disappear in this century if no action is taken. We respectfully suggest that the following measures, whether by scientists, educators, or concerned citizens, would have the largest positive impact:

1. Parnassians are among the largest and most charismatic mountain butterflies, and are easy to recognize in their habitat. There are numerous monitoring studies on *Parnassius apollo* but fewer on other *Parnassius* species. We need a broader view of the status of populations of other species, including the effect of climatic changes and other anthropic factors on the extinction risks of *Parnassius*, particularly in Central Asia.

2. Parnassians show high intra-specific variability due to disjunct distributions in isolated habitats (valleys, mountain summits). Better species delimitations would ultimately support clearer understanding of what to protect.

3. Parnassians are excellent indicator species of the overall condition of ecosystems and for monitoring the environmental quality of endangered biotopes. They also serve umbrella species for protecting a wide range of co-existing species in the same habitats. Active measures to protect high-altitude meadows in *Parnassius* ecosystems, including limiting grazing by cattle and other ungulates, would greatly help them to cope with climate change.

4. Parnassians are widely-recognized symbols of endangered montane invertebrates, akin to what pandas represent for vertebrates. Their size, beauty, and familiarity make them excellent candidates as flagship taxa for communicating conservation concerns and engaging the public. Parnassians are particularly useful in education, turning students' attention to the small living creatures that deserve protection. This is an opportunity for educators to play a disproportionate role in forestalling the extinction of these appealing creatures.

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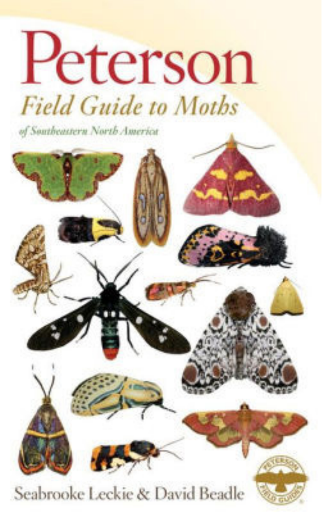
Book Review

Peterson Field Guide to Moths of Southeastern North America, by Seabrooke Leckie and David Beadle. 652 pages, 11.5 cm by 18.5 cm, soft laminate cover; ISBN 13: 978-0-544-25211-0; $29.00; Houghton Mifflin Harcourt, Boston & New York; Publication date: March 2018.



This book is a companion to one covering moths of northeastern North America by the same authors (Beadle & Leckie 2012), and many of our comments (Adams & Peigler 2013) pertaining to that book also apply to this one. Again, the moths are illustrated in living poses, usually with wings folded like we see them resting on a substrate in the field, thus providing an enhanced dimension to its purpose as a *field* guide. The moths are all shown in color with more than 2300 photographs that have been digitally manipulated, leading to illustrations that are clearly not paintings, but not quite photographs either. This process results in accurate and aesthetically appealing illustrations, and accuracy is critical for correctly identifying many moths. The authors have meticulously documented the source of all of their illustrations in five full pages of photo credits near the end of the book. We were very pleased to see that they use the updated taxonomy from Pohl et al. (2016), and it is worth noting that using this new taxonomy, the Thyridoidea, Hyblaeoidea, and Pyraloidea are all now macromoths (part of Obtectomera).

One of us (RSP) would like to note that if he had had this book in the 1970s and 1980s when he collected and pinned thousands of moths in South Carolina and eastern Texas (without direct access to a reference collection), he could have put a name on almost every moth he collected, even many Microlepidoptera. When Covell's (1984) Peterson field guide finally became available, that was a big help, but the coverage of species by these authors is far greater. In the same way, if only Wagner's (2005) field guide to caterpillars had been available 40 years earlier, life for this collector and rearer would have been much easier. However, we suppose that the appearance of Holland (1903) must also have been celebrated by many grateful lepidopterists.

As in our earlier review, the silhouettes are often too large or small; for example, the one for *Citheronia sepulcralis* is clearly a male based on the tip of the abdomen, but that silhouette is too large for a male and too small for a female.

