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Cover Illustration: A portrait of *Ignata caldas* Robbins **new species**, a common hairstreak with a confused taxonomy, in Veracruz, Mexico on May 14, 2008. Image by Kim Garwood. See journal article on page 1.

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FOUR COMMONLY CONFUSED HAIRSTREAKS (LYCAENIDAE, THECLINAE, EUMAEINI): THREE NEED NAMES, ONE DOES NOT

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ABSTRACT. The taxonomy of four relatively common Neotropical eumaeine hairstreak species has been confused. Newly described are *Iaspis andersoni* Robbins, **new species**, differentiated from *I. talayra* (Hewitson), *I. castitas* (Druce), and *I. exiguus* (Druce); *Michaelus joseph* Robbins, **new species**, differentiated from *M. ira* (Hewitson); and *Ignata caldas* Robbins, **new species**, differentiated from *I. gadira* (Hewitson). *Iaspis andersoni* is unnamed because of a taxonomic misidentification made more than a century ago. The latter two are undescribed because the types of *M. ira* and *I. gadira* are not the species that they had been thought to be. Populations in the *Arawacus togarna* (Hewitson) species complex from Mexico and Costa Rica have been treated as two distinct species, but new data on geographical variation of wing pattern and male genitalia suggests that this classification is incorrect. A lectotype for *Thecla exiguus* Druce, 1907 is designated because taxonomy of the *Iaspis talayra* group in the Amazon Region is unresolved. A lectotype for *Thecla togarna* Hewitson, 1867 is designated because an incorrect type locality has engendered confusion.

Additional key words: *Androconia*, *Arawacus*, *Iaspis*, *Ignata*, Larval foodplants, *Michaelus*

More than 20% of the approximately 1,100 known species of Neotropical Eumaeini (Lycaenidae: Theclinae) are undescribed (Robbins 2004b). Most are exceedingly rare in museum collections, of which some recently described species are representative (Bálint 2003; Nicolay & Robbins 2005; Robbins & Duarte 2005; Hall & Willmott 2005; Hall *et al.* 2005; Robbins & Busby 2008a, b). This rarity makes it difficult to assess intra- and inter-specific variation, which, in turn, makes it difficult to show that they are distinct under a biological species concept. However, a few relatively common and widespread eumaeine species lack names because two species were lumped under one name or because a type specimen was a different species than it had been thought to be (Robbins 2004a, b). In this paper, I describe three such species. Finally, new data on geographical variation show that a common, putatively unnamed species is a geographical variant of a species with a name. This variation is documented.

MATERIALS AND METHODS

Genitalic dissections were made following standard techniques (Robbins 1991), and the number of dissections examined for each species is noted. Genitalic terms follow those in Klots (1970), as modified

for the Eumaeini by Robbins (1991). Androconial terminology follows Robbins (1991). Wing vein terminology follows Comstock (1918). Snodgrass (1935) is used as a reference for other morphological structures.

Taxonomic decisions were based upon an analysis of morphological variation (the number of specimens examined is stated in each description) in the museum and private collections noted below. A diagnosis and the reasons for the generic placement of each taxon are presented. Also, the reasons for considering each of the newly available names distinct under a biological species concept are given. The history of each species name is supplemented with new information, where relevant. Males and females were associated by their similar geographic distributions and by their ventral wing patterns, which are barely sexually dimorphic for the species treated in this paper (Figs. 1–13). All species discussed in this paper belong to the Eumaeini as characterized by Eliot (1973).

Brackets are used for information not explicitly noted on holotype labels and for description of holotype labels. All labels on holotypes are printed unless noted otherwise. Months are abbreviated by their first three letters in English. Forewing length of the type series for

each new name was measured with a vernier caliper and reported as a mean, standard deviation, and sample size.

Acronyms for the collections from which data are cited are as follows: (AA) Annette Aiello Collection, Ancón, Panamá; (BMNH) Natural History Museum, London, UK; (CMNH) Carnegie Museum of Natural History, Pittsburgh, PA, USA; (FIOC) Fundação Instituto Oswaldo Cruz, Rio de Janeiro, Brazil; (JHKW) Jason Hall and Keith Willmott Collection, Smithsonian Institution, Washington, DC, USA; (MIZA) Museo del Instituto de Zoología Agrícola, Maracay, Venezuela; (NMCR) Museo Nacional de Costa Rica, San José, Costa Rica; (USNM) National Museum of Natural History, Smithsonian Institution, Washington, DC, USA.

TAXONOMIC RESULTS AND DISCUSSION

Iaspis andersoni Robbins **new species**

History. Hewitson (1868) named *Thecla talayra* from a Rio de Janeiro male (Fig. 1). The type has a distinctive off-white underside ground color and lacks an orange-red spot distal of the postmedian line in cell Cu_2-2A (arrow in Fig. 1). This male also possesses a scent pad at the anterior-distal end of the discal cell that is covered with iridescent blue scales and that is bordered anteriorly at vein R_3 (the same as that illustrated in Fig. 15).

Despite these distinctive characters, the taxonomy of *T. talayra* is confused because of decisions made more than a century ago. Godman & Salvin (1887–1901) noted that *T. talayra* is a common species in Central America (Figs. 4–5), but differed slightly from the one Brazilian female in their possession, which had a “yellow patch at the anal angle”. This description does not match the orange-red spot at the anal angle of the type of *T. talayra* (Fig. 1) and was probably another species. Druce (1907) described *Thecla castitas* as a variety of *T. talayra* from Para and Espiritu (sic) Santo, Brazil and stated that it has “a very different appearance below” and may be a distinct species (Fig. 2). Druce (1907) also described *Thecla exiguus* from Surinam (Fig. 3). This species has a wing pattern that is similar to that of *T. castitas*, but Druce presented no evidence why *T. castitas*—and not *T. exiguus*—was a geographical form of *T. talayra*.

Draudt (1919–1920) followed Druce, treating *Thecla talayra* Hewitson as a lowland species that occurs from Mexico to southern Brazil, with *T. castitas* as a geographical form and *T. exiguus* as a distinct species. Most of these names were transferred to *Iaspis* (Johnson 1991), but D'Abrera (1995) basically followed the classification in Draudt. Austin & Johnson (1996)

divided *Iaspis* into “groups”, including the *I. talayra* group, based on the size of the dorsal forewing scent pad, but no measurements or precise morphological details were presented to support this action. They also described *Iaspis ornata*, *I. minuta*, *I. ambiguanota*, *I. fumosa*, and *I. sinenota* in the *I. talayra* group from Rondônia (Brazil). Robbins (2004a, b) provisionally synonymized the last four names with *I. castitas* because the interspecific differences reported by Austin & Johnson (1996) were less than previous assessments of intraspecific eumaeine variation (J. Brown 1983; Robbins 1990).

In sum, the name *Iaspis talayra* represents a distinct wing pattern phenotype (Fig. 1) with little variation in the Atlantic Region, as demarcated by K. Brown (1982). This phenotype has an off-white ground color ventrally and lacks an orange-red spot distal of the postmedian line in cell Cu_1-Cu_2 . The names *Iaspis castitas* and *I. exiguus* represent a variety of wing pattern phenotypes in the Amazonian Region (including the Orinoco and neighboring drainages, sensu K. Brown 1982). All differ from *I. talayra* in possessing a gray ground color ventrally and an orange-red spot on the distal edge of the postmedian line in cell Cu_2-2A (Figs. 2–3). The dorsal forewing wing pattern, including structure of the scent pad, appears to be the same as *I. talayra*. The number of species in the *I. talayra* species group in the Amazon Region is yet an open question. Finally, there is a distinct wing pattern phenotype from northern Colombia to Mexico that does not have a name (Figs. 4–5).

Diagnosis. The blue dorsal color of males (Fig. 4 top) of *I. andersoni* is perhaps the most diagnostic character, being consistently more brilliant in the study series than that of *I. talayra*, *I. castitas*, or *I. exiguus* (Figs. 1–3 top). Additionally, this Central American phenotype has a more silver ventral ground color than these species. Finally, there is a pair of terminal “spines” (Fig. 19) at the lateral edges of the penis tip in *I. andersoni* that is lacking in *I. castitas*, but a larger study series may show this trait to be variable intraspecifically.

Size. Mean male forewing length = 1.2 cm, sd = 0.09, n = 6. Mean female forewing length = 1.1 cm, sd = 0.10, n = 3.

Reasons for recognizing it as a distinct biological species. Throughout its range from Mexico to northern Colombia (Fig. 30), the wing pattern of male *I. andersoni* varies little and is always distinct from the wing patterns of male *I. castitas* and *I. exiguus* in South America. The range of *I. andersoni* is not known to overlap the ranges of the Amazonian “phenotypes” in the *I. talayra* species group (as listed in Austin & Johnson 1996). If sympatry with an Amazonian

“phenotype” were discovered, it would be necessary to determine whether distinguishing characters intergrade.

Generic placement. The placement of *I. andersoni* in *Iaspis* is based on three characters. First, a membranous “duct” connects the anterior end of the female genitalia ductus bursae where the ductus seminalis arises and the posterior end of the corpus bursae in *Iaspis* (Figs. 21–22), a structure that is unreported in other eumaeine genera. Second, a red spot on the distal edge of the postmedian line in cell Cu_2-2A on the ventral hindwing (Figs. 2–5) occurs in some *Iaspis* (including *I. andersoni*) and the *Lamprospilus* Section of the Eumaeini (especially *Calycopis* Scudder). *Iaspis* lacks the synapomorphies of the *Lamprospilus* Section (Duarte & Robbins, in prep.), for which reason the red spot is presumed to be independently derived in *Iaspis*. Third, the male genitalia of *Iaspis* vary little interspecifically (Figs. 19–20), but the squat valvae and overall structure are distinctive (Austin & Johnson 1996). A pair of small terminal spines on the lateral penis tip occurs only in some *Iaspis*, including *I. andersoni* (Fig. 19).

Nomenclature. The International Commission on Zoological Nomenclature (1967) settled confusion about the type species of *Iaspis* Kaye. Johnson (1991) designated a lectotype for *Thecla talayra* Hewitson (Fig. 1). Austin & Johnson (1996) designated a lectotype for *Thecla castitas* Druce (Fig. 2). Because the taxonomy of the Amazon Basin phenotypes is unresolved, as noted, I designate a male lectotype for *Thecla exiguus* Druce (Fig. 3) for the purpose of stabilizing the name. The lectotype is deposited in the BMNH and has the following labels: a round red type label, a white label “B.M. No. Rh 630”, and a green locality label “Surinam ex coll. Fruhstorfer”.

Holotype ♂ (Fig. 4). [white label, the day is handwritten in black ink] PANAMA: Canal Zone, Summit[, Cacao Plantation Road], 1 IV[Apr] 1979, leg. R. Robbins. [white label] R. K. Robbins Collection. [red label] HOLOTYPE *Iaspis andersoni* Robbins. Deposited USNM.

Paratypes (5♂ & 3♀). Panamá, Canal Zone (now Canal Area): 2♂ & 1♀ Summit, 29 Mar 1979 leg. R. Robbins, 1 Apr 1979 leg. R. Robbins, 24 Mar 1964 leg. G.B. Small. 2♂ La Pita, 1 Jun 1963 leg. G. B. Small, 16 Apr 1963 leg. G. B. Small. Panamá Province: 1♂ & 2♀ Cerro Campana 15 Dec 1963 leg. G. B. Small, 26 Jan 1966, leg. S. S. Nicolay, 23 Dec 1963 2000', leg. G. B. Small. All deposited USNM.

Type locality. Cacao Plantation Road in 1979 was a dirt road through late secondary lowland forest that was used for dry season training exercises by the United States and Panamá military. Ridgely (1976) discussed Cacao Plantation Road in the section on “Summit Gardens and Vicinity”, referring to it as the road that is “about a mile beyond Summit Gardens (toward

Gamboa)”. In 2000, Cacao Plantation Road was a narrow, overgrown dirt path that was called a nature trail.

Etymology. This species is named in honor of Commander Richard A. Anderson, whose collecting greatly increased our knowledge of the Nicaraguan and Panamanian butterfly faunas, especially Lycaenidae and Hesperidae. It is a noun in the genitive case of masculine gender.

Habitat. *Iaspis andersoni* is common in moderately disturbed wet and dry lowland forest from sea level to 1,100 m elevation.

Larval foodplants. *Iaspis andersoni* appears to be polyphagous, having been reared on a number of different plants. A male (deposited NMCR) was reared from a larva that Isidro Chacón found on 1 Dec 1992 on *Souroubea* (Marcgraviaceae) at Horquetas de Sarapiquí, El Plástico, Heredia, Costa Rica (600 m). Janzen & Hallwachs (2008, adult vouchers in USNM) in the Area de Conservacion Guanacaste, Alajuela and Guanacaste Provinces, Costa Rica, reared two males from *Inga oerstediana* (Fabaceae) (07-SRNP-65853, 08-SRNP-21004), two females from *Inga spectabilis* (Fabaceae) (07-SRNP-4715, 07-SRNP-4716), and two females from *Miconia lacera* (Melastomataceae) (07-SRNP-70877, 07-SRNP-70878). A caterpillar of *I. andersoni* is illustrated (Fig. 14).

Distribution (Fig. 30). Mexico to northern Colombia (Rio Magdalena Valley), including Isla Coiba off the west coast of Panamá.

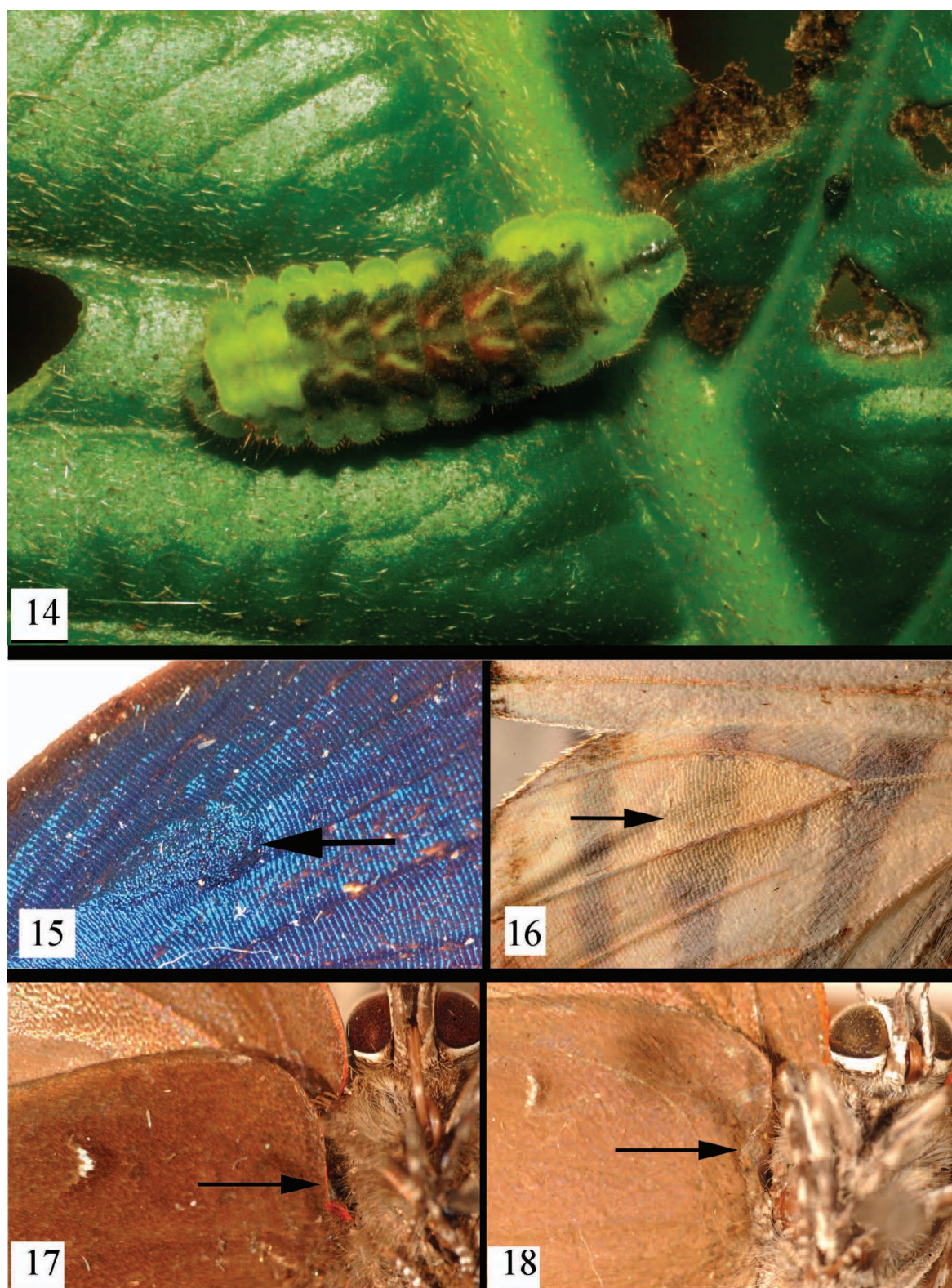
Study series. For this paper, I examined 87 males and 16 females of *I. andersoni* from 7 countries, including genitalic dissections of 2 males and 2 females; 59 males and 23 females in the *I. castitas* species complex from 7 countries in the Amazon Region, including genitalic dissections of 3 males and 3 females; 10 males and 1 female of the *I. talayra* from 2 states in Brazil, including 1 male and 1 female genitalic dissection; and the lectotypes of *I. talayra*, *I. exiguus*, and *I. castitas* (BMNH).