Also as in our earlier review, the range maps are a major issue, but at least they acknowledge this on pg. 15. We often know little about actual ranges, particularly of the micro groups, and representing ranges using their ecoregion technique can be very misleading. Although they do not mention using the Moth Photographers Group (MPG) as a resource, the range maps are remarkably similar in many cases, including those with significant errors, such as for *Apamea vultuosa*, where this mountainous moth is shown in northern Florida on both MPG and in this book. Other moths with significant range issues are *Metanema inatomaria, Cisthene unifascia, C. tenuifascia, Tathorhynchus exsiccata*, and *Cydosia aurivitta* which are all shown to be much more expansive in the east than they actually are. *Cabera variolaria, Catocala cara, Syngrapha rectangula*, and *Acronicta funeralis* are shown much farther south than actual ranges. And the extensive range given for *Seirarctia echo*, which is restricted to peninsular Florida, is simply bizarre. The occasional range given for *Erinnyis ello* should also be shown for *E. obscura*, which actually moves north much more frequently than *ello*. A few species have underrepresented ranges, such as for *Catocala consors* and *Plagiomimicus navia*. Having said this, the ranges are significantly better in this guide than they were in the northeastern guide. In some cases, the extended ranges given along the eastern coast have been confirmed by recent collections in coastal Georgia for species such as *Phrudocentra centrifugaria, Palpidia pallidior*, and *Leucania pedipalpis*.

The major criticism from BGS is that the book could have been greatly improved with just a little consultation with known experts, instead of just fellow photographers, who are riding on the backs of these experts to identify moths. Not a single microlepidopterist is thanked for help in the Acknowledgements. Only one professional lepidopterist from the southeast is thanked (Charlie Covell – who only moved to the southeast in retirement). There are significant resources available through experienced and skilled experts in virtually all states in the South now. These include Ed Knudson in Texas, Richard Brown in Mississippi, Vernon Brou in Louisiana, James Hayden, Debbie Matthews, Jeff Slotten, John Heppner, and many others in Florida, James Adams and Lance Durden in Georgia, Brian Scholtens in South Carolina, and Bo Sullivan in North Carolina. All could have provided significant data and comments, and would have been happy to do so. The impression left is that data from collectors were not wanted, and this book is pitched exclusively for moth watchers/photographers. There is no text about collecting or study techniques with specimens. Yet, it is from the collectors that most watchers learn moths. Bob Patterson recognized this early on and sought information from this very knowledgeable group as he constructed MPG. One wonders if these authors learned micromoths from MPG (essentially the only thing available except MONA fascicles and primary literature, which are barely cited). Just one example of an uncited but important microlepidoptera source is the Gilligan et al. (2008) volume on Tortricidae of the Midwest, which is immensely helpful for identification in this difficult group.

A few points pertaining to Bombycoidea can be mentioned. The forewings shown on the female of *Anisota stigma* on page 251 appear too pointed. The common name for *Anisota senatoria* has been orange-striped oakworm for over 130 years, yet Leckie and Beadle call it orange-tipped oakworm, a name also used by Covell (1984); we have not been able to track an earlier use of that erroneous common name. It is disappointing that a book on *southeastern* moths would omit species associated with the Southeast such as *Anisota consularis* and *A. peigleri*, but at least *Callosamia securifera* is treated. The figures for *Callosamia promethea* are both erroneous in that the "male" is actually a female, and the female is actually *C.angulifera*; this error is even more remarkable because both sexes are correctly illustrated in the northeastern guide. Subfamilies are distinguished for Saturniidae and Sphingidae, but there are no subfamilies given for Lasiocampidae. The coverage of the few Apatelodidae is excellent.

It was a nice surprise to see *Urania fulgens* included, reminding us that this splendid moth can occasionally be seen in Florida and Texas as a migrant.