Michaelus joseph Robbins new species

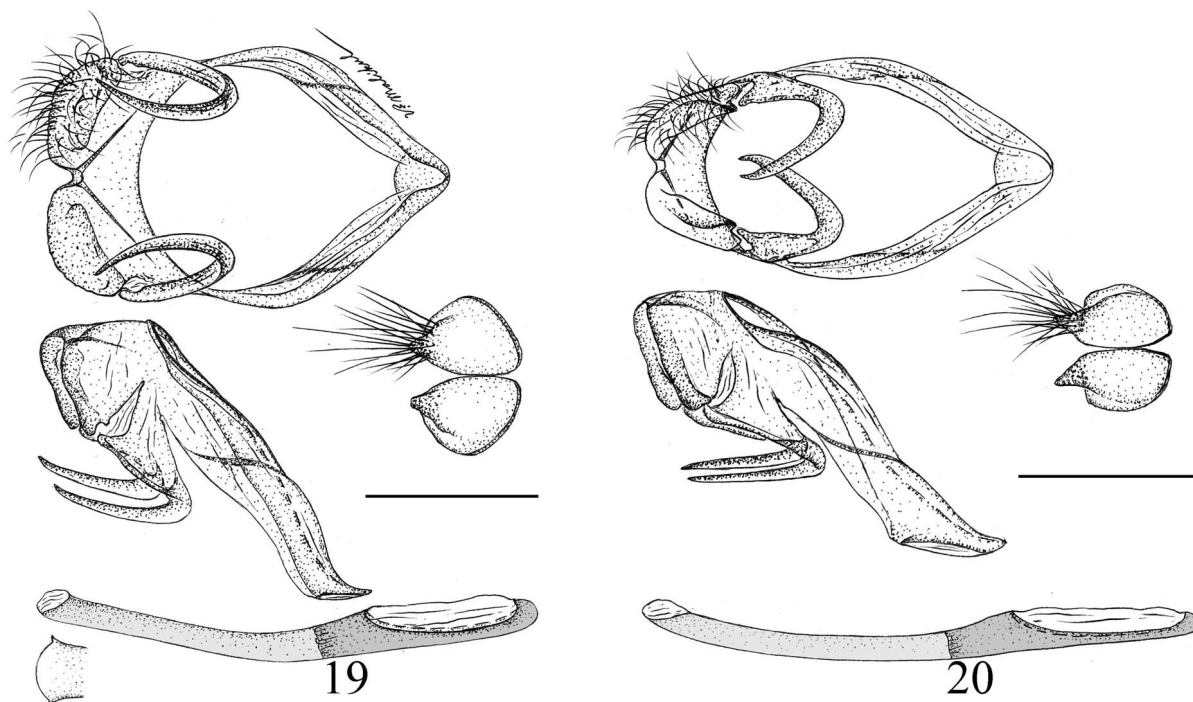
History and new information. Nicolay (1979) described *Michaelus* and recognized five species including *M. ira* (Hewitson) and *M. vibidia* (Hewitson). He illustrated the genitalia and wing pattern of these species and gave their distributions. Although Nicolay correctly recognized that he was treating two biologically distinct sympatric species, Robbins (2004a, b) synonymized these names because the Hewitson types of *M. ira* (the older name) and *M. vibidia* are the same species (Robbins 2004a, b).



FIGS. 1-13. Adults, dorsal on top, ventral on bottom except for fig. 13. 1. ♂ *Iaspis talayra* lectotype, Rio de Janeiro, Brazil, arrow points to lack of orange-red scales on the distal border of the postmedian line in cell Cu_2-2A . 2. ♂ *I. castitas* lectotype, Para, Brazil. 3. ♂ *I. exiguus* lectotype, Surinam. 4. ♂ *I. andersoni* holotype, Panamá. 5. ♀ *I. andersoni* paratype, Panamá. 6. ♂ *Michaelus joseph* holotype, Panamá. 7. ♀ *M. joseph*, Costa Rica. 8. ♂ *Ignata caldas* holotype, Panamá. 9. ♀ *I. caldas* paratype, Panamá. 10. ♀ *Ignata gadira* holotype, Guatemala. Arrow on right points to pale gray scales in middle of hindwing. Arrow on left points to black anal lobe spot lacking red scales. 11. ♂ *Thecla togarna* original illustration, "Venezuela". 12. ♂ *Arawacus togarna* lectotype, Mexico. 13. ♂ *A. togarna* ventral, Belize on top, Costa Rica on bottom. Scale 1 cm.



FIGS. 14-18. **14.** Larva (dorsal aspect) of *Iaspis andersoni* eating *Inga spectabilis* (Fabaceae) (Costa Rica, 07-SRNP-4715, image courtesy Janzen & Hallwachs). **15.** Dorsal forewing scent pad (arrow) of *Iaspis andersoni* (Panamá) with iridescent blue scales. **16.** Dorsal hindwing scent patch (arrow) of *Aravacus togarna* (Costa Rica). **17.** Base of the ventral wings of *Michaelis joseph* (Panamá) with red scales (arrow). **18.** Base of the ventral wings of *M. ira* (Panamá) without red scales (arrow).



FIGS. 19-20. *Iaspis* male genitalia, ventral aspect of genital capsule and valvae (top), lateral aspect of genital capsule and penis (bottom), posterior to left, scale 0.5 mm. **19.** *I. andersoni* (Panamá). Penis tip in dorsal aspect (enlarged) showing terminal "spines". **20.** *I. castitas* (Peru).

In sum, the species that Nicolay called *M. vibidia* should be called *M. ira* (Robbins 2004b), and the species that Nicolay referred to as *M. ira* does not have a name and is being described as *M. joseph*.

Diagnosis. *Michaelus joseph* is the only *Michaelus* that has red scales at the base of the ventral hindwing (Fig. 17). There is a detailed description of *M. joseph* under the name *M. ira* in Nicolay (1979), including excellent genitalic figures. The holotype and a female of *M. joseph* are illustrated (Figs. 6-7).

Size. Mean male forewing length = 1.6 cm, sd = 0.10, n = 6.

Reasons for recognizing it as a distinct biological species. *Michaelus joseph* and *M. ira* have similar wing patterns, but are sympatric and synchronic throughout the range of *M. joseph*. For example, they occur at the same time of year in Guanacaste (Costa Rica), the Canal Area (Panamá), Madre de Dios (Peru), and Rondônia (Brazil) (vouchers in USNM). They differ consistently in the structure of the genitalia and wing pattern, as noted by Nicolay (1979). They also differ in the presence of red scales at the base of the ventral hindwing.

Generic placement. Nicolay (1979) provided characters for the placement of *M. joseph* in *Michaelus*, but a phylogenetic analysis is yet lacking.

Nomenclature. *Thecla ira* Hewitson was described from a presumably single Mexican male in the Saunders Collection. A male in the BMNH is labeled as the holotype of *Thecla ira* (B.M. type No. Rh 670, Type H.T.). *Thecla vibidia* Hewitson was described from a presumably single Amazonian male in the Hewitson Collection. A male in the BMNH is labeled as the type of *T. vibidia* (B.M. type No. Rh 668), and Godman & Salvin (1887-1901: 44) referred to it as the type.