As for the Geometroidea and Noctuoidea, the book has remarkably few errors, indeed a lot less than reported for the northeastern guide in Schweitzer (2017). Three obvious mistakes include the genus *Hypagyrtis* (pg. 323), where the one non-melanic picture of *H. unipunctata* looks more like *H. piniata* (or an odd northern morph of *H. unipunctata*), and the four pictured *H. esther* include a pair each of both *H. esther* and *H. unipunctata*. The second is *Hyperstrotia nana*, where the name *nana* has been shown to have precedence over *H. villificans*; the moth pictured is now correctly called *H. aetheria*. Considering how recently this change happened, they probably can be excused for this, although this change is in Pohl, et al. (2016). The third is for *Xestia badicollis*, where the second specimen is almost undoubtedly *X. praevia*. The specimen of *Metaxaglaea violacea* does not look like *violacea*, but the specimen could be worn, and positive identification is easier with a view of the hindwing and underside of the forewing. There may be other errors in difficult genera where genitalic dissection is needed, but no other obvious misidentifications were noted.

Overall, the treatment of the Microlepidoptera is pretty good. People interested in identification of these challenging groups will be able to get a good start with this book. The authors did a tremendous amount of work compiling the photos, writing accounts, and updating taxonomy. It was a large undertaking and BGS recommends the book as a great starting place for the study of these moths.

Having said that, BGS would like to make several points specifically with regard to covering identification and biology of micromoths: 1) The authors really need to emphasize that positive identification for many micromoths absolutely requires dissection. This is discouraging for those wanting positive identification for their photos, but we end up with lots of unreliable data from 'positively identified' photos of species that simply can't be determined by photo. Just one example is the genus *Aethes*, where there are lots of species and genitalia are required for most determinations. The same is true for many other Tortricidae and Pyraloidea, and other micro groups. If we want to document diversity, as indicated in their Introduction, then we have to encourage collecting and studying via dissection for micros. 2) As has been the case for nearly all guides, the true microleps are severely underrepresented. I don't really say this as a criticism, because these species are basically impossible to identify using photos: e.g. Nepticulidae, Tischeriidae, Bucculatricidae, Coleophoridae, and Blastobasidae. They also avoided the often more common, but very difficult to identify species in genera like *Olethreutes* (Tortricidae). However, the authors could indicate how many species are in these groups, that what is pictured is only a very small sampling of what occurs in the area, and that most can NOT be identified by photos. It is not good enough to say that a genus or species group contains SEVERAL look-alike species. This gives the very mistaken impression that photographers are actually seeing and identifying the species pictured, which in many instances may not be the case. These genera or families contain MANY species, that are often look-alikes. Any serious identifications need dissections and/or consultation with experts. 3) A smaller point: If multiple morphs could not be shown (particularly in Tortricidae), then they should at least be mentioned, or readers should be sent to another source to see them. As just one example, *Archips grisea* males and females look very different, but they only picture males. Of course, the same applies to many macros as well.

There are a few naming issues in the micro sections of the book, such as their use of Cochylid (no longer a family) instead of Cochylini, *Archips* leafrollers instead of Archipine leaf rollers (there are several genera presented under that heading), Sparganothid instead of Sparganothine leafrollers, and Phycitinine, instead of the correct Phycitine.