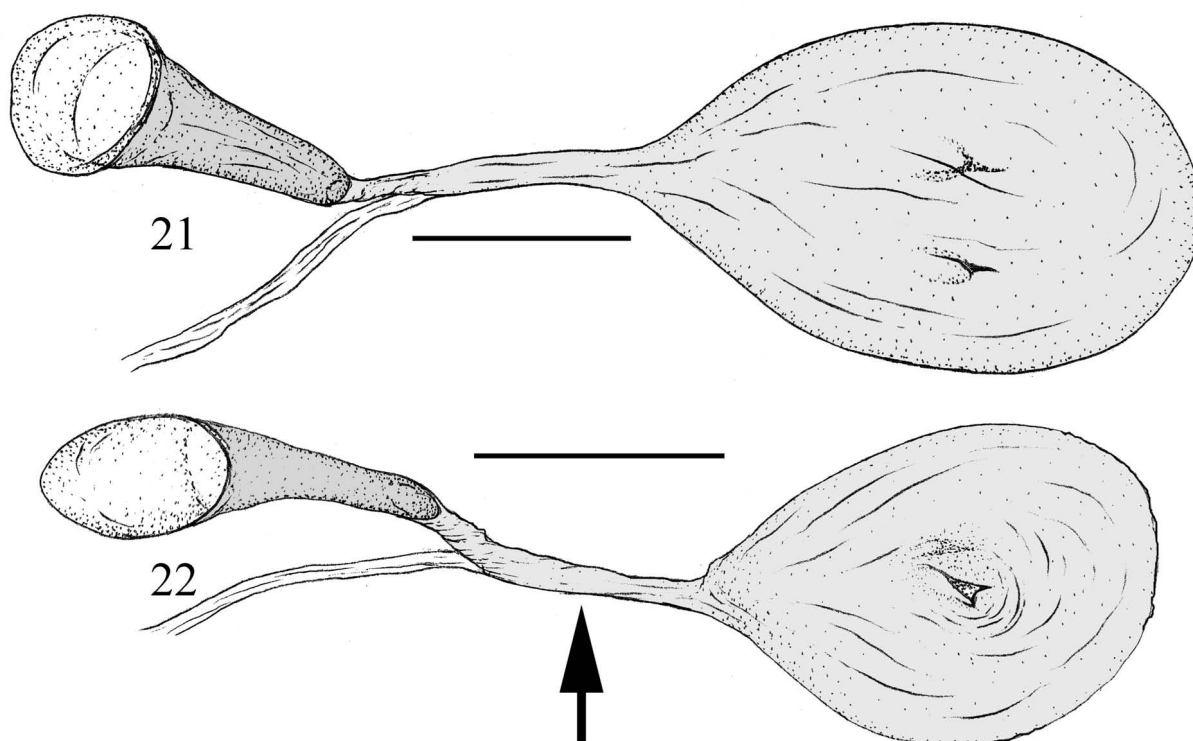
Holotype ♂ (Fig. 6). [white label, date handwritten in blue ink] Madden Forest Pre.[serve], Panamá, C.[anal] Z.[one]. VII[July]-24-[19]69, [leg.] G. B. Small. [red label] HOLOTYPE *Michaelus joseph* Robbins. Deposited USNM.

Paratypes (5♂). Panamá, Canal Area, leg. G. B. Small: Piña, 12 Jan 1965; Madden Dam, Apr 1968; Madden Forest, 19 Jul 1969; Madden Forest, 5 Aug 1968; Panamá Province, Bayano, 16 Nov 1974, G. B. Small. All deposited USNM.

Type locality. Ridgely (1976) mapped Madden Forest and described it as a fairly large forest reserve straddling the Continental Divide northeast of Summit Gardens. Unfortunately, much of Madden Forest had been clear-cut by 1980 (pers. obs.). However, larger tracts of forest just to the northwest (Summit to Pipeline Road) are now protected in Soberanía National Park.

Etymology. *Michaelus joseph* is named for Nicolay's grandson Joseph Nicolay. It is an indeclinable noun in apposition of masculine gender.

Habitat. *Michaelus joseph* inhabits lowland forests,



FIGS. 21-22. *Iaspis* ductus copulatrix (female genitalia), ventral aspect, posterior to left, scale 0.5 mm. **21.** *I. andersoni* (Panamá). **22.** *I. castitas* (Peru), arrow points to membranous duct connecting the corpus bursae to the ductus bursae.

ranging from those that lack a dry season to those that are seasonally dry with many deciduous trees. It is a rarer species in collections than *M. ira*.

Larval foodplant. *Michaelus joseph* has not been reared, but flowers of Bignoniaceae are the expected foodplant. Individuals of *M. ira* were reared from the fallen flowers of *Pithecoctenium* and *Pyrostegia* in the Bignoniaceae in southern Brazil (Zikán & Zikán 1968 under the name *Thecla venustula* [a nomen nudum], deposited FIOC) and in Panamá (Robbins & Aiello 1982 under the name *Thecla vibidia*, deposited AA).

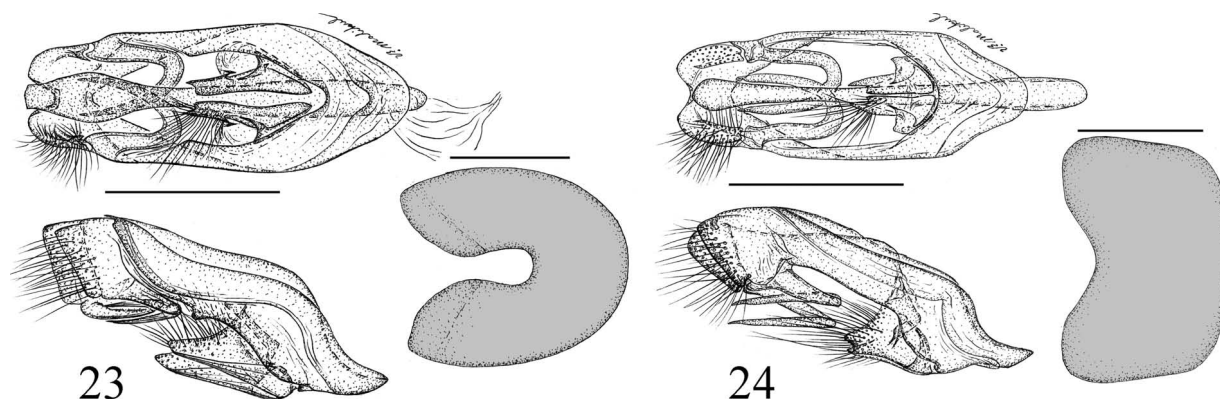
Distribution (Fig. 31). From Costa Rica to the western Amazon in Peru and Brazil. Nicolay (1979) also recorded specimens from Belize, Venezuela, Colombia, Bolivia, and the central Amazon Basin in Brazil, but I have not seen these specimens.

Study series. For this paper I examined 44 males and 9 females of *M. joseph* from 5 countries, including genitalic dissections of 3 males and 1 female; and 84 males and 33 females of *M. ira* from 10 countries, including genitalic dissections of 2 males and the genitalic figures in Nicolay (1979). I also examined the holotypes of *M. ira* and *M. vibidia* (BMNH) with a binocular microscope.

Ignata caldas Robbins new species

History and new information. Hewitson (1867) described the tailless *Thecla gadira* from a Guatemalan female (Fig. 10). Godman & Salvin (1887–1901) illustrated a Guatemalan male of *T. gadira* and named *Thecla minthe*—another tailless species with a very similar wing pattern—from a Mexican male. This taxonomy was followed in Draudt (1919–1920) and D'Abrera (1995). Both *gadira* and *minthe* were transferred to *Ignata* Johnson (Robbins 2004b), where they were treated as synonyms because their holotypes are the same species. Although Godman & Salvin (1887–1901) correctly realized that there are two species, the less common species, which they called *Thecla minthe*, is *Ignata gadira* (Robbins 2004b). The more common and widespread of the two, which Godman and Salvin called *Thecla gadira*, does not have a name.

Diagnosis. The ventral wing pattern of both sexes of *I. caldas* has a small orange-red spot at the anal angle (occurring without exception in the study series) and no light gray scales in the middle of the hindwing (Figs. 8–9). In both sexes of *I. gadira*, the anal angle spot is black (as noted by Hewitson 1867) and there are light



FIGS. 23–24. *Ignata* male genitalia, ventral aspect (top), lateral aspect (bottom), 8th abdominal tergum (right), posterior to left, scale 1 mm. **23.** *I. caldas* (Panamá). **24.** *I. gadira* (Costa Rica).

gray scales in the middle of the hindwings (Fig. 10). Additionally, male dorsal blue color of *I. caldas* is a darker hue than that of male *I. gadira*, the scent pad is larger, and the ventral forewing lacks the iridescent blue sheen of *I. gadira* (well-illustrated in Godman & Salvin 1887–1901 and D’Abrera 1995 under the names *Thecla gadira* and *Thecla minthe*, respectively). Finally, male and female genitalia, including shape of the male 8th tergum, valvae, and ductus bursae differentiate *I. caldas* from *I. gadira* (Figs. 23–26).

Size. Mean male forewing length = 1.3 cm, sd = 0.10, n = 6. Mean female forewing length = 1.3 cm, sd = 0.11, n = 7.

Reasons for recognizing it as a distinct biological species. *Ignata caldas* and *I. gadira* differ in wing pattern, androconia, male genitalia, and female genitalia, as noted above. They are sympatric in Nicaragua (Robbins & Anderson submitted) and Panamá (Robbins & Small 1981). Individuals with intermediate character states are unknown in areas of sympatry or allopatry. The results of preliminary phylogenetic analyses indicate that they are phylogenetically distinct species (Robbins unpubl.). Whereas *I. gadira* is restricted to Central American montane forest (600–1750 m), *I. caldas* occurs in both lowland and montane forest from Mexico to the upper Amazon Basin.

Generic placement. The original description of *Ignata* (Johnson 1992) included no synapomorphies for the genus, and the genus as described was not monophyletic (Robbins 2004a). *Ignata* was placed in the *Panthiades* Section (see Robbins & Duarte 2004 for

characters) and provisionally characterized in Robbins (2004b) by the readily recognizable “smooth” blue iridescence on the dorsal wings of males (Fig. 8) and by the wide posterior penis in ventral aspect (Figs. 23–24) that is somewhat flattened in lateral aspect (similar to penis shape in *Parrhasius* Hübner, Nicolay 1979). Results of an ongoing phylogenetic analysis of *Ignata* and its relatives may modify the current generic classification of these species.

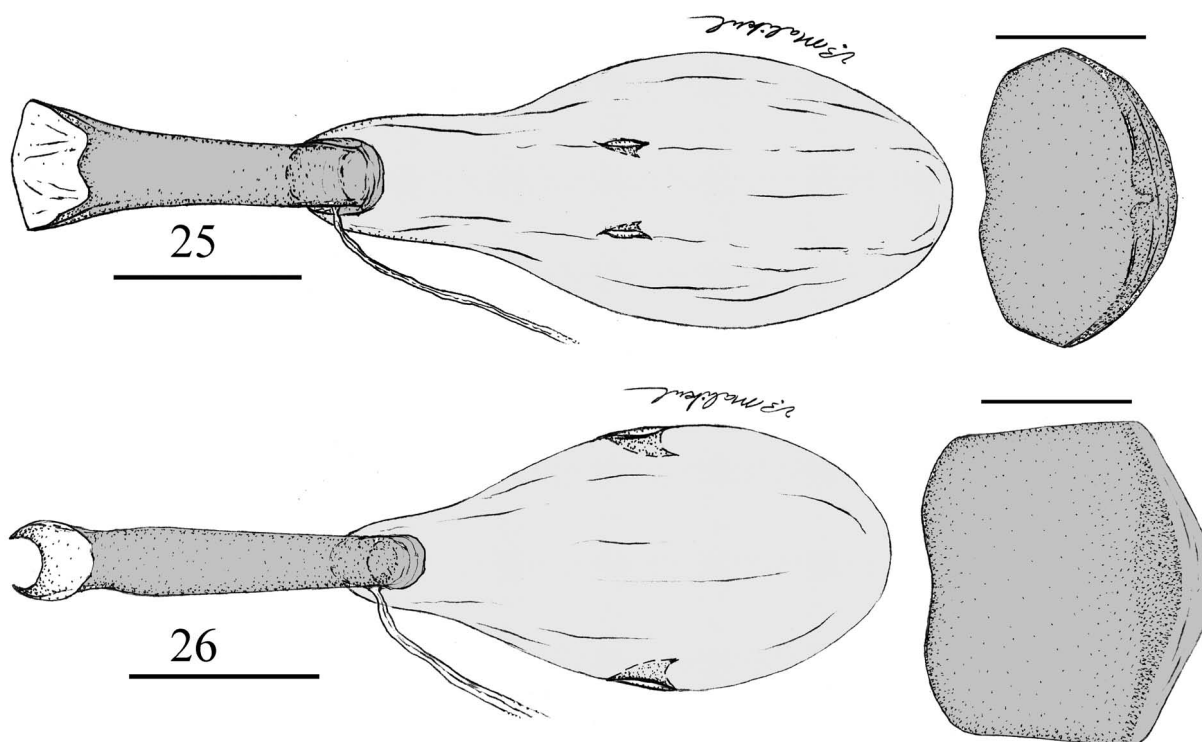
Holotype ♂ (Fig. 8). [white label, elevation and date handwritten in black ink] Panamá, [Panama Province], Cerro Campana, 1000 ft, 4 Aug 1967, leg. G. B. Small. [red label] HOLOTYPE *Ignata caldas* Robbins. Deposited USNM.

Paratypes (5♂ & 7♀). Panamá, Cerro Campana, leg. G. B. Small: 1♀ 1500 ft, 23 Jan 1965; 2♀ 2000 ft, 23 Dec 1963; 1♀ 2000ft, 4 Jan 1964; 1♀ 2000ft, 5 Jan 1964; 2♂ 2000 ft, 8 Dec 1963; 1♀ 2500 ft, 9 Sep 1967. Panamá, Panamá Province, Cerro Campana, leg. R. Robbins, 1♀ 500 m, 23 Feb 1979. Panamá, Chiriquí Province, Potrerillos, 3600 ft, leg. G. B. Small: 2♂ 27 Dec 1965; 1♀ 29 Dec 1965. All paratypes deposited USNM.

Type locality. The type locality is remnant forest and scrub vegetation surrounded by pasture along the road from the Pan American Highway to Cerro Campana (further descriptions in Ridgely 1976, Robbins & Small 1981).

Etymology. *Ignata caldas* is named for my wife, insect population ecologist Astrid Caldas, who conducted dissertation research on butterflies at the type locality. It is an indeclinable noun in apposition of feminine gender.

Habitat. *Ignata caldas* occurs in wet and seasonally dry forest from sea level to 1,100 m in Central America and from the Amazon lowlands to 1,900 m on the eastern slope of the Andes.



FIGS. 25-26. *Ignata* female genitalia, ductus copulatrix (left), 8th abdominal tergum (right), ventral aspect, posterior to left, scale 1 mm. **25.** *I. caldas* (Panamá). **26.** *I. gadira* (Panamá).

Larval foodplant. Unknown.

Distribution (Fig. 32). *Ignata caldas* ranges from Mexico to southeastern Peru in the Amazon Basin (Rio Madre de Dios drainage). This species undoubtedly occurs in Bolivia and Brazil near the border with Peru.

Study series. For this paper I examined 42 males and 31 females from 9 countries of *I. caldas*, including genitalic dissections of 6 males and 3 females, and 22 males and 11 females from 5 countries of *I. gadira*, including genitalic dissections of 2 males and 2 females. I also examined the holotypes of *I. gadira* and *I. minthe* (BMNH).

Arawacus togarna (Hewitson)