The following are notes on specific families, genera or species. The authors state casebearers (Coleophoridae) and relatives 'will come to lights in small numbers.' Some *Coleophora* spp., some *Mompha* spp., many Blastobasidae, and lots of others, come to lights in very large numbers, but if you aren't looking for them, they are overlooked. *Coleophora* is an excellent genus to illustrate how little we know. There are tens, if not hundreds of species, of which this book pictures only two species. In cases like this, it is incumbent to indicate how unlikely it is that you can identify any *Coleophora* using only photographs. Even MPG has a very limited selection, and J.F. Landry would tell you most must be reared and/or dissected for positive identification. In the Gelechiidae, they state that *Pubitelphusa latifasciella* is sometimes mostly dusky gray with a ghost of the typical pattern. In my experience this is more the rule than the exception throughout much of the south. Northern populations tend to have a more prominent white band. For *Dichomeris georgiella*, I (BGS) suspect at least one of the pictured individuals is *D. ventrella*, which seems to be much more common along the Atlantic SE states. In the Tortricidae, for distinguishing *Choristonera rosaceana* vs. *C. parallela* they miss the most obvious characters to distinguish these two: male costal fold present in *rosaceana* but absent in *parallela*, the outer band extends from the apex to the tornus in *parallela*, and the apex of the hindwing in females is orange in rosaceana. In the Pyraloidea, the specimen of *Tallula watsoni* pictured is likely *Tallula atrifascialis*. I have only found *T. watsoni* along the immediate coast in GA and it is known from FL. The size and hindwings are different in the two, and the forewing markings of *T. atrifascialis* are typically darker. I have doubts about the identification of *Fissicrambus haytiellus*. Jim Hayden has done a series of dissections and shown that wing pattern is often not a good character in several similar species of *Fissicrambus*. For *Scoparia basalis*, much of range may represent *Scoparia dominicki*, and almost certainly so along the coastal plain where I have never taken *S. basalis*. *Glaphyria sequistrialis* is usually much more orange-yellow in color. *Aethiophysa invisalis* cannot be told from *A. consimilis* in the south without dissection. Over most of the north, only the former species is present, but both are common in the south. *Diastictis argyralis* also has look-alikes in the SE, and they must be dissected. *Blepharomastix ranalis* is usually a more light yellow brown. For *Desmia funeralis* and *maculalis*, the guide shows a dorsal MALE in *funeralis*, but a dorsal FEMALE in *maculalis*. Their patterns are quite different, and this causes lots of confusion in learners. For *Palpita quadristigmalis*, I suspect this may be either *P. persimilis* or *P. kimballi*. The wings don't seem transparent enough for typical *P. quadristigmalis*. *Diacme* is a mess. I'm not certain we know what is what at all in this genus. There are seasonal forms, and male/female differences. *D. elealis* and *D. adipaloides*, in particular seem to be a major problem. The coloration is highly variable, and I would call both pictured individuals *D. adipaloides*, but the genus needs revision. No *Hahncappsia* are figured. The specimen of *H. mancalis* pictured is *Crocidophera tuberculalis*. Most *Hahncappsia* cannot be reliably determined except through dissection. The same is true for *Helvibotys* and *Neohelvibotys*, which are very similar in appearance. In some cases, you can say a particular identification is likely based on location and abundance, but generally you can't tell for certain.

Although we did not do an full review of foodplants, there were a couple of long lists of foodplants given for species (*Seirarctia echo, Derrima stellata*) for which we would like to know the source, as a number of the plants listed seem very unlikely as natural food choices for the moths.

We thank Ryan St Laurent (Univ. of Florida) for pointing out some errors in the book that we have mentioned here.

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JAMES K. ADAMS, Dept. of Natural Sciences, Dalton State College, 650 College Drive, Dalton, Georgia 30720, jadams@daltonstate.edu; RICHARD S. PEIGLER, Dept. of Biology, University of the Incarnate Word, 4301 Broadway, San Antonio, Texas 78209, peigler@uiwtx.edu; and BRIAN G. SCHOLTENS, College of Charleston, 66 College Street, Charleston, SC 29424 scholtensb@cofc.edu.

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tgilliga@gmail.com

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Brian Scholtens
Biology Dept., College of Charleston, 66 College St.
Charleston, SC 29424-0011
(843)953-8081
scholtensb@cofc.edu

Past President

John Calhoun
977 Wicks Drive, Palm Harbor, FL 34684-4656
(727)785-0715
bretcal1@verizon.net

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(530)265-8046, ***michaelmerlecollins@comcast.net***

Jean-François Landry
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Ottawa, Ontario K1A 0C6,
CANADA, (613)759-1825
Jean-Francois.Landry@agr.gc.ca

Annette Aiello
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American Embassy
PANAMA 9100 Panama City Place, Washington, D.C.
20521-9100, (507)212-8022
aielloa@si.edu

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Michael Toliver
Division of Math and Science, Eureka College
300 E. College Ave.
Eureka, IL 61530-1500
miketol@eureka.edu

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Kelly M. Richers
9417 Carvalho Court
Bakersfield, CA 93311
(661) 665-1993 (home)
kerichers@wuesd.org

Assistant Secretary & Assistant Treasurer

Chris Grinter
The California Academy of Sciences, 55 Music Concourse Drive, San Francisco, CA
94118; 847-767-9688
cgrinter@gmail.com

Publications Manager

Kenneth R. Bliss
1321 Huntington Trail
Round Rock, TX 78664
(512)850-1700
krbliss@gmail.com