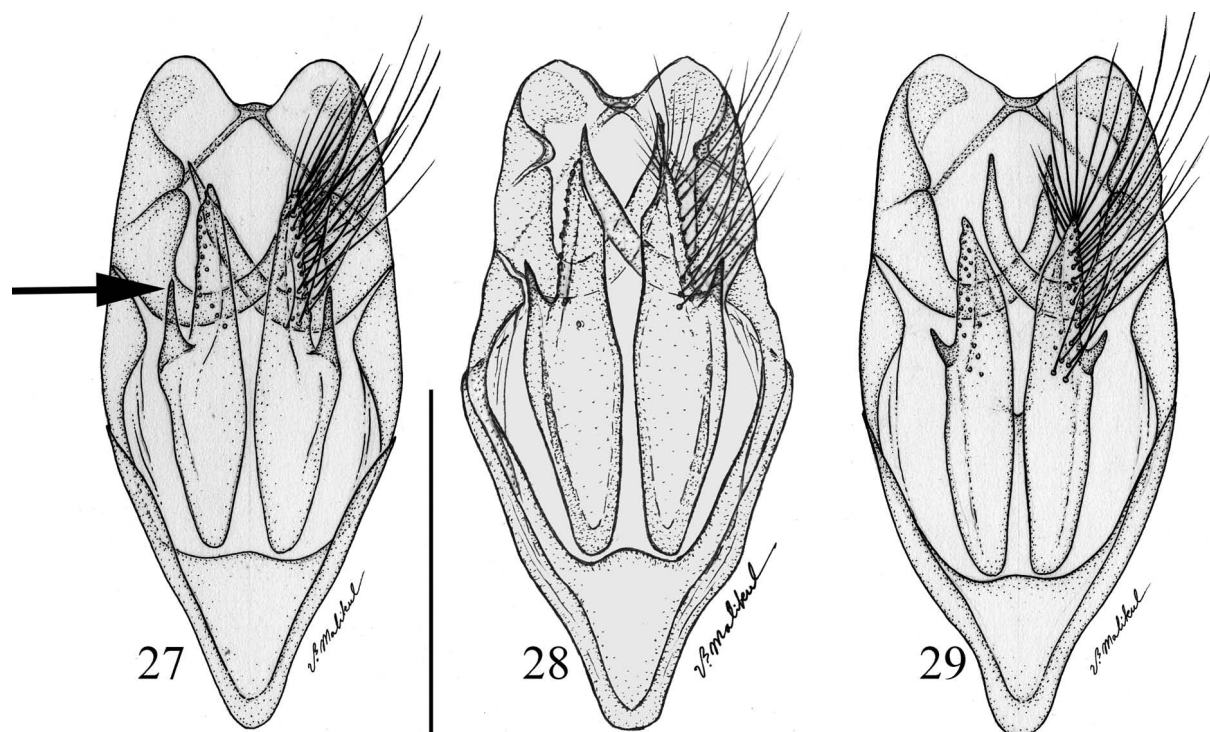
History and new information. Following Godman & Salvin (1887–1901), Draudt (1919–1920) distinguished *Thecla togarna* Hewitson with four ventral hindwing brown/black bands from *T. linus* (Fabricius) with five. He divided the former into geographical “forms” *Thecla togarna* and *Thecla lincoides* Draudt.

The late H. K. Clench (unpublished manuscript in CMNH) transferred the “four-banded” *togarna* and *lincoides* to *Arawacus* (previously characterized in

Clench 1961) and treated them as subspecies of the “five-banded” South American *A. aetolus* (Sulzer), which is a senior synonym of *A. linus* (Comstock & Huntington 1961). He further noted that there were two wing pattern forms from Guatemala to Costa Rica on the Atlantic slope of Central America and that both differed from that of *A. a. togarna* to the north and from that of *A. a. lincoides* to the south. He planned to name these wing pattern phenotypes as subspecies, but had not yet examined the genitalia of these taxa at the time of his death.

Some subspecies of *A. aetolus*, which Clench had based on wing pattern and androconial characters, also have distinct genitalia. Because there was no evidence for hybridization at the distribution edges where these putative subspecies meet (with one exception in South America), Robbins (2000) treated them as distinct species. The unnamed wing pattern phenotypes from Guatemala to Costa Rica have distinct male genitalia, for which reason they were noted to be a distinct species (Robbins 2000) and were so treated by Dyer & Gentry (2002), Robbins (2004b), Colwell & Longino (2008), and Janzen & Hallwachs (2008).

As part of a project on the butterflies of Belize (Shuey



FIGS. 27-29. Variation of *Arawacus togarna* male genitalia, ventral aspect of genital capsule with penis removed, posterior to top, scale 1 mm. **27.** Mexico "long tooth, parallel". **28.** Belize "short tooth, parallel". **29.** Costa Rica "short tooth, oblique". Arrow points to tooth on valva.

et al. 2005), eight males and two females from Belize were donated to USNM. Variation of wing pattern and male genitalia in this sample suggests hybridization between the unnamed taxon and *A. togarna*.

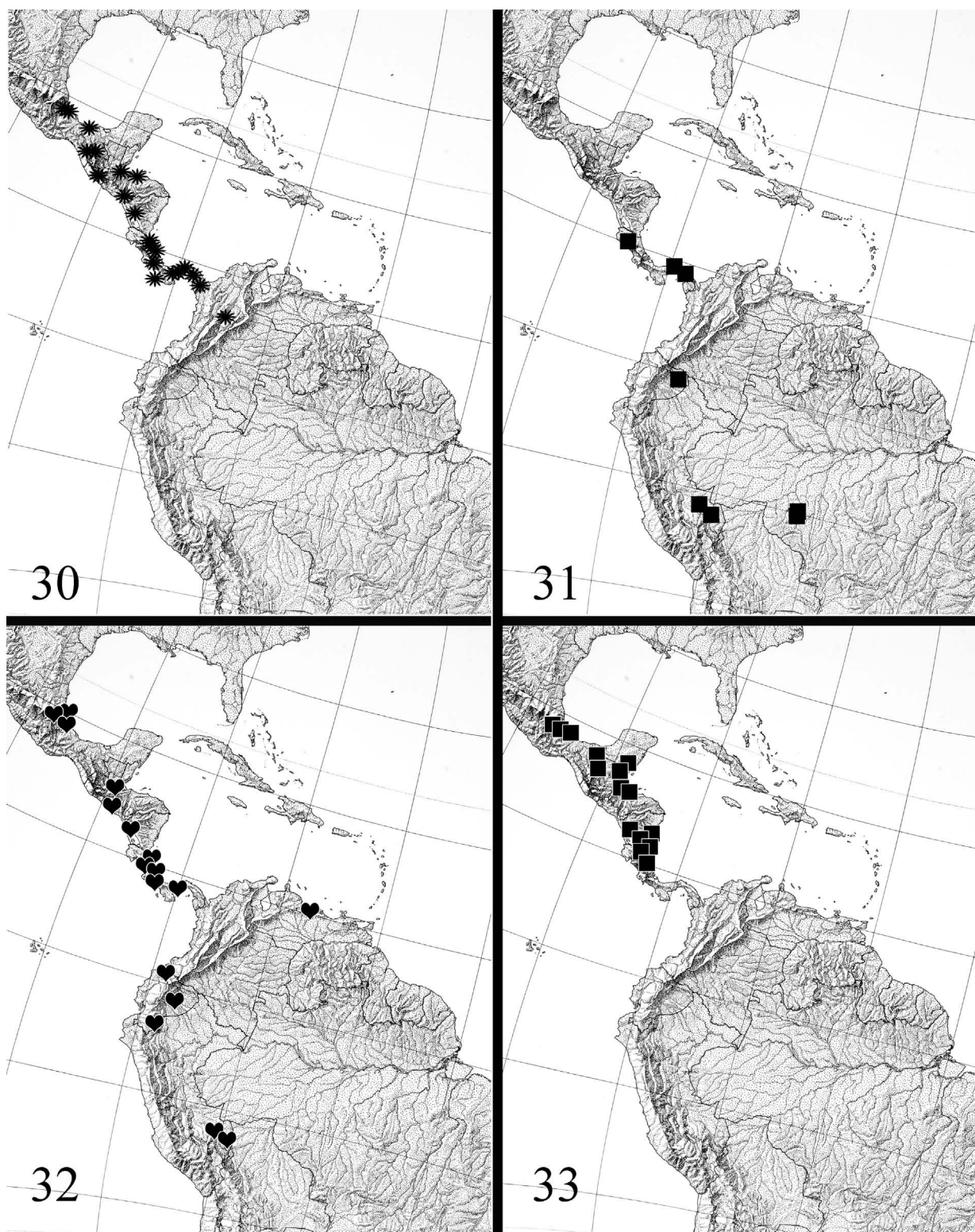
Variation. The black bands on the ventral wings of *A. togarna* are narrowest in Mexico and widest in Costa Rica (Figs. 12–13). The submarginal orange-yellow ventral hindwing band may extend posteriorly to the anal lobe (Fig. 12), to vein 2A (Fig. 13 top), or to vein Cu_2 (Fig. 13 bottom). The tooth on the male genitalia valvae may be "long" and parallel to the sagittal plane (Fig. 27), shorter in length and parallel to the sagittal plane (Fig. 28), or shorter in length and at an oblique angle (Fig. 29). Position of the tooth on the valva is also highly variable (Figs. 27–29). There is no substantive variation in the structure of the female genitalia within *A. togarna*.

Reasons for expanding the concept of *A. togarna* as a biological species. Ventral wing pattern and male genitalia in Mexico do not vary much and are distinct from the ventral wing pattern and male genitalia that occur with little variation in Costa Rica (cf. Figs. 12, 13 bottom, 27, 29). However, in Guatemala and Belize, intermediate wing pattern and male genitalia forms occur, and the same wing pattern forms of *A. togarna*

may have different male genitalia and vice versa. This result is most consistent with the hypothesis that the populations from Mexico to Costa Rica are one species.

Nomenclature. To stabilize the nomenclature of *Thecla togarna* Hewitson, 1867, a lectotype is designated. The lectotype is a male from the Hewitson Collection (Fig. 12) in the BMNH that has a red label "lectotype male designated by G. Lamas 2004," but Lamas did not publish the lectotype designation. The lectotype is labeled Mexico, but in the original description, *Thecla togarna* was stated to be from Venezuela. Several lines of evidence suggest that Hewitson made a simple mistake. First, the proposed lectotype is a remarkably good fit to the illustration in the original description both in wing pattern and the way that the wings are set (Figs. 11–12). Second, the proposed lectotype is from the Hewitson collection, and no other extant specimen from that collection fits the original description. Third, *A. togarna*, which is clearly recognizable from the original description (Fig. 11) as the form that occurs widely in Mexico is unknown from Venezuela. There are no Venezuelan specimens in MIZA (Robbins unpubl.) nor are any others reported from any other museum collection.

Habitat. Wet lowland forest. *Arawacus togarna* is



FIGS. 30-33. Distributions. **30.** *Iaspis andersoni* (stars). **31.** *Michaelus joseph* (squares). **32.** *Ignata caldas* (hearts). **33.** *Arawacus togarna* (squares).

unrecorded from seasonally dry forest, but two specimens were collected at a locality 14 km east of Managua that is a mosaic of habitats (Anderson, pers. comm.).

Larval foodplants. The caterpillars of *A. togarna* eat the leaves of many species of *Solanum* (Solanaceae) in Costa Rica. Records from Janzen & Hallwachs (2008, Area de Conservacion Guanacaste, Alajuela and Guanacaste Provinces, 16 vouchers in USNM,) are *Solanum jamaicense* (07-SRNP-42513), *S. hayesii* (06-SRNP-65566, 06-SRNP-30585, 06-SRNP-30581, 06-SRNP-30247, 06-SRNP-30785, 00-SRNP-12688, 06-SRNP-30789, 06-SRNP-30784, 06-SRNP-65564, 07-SRNP-30003, 07-SRNP-30928), *S. rugosum* (06-SRNP-42660), and *S. schlechtendalianum* (05-SRNP-31191, 06-SRNP-30821, 05-SRNP-32441). Records from Dyer & Gentry (2002, 4 vouchers in USNM) are *S. adherens*, *S. rudepanum*, *S. aturense* (*sipuranoides*), *S. rugosum*, *S. jamaicense*, and *S. (Cyphomandra) hardtweegii* (cf. Bohs 1995 for generic nomenclature). *Arawacus togarna* has also been recorded in Colombia on *Cestrum mariquitense* (Solanaceae) (Beccaloni *et al.* 2008), but this record is a misidentification because *A. togarna* does not occur in Colombia (no vouchers were noted).

Distribution (Fig. 33). *Arawacus togarna* occurs on the Atlantic slope of Central America from central Mexico to Costa Rica. It is unknown from the Pacific slope, but two individuals from 14 km east of Managua were found in Nicaragua's central rift valley (Robbins & Anderson in prep.). Specimens in the *A. togarna* species complex from Panamá and from the Pacific coast of Costa Rica are *A. lincoides*, not *A. togarna*.

Remarks. A "cream" colored dorsal hindwing scent patch occurs in all males of *A. togarna* (Fig. 16). It has not been reported previously, probably because its color is very similar to the surrounding "white" scales (Fig. 12 top). It occurs in *A. togarna*, *A. lincoides*, *A. aetolus* (Sulzer), and in modified forms in *A. separata* (Lathy) and *A. aethesa* (Hewitson) (Robbins unpubl.). In *A. lincoides* in Panamá, landed males being courted by other males rapidly vibrate their hindwings (Robbins unpubl.), a behavior that could conceivably be related to pheromones disseminated by these androconia.

Study series. For this paper, I examined 88 males and 36 females of *A. togarna* from 6 countries, including 17 male and 6 female genital dissections and 20 adults reared from larvae. I also examined an image of the lectotype of *A. togarna* provided by G. Lamas. Finally, I had access to the extensive data collated by Clench.

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CORRELATION OF BODY SIZE OF MOTHS CAPTURED BY LIGHT TRAP WITH NINE ENVIRONMENTAL VARIABLES

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ABSTRACT. A single light trap in southern Georgia, USA, operated 29 times for two consecutive days over a 13-month period, captured almost 12,000 moths in six body length categories. Increasing size of moths was related to decreasing number of individuals captured. The smallest moths were the most frequently captured from late spring to early fall, and the least frequently captured at other times of the year. The smallest size (<6 mm) showed capture values widely divergent through time, whereas the intermediate category (11–15 mm and 16–20 mm) size values were the least divergent through time, suggesting that the smallest sized moths were the group most affected by environmental variables. The largest size categories, 21–25 mm and 26–30 mm, represented less than four percent of the total captures and were most frequently captured during the coldest temperatures and during rain. Environmental conditions the six days prior to trap operation were not consistently similar to those conditions prevailing during trap operation and in some cases did affect trap captures. Maximum temperature during trap operation was the best single explanatory variable for the occurrence of all captured moths, whereas minimum temperatures during trap operation was the best explanatory variable for the smallest size class, and rain prior to trap operation was the best single explanatory variable for the intermediate size classes.

Additional key words: size relationships, environmental factors

Humans have been watching insects attracted to light since at least the acquisition of fire. Since then, although many refinements have occurred in man's production of light, humans are still attempting to understand the factors associated with the attraction of insects to light. One part of that attempt has been the use of light traps to capture nocturnal insects, with an accumulating extensive research literature examining the reasons insects are attracted to light and under what conditions capture occurs (Hienton 1974). More recent investigations have studied the attractive properties of light (Eguchi *et al.* 1982), the types of insects attracted to light (Muirhead-Thomson 1991), and the effects of numerous factors on the capture of insects, particularly moths, at light traps. Such variables have included trap type and location (Hartstack 1979), habitat (Butler *et al.* 1999), season (Taylor 1986), yearly characteristics (White 1991), latitude (Bowden 1984), temperature (Dreisig 1986), relative humidity (Mizutani 1984), and the amount of moon illumination (Nowinszky *et al.* 1979), rainfall (Tucker 1983), and wind (McGeachie 1989).

In all of these studies mentioned, what has not explicitly been examined is the role of insect size as it relates to capture frequency and the influence of environmental factors. Believing, as Calder (1984) has stated, that “any biological study must first consider size as the most significant characteristic of an animal”, my first project involving populations of nocturnal moths was to examine the effect of various environmental variables on different sizes of moths captured at light traps. The following study, using a single light trap, attempts to determine the relationship between nine

environmental factors, occurring before and during trap operation, and the size of the captured moth.

MATERIALS AND METHODS

The collection site was located in Tifton, Tift Co., GA, one mile from the University of Georgia Coastal Plain Experiment Station. The light trap was an omnidirectional, gravity-type trap with four vertical baffles that surrounded a 15-W black light lamp and was mounted vertically 5 feet above ground over a 30 cm diameter funnel to which was attached a collecting can containing different sized mesh separating screens. The trap was located at the interface of a 1-acre second-growth woodland and a 1-acre pecan plantation with a mowed grass floor. The site was surrounded by an established (>20 yr) residential neighborhood with large lots, many mature trees, streams nearby, and minimal vehicular traffic. Nine environmental variables that might affect the capture of moths at a light trap were recorded during trap operation and the preceding six days and included: (1) temperature (°C) - minimum and maximum, (2) rainfall (cm) - total amount in period, (3) wind (meters/sec.) - mean daily, (4) moon phase (0 = new, 1/4, 1/2, 3/4, 1 = full). Temperature values were obtained on-site with a maximum-minimum thermometer, rainfall and wind values were obtained from the adjacent experiment station official weather records, and moon phases were calculated from a local almanac. The six day period preceding a light trap sampling period represents the shortest interval in the entire study between consecutive sampling periods and thus was chosen as the standard interval of analysis before all sampling periods.

TABLE 1. Total number of moths captured in each size class in 29 sampling periods from 28 March 1981 to 7 May 1982 at Tifton, Tift Co., GA.

Size Class (mm)	Range of Values	Total No.	% of total
< 6	0-878	5180	43.2
6-10	2-526	3394	28.3
11-15	6-488	2268	18.9
16-20	2-97	747	6.2
21-25	0-34	330	2.8
26-30	0-12	68	0.6
Totals		11,987	100.0

The light-trap was operated approximately every two weeks from 2 hours before sunset to 1 hour after sunrise for two consecutive nights, for a total of 29 sample periods beginning 28 March 1981 and ending 7 May 1982. The contents of the trap container were bagged and frozen each morning, for subsequent processing. Later, after thawing and sorting, each moth was placed against a marked scale to determine its body length and its placement in one of six size categories (all in mm): <6, 6–10, 11–15, 16–20, 21–25, 26–30. Data from the two consecutive nights of trap operation were combined into one sample, with subsequent entry into an IBM main-frame and analysis by SAS GLM procedures.