Editor, News of The Lepidopterists' Society

James K. Adams
School of Sciences and Math
Dalton State College
650 College Drive
Dalton, Georgia 30720
(706)272-4427
jadams@daltonstate.edu

Editor, Journal of The Lepidopterists' Society

Keith Summerville
Dept. of Environmental Science and Policy, 131 Olin Hall, Drake University
Des Moines, IA 50311-4505
(515)271-2498
ksummerville@drake.edu

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Chief Season Summary Coordinator and Editor

Leroy C. Koehn
3000 Fairway Court
Georgetown, KY 40324
(502) 542-7091
leptraps@aol.com

Zone 1, The Far North:

Crispin Guppy
5 Boss Road, Whitehorse,
Yukon Y1A 5S9, Canada
(778) 256-1251
csguppy@gmail.com

Zone 2, The Pacific Northwest:

Jon H. Shepard
4925 SW Dakota Ave.
Corvallis, OR 97333
(541) 207-3450
shep.lep@netidea.com

Zone 3, The Southwest:

Ken Davenport
8417 Rosewood Avenue
Bakersfield, CA 93306
(661) 366-3074
kdavenport93306@yahoo.com
with help on moths from Kelly Richers (see Treasurer, this page)

Zone 4, The Rocky Mountains:

Chuck Harp
8834 W. Quarto Ave.
Littleton, CO 80128-4269
(720) 981-5946
cehmoth@aol.com

Zone 5, The Plains:

Michael M. Ellsbury
70855 Highway 8
Fairbury, NE 68352-5565
(402) 300-1969
bugsnrails@gmail.com

Zone 6, Texas:

Mike A. Rickard
411 Virgo Street
Mission, TX 78572
(956) 519-0132
Cell: (281) 734-1110
folksinger4@yahoo.com

Zone 7, Ontario and Quebec:

Jessica E. Linton
245 Rodney Street
Waterloo, ON, Canada
N2J 1G7, (519) 489-2568
Cell: (519) 502-3773
jessicalinton86@gmail.com

Zone 8, The Midwest:

Thomas Jantscher
2800 Rustic Pl. Apt. 206
Little Canada, MN 55117-1389, (612) 875-1710
tjantscher@gmail.com

Zone 9, The Southeast:

Brian G. Scholtens
Biology Department
College of Charleston
66 College Street
Charleston SC 29424-0001
(843) 637-6224
scholtensb@cofc.edu

Zone 10, The Northeast:

Mark J. Mello
c/o Lloyd Center,
430 Potomska Rd
Dartsmouth, MA 02748
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Isabel Vargas Fernandez
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ivf@ciencias.unam.mx

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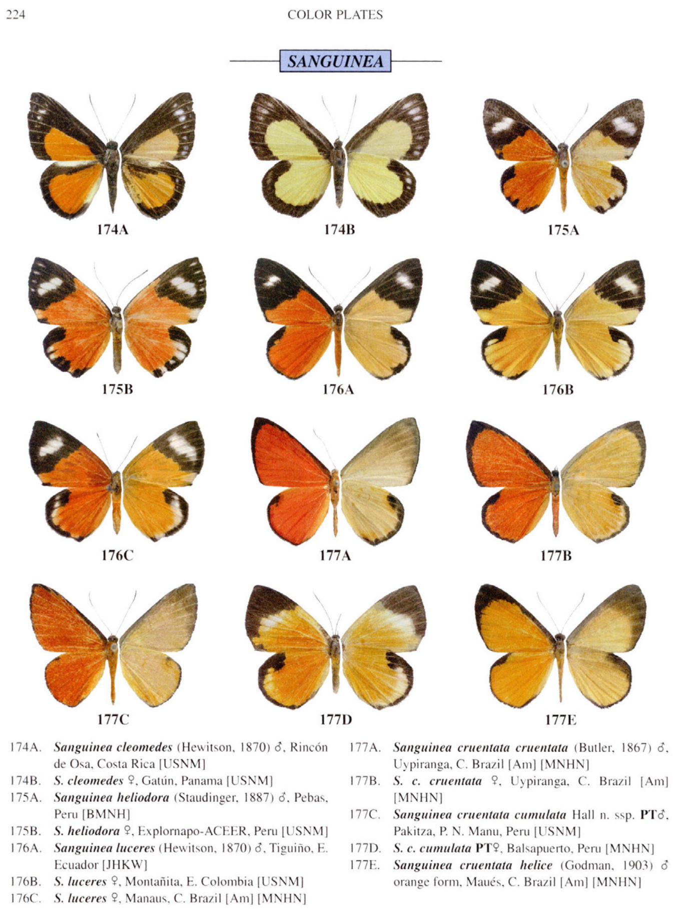
Fig. 196. A. ***Parvospila lucianus*** ♀, Tambopata Research Center, Río Tambopata, S.E. Peru [RC]. **B**. ***Periplacis hebrus*** ♂, Pimpilala, nr. Tena, E. Ecuador [KRW]. **C**. ***Pseudolivendula hemileuca*** ♂, Finca San Carlo, nr. Tena, E. Ecuador [DHA]. **D**. ***Pseudolivendula byzeres*** ♂, Finca San Carlo, nr. Tena, E. Ecuador [DHA]. **E**. ***Pandemos pasiphae*** ♂, Cristalino Jungle Lodge, nr. Alta Floresta, S.W. Brazil (MT) [GC]. **F**. ***Adelotypa borsippa*** ♂, mouth of Río Añangu, Río Napo, E. Ecuador [KRW]. **G**. ***Argyraspila tavakiliani*** ♂, Finca San Carlo, nr. Tena, E. Ecuador [DHA]. **H**. ***Hypophylla sudias*** ♂, Catemaco, E. Mexico [DW]. **I**. ***Hypophylla sudias*** ♀, Mexico [JG]. **J**. ***Calospila parthaon parthaon*** ♂, Amazonia Lodge, nr. Shintuya, S.E. Peru [KG]. **K**. ***Setabis myrtis*** ♂, Caixuanã, E. Brazil (Pa) [AJ]. **L**. ***Setabis pythioides*** ♀, Orchids Paradise Hotel, nr. Tena, E. Ecuador [KG]. **M**. ***Setabis lagus lagus*** ♂, Cristalino Jungle Lodge, nr. Alta Floresta, S.W. Brazil (MT) [RH]. **N**. ***Setabis epitus*** ♀, Rio Parauri, W. Brazil (Am) [GC]. **O**. ***Setabis serica serica*** ♀, Cristalino Jungle Lodge, nr. Alta Floresta, S.W. Brazil (MT) [GC]. Photo credits: AJ = Amy Johnson; DHA = David Ahrenholz; DW = Dan Wade; GC = Gill Carter; JG = Jeffrey Glassberg; KG = Kim Garwood; KRW = Keith Willmott; RC = Rick Cech; RH = Richard Hoyer.



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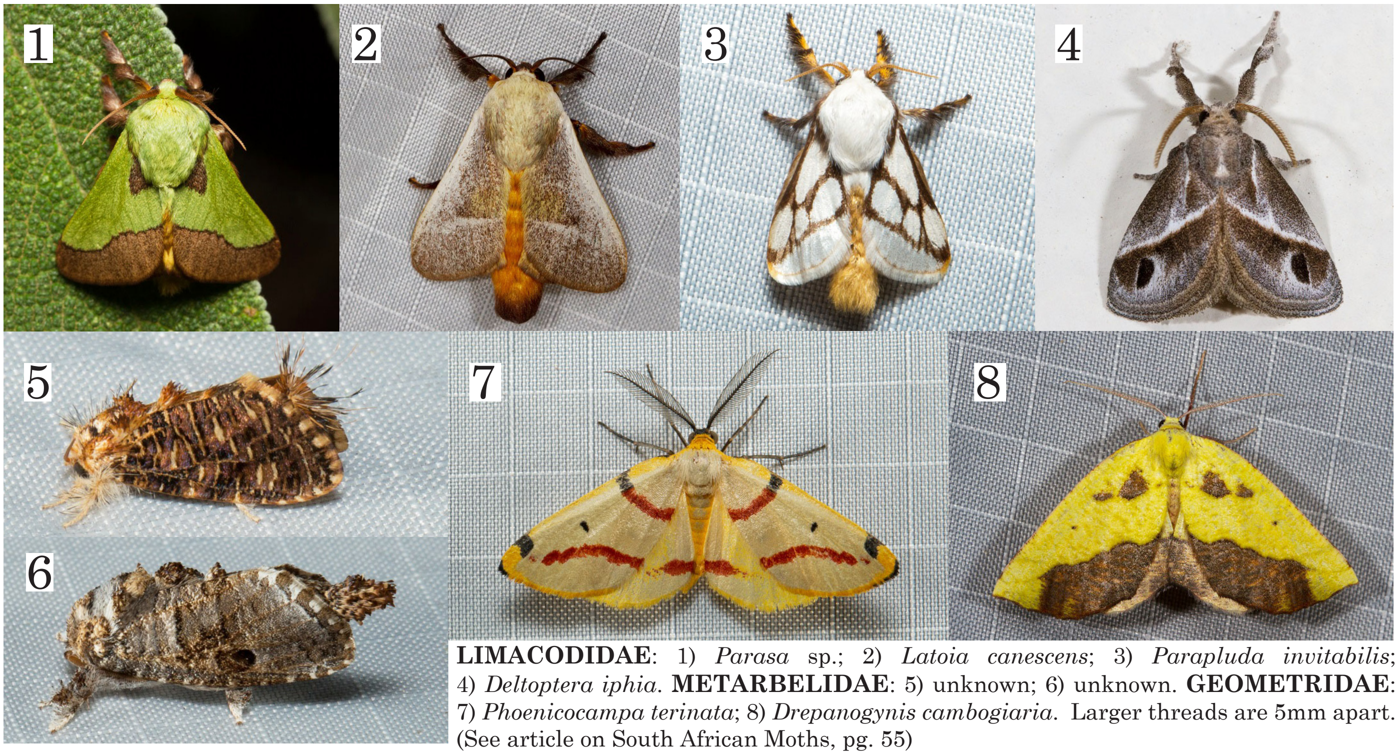
174A.	***Sanguinea cleomedes*** (Hewitson, 1870) ♂, Rincón de Osa, Costa Rica [USNM]
174B.	***S. cleomedes*** ♀, Gatún, Panama [USNM]
175A.	***Sanguinea heliodora*** (Staudinger, 1887) ♂, Pebas, Peru [BMNH]
175B.	***S. heliodora*** ♀, Explornapo-ACEER, Peru [USNM]
176A.	***Sanguinea luceres*** (Hewitson, 1870) ♂, Tiguiño, E. Ecuador [JHKW]
176B.	***S. luceres*** ♀, Montañita, E. Colombia [USNM]
176C.	***S. luceres*** ♀, Manaus, C. Brazil [Am] [MNHN]
177A.	***Sanguinea cruentata cruentata*** (Butler, 1867) ♂, Uypiranga, C. Brazil [Am] [MNHN]
177B.	***S. c. cruentata*** ♀, Uypiranga, C. Brazil [Am] [MNHN]
177C.	***Sanguinea cruentata cumulata*** Hall n. ssp. **PT**♂, Pakitza, P. N. Manu, Peru [USNM]
177D.	***S. c. cumulata*** **PT**♀, Balsapuerto, Peru [MNHN]
177E.	***Sanguinea cruentata helice*** (Godman, 1903) ♂ orange form, Maués, C. Brazil [Am] [MNHN]

Two plates from "A Monograph of the Nymphidiina (Lepidoptera: Riodinidae: Nymphidiini): Phylogeny, Taxonomy, Biology, and Biogeography, by Jason P. W. Hall. (See Marketplace ad, pg. 89)



LIMACODIDAE: 1) *Parasa* sp.; 2) *Latoia canescens*; 3) *Parapluda invitabilis*; 4) *Deltoptera iphia*. **METARBELIDAE**: 5) unknown; 6) unknown. **GEOMETRIDAE**: 7) *Phoenicocampa terinata*; 8) *Drepanogynis cambogiaria*. Larger threads are 5mm apart. (See article on South African Moths, pg. 55)