RESULTS

From 28 March 1981 to 7 May 1982, 11,987 moths were captured during 29 sampling periods. Arranged by size categories, decreasing size was related to increasing numbers of individuals captured (Table 1). Combining the 29 sampling periods into 15 composite periods (Table 2) shows that the smallest size moth was the most frequently collected from mid-May to early September and then again from the following mid-April to early May. Members of this size class were some of the least frequently collected at other times of the year.

Table 3 examines within a size category the amount of variability in the mean number of captures through time, expressed as a ratio of the lowest value to the highest value. The 15 composite periods show that the 16–20 mm size category has mean capture values with the smallest difference between the lowest and the highest values through the entire 13-month period, with the <6 mm size category showing mean capture values widely divergent through time.

Nine environmental variables were monitored during the 13-month sampling period. Table 4 indicates that

environmental conditions the six days prior to trap operation were sometimes substantially different from days when the light trap was operating. For the entire 13-month period, minimum temperatures were lower and total rainfall was greater prior to trap operation, whereas maximum temperatures and daily wind were about the same during and before trap operation. Considering the entire 13-month period, only some of the nine environmental variables were significantly correlated. In a 9×9 paired correlation matrix yielding 36 possible correlations, there are 6 positive and 6 negative correlations that are statistically significant (Table 5). Minimum temperatures during trap operation are significantly correlated with maximum temperatures (positive) and wind (negative) during the same period, and with minimum and maximum temperatures (positive) during the prior six days. Maximum temperatures during trap operation are significantly correlated with wind (negative) during the same period and with minimum and maximum temperatures (positive) and rain (negative) during the prior six days. Minimum temperatures during the six days prior to trap operation are significantly correlated with maximum temperatures (positive) and with wind and rain (negative) during the same period. Maximum temperatures during the six days prior to trap operation are significantly correlated (negative) with wind during trap operation.

An attempt to determine by stepwise regression the best explanatory model for the occurrence during the entire 13-month sampling period of all moth size classes indicated that maximum temperatures during trap operation was the best single explanatory variable (Table 6). Adding moon phase produced the best two-variable model and adding the rain variable during trap operation produced the best three-variable model. For the various size classes, the best explanatory model using only one variable was minimum temperatures during trap operation for the <6 mm class, maximum temperatures during trap operation for the 6–10, 21–25, and 26–30 mm size classes, and rain during the prior six days for the 11–15 and 16–20 mm size classes (Table 6).

DISCUSSION

Methodology considerations. Body mass or body volume values are commonly used in studies of animal assemblages (Blackburn *et al.* 1993; Siemann *et al.* 1999). In the present study, body length, rather than body mass values, was obtained for the captured moths. Attempting to weigh each moth, besides being more time consuming, would have introduced considerable variation due to the different states of dehydration present in samples. It has been demonstrated with

TABLE 2. Mean number of moths captured and percent of total capture per two consecutive nights in six size classes during 15 composite sampling periods (numbers captured read within rows and within columns; percent values read within rows; two trap nights = one sampling interval, two sampling intervals = one composite sampling period).

Sampling intervals	Period #	Trap nights	<6mm	6–10	11–15	16–20	21–25	26–30	Mean Total
28–30 Mar; 4–6 Apr	1	4	0.5 0.7%	10 13.5	30 40.5	25 33.8	6 8.1	2.5 3.4	74.0
11–13 Apr; 18–20 Apr	2	4	18 8.3	49 22.5	107.5 49.3	29 13.3	12 5.5	2.5 1.1	218.0
25–27 Apr; 2–4 May	3	4	46 16.6	90 32.4	104.5 37.7	26.5 9.5	8.5 3.1	2 0.7	277.5
9–11 May; 16–18 May	4	4	175 47.5	104.5 28.4	66.5 18.0	11.5 3.1	10 2.7	1 0.3	368.5
23–25 May; 30 May– 1 Jun	5	4	505.5 60.0	178 21.1	98 11.6	34.5 4.1	21 2.5	5 0.6	842.0
15–17 Jun; 30 Jun–2 Jul	6	4	559 71.6	156.5 20.1	38 4.9	21 2.7	4.5 0.6	1.5 0.2	780.5
16–18 Jul; 31 Jul–2 Aug	7	4	130 24.5	228.5 43.0	93 17.5	37.5 7.1	34 6.4	8 1.5	531.0
16–18 Aug; 1–3 Sep	8	4	484 54.7	311.5 35.2	57 6.4	12.5 1.4	17 1.9	3.5 0.4	885.5
15–17 Sep; 30 Sep– 2 Oct	9	4	240.5 29.9	233.5 29.0	259 32.2	54 6.7	16 2.0	1.5 0.2	804.5
17–19 Oct; 4–6 Nov	10	4	26.5 10.1	95 36.2	97.5 37.1	39 14.9	4 1.5	0.5 0.2	262.5
18–20 Nov; 24–26 Dec	11	4	2 5.8	7.5 21.7	16.5 47.9	7.5 21.7	2 2.9	0 0	34.5
20–22 Jan; 18–20 Feb	12	4	1.5 3.1	9 18.4	24.5 50.0	9.5 19.3	4.5 9.2	0 0	49.0
11–13 Mar; 1–3 Apr	13	4	18.5 10.9	54 31.9	63 37.2	23 13.5	8.5 5.0	2.5 1.5	169.5
14–16 Apr; 28–30 Apr	14	4	174.5 50.4	90.5 26.2	45 13.0	22.5 6.5	7 2.0	1.5 0.4	341.0
5–7 May	15	2	407 58.1	159 22.7	68 9.7	41 5.8	22 3.1	4 0.6	701.0
28 Mar 81 – 7 May 82		58	2744.8 43.2%	1698.8 28.3	1133.7 18.9	380 6.2	163.5 2.8	33.3 0.6	6339.0

other organisms that “linear measurements, having lower coefficients of variation, were preferable over use of body mass to express size” (Rising & Somers 1989). Body length is typically used in research as a measure of size in most winged insects, with Lepidoptera as the principle exception (e.g. Novotny & Kindlmann 1996). In Lepidoptera studies, body length is typically not

considered an adequate measure of organism size; wing length (e.g. Summerville *et al.* 2006) or wing span (e.g. Nieminen *et al.* 1999) is the preferred metric. Support for this view was provided by Miller (1977), who within a single family of Lepidoptera demonstrated that forewing length was a good substitute for biomass as a size index. As documented by Greenewalt (1962),

TABLE 3. Ratio of the lowest to the highest mean capture value for each moth size within the entire 15 composite sampling period (capture values from Table 2).

Moth Size (mm)	Lowest Mean Captured	Highest Mean Captured	Capture Ratio	Capture Rank
<6	0.5	559	1:1118	6
6–10	6	311.5	1:52	4
11–15	13.2	259	1:19.7	2
16–20	6	54	1:9	1
21–25	0.8	22	1:27.5	3
26–30	0.1	5.3	1:53	5
Total	4.4	201.8	1:45.6	

TABLE 4. Environmental variable values (variable followed by the number '1' represents events occurring while the light trap was in operation; the number '2' represents events occurring the preceding six days).

Variable	Mean	Std. Dev.	Range
Min Temp 1	14	5.08	4–23
Min Temp 2	8.97	8.61	-13–23
Max Temp 1	28.89	4.45	20–38
Max Temp 2	30.89	3.68	23–37
Rain 1	0.41	0.94	0–3.8
Rain 2	3.44	3.86	0–13.4
Wind 1	52.48	22.84	27–130
Wind 2	53.62	13.52	28–80
Moon	0.50	0.36	0–1

TABLE 5. Significant correlations between environmental variables (variable followed by the number '1' represents events occurring while the light trap was in operation; the number '2' represents events occurring the preceding six days).

Variable 1	Variable 2	Correlation Coefficient	Probability
Min Temp 1	Min Temp 2	+ 0.81	< 0.001
Min Temp 1	Max Temp 1	+ 0.71	< 0.01
Min Temp 1	Max Temp 2	+ 0.69	< 0.001
Min Temp 1	Wind 1	- 0.44	< 0.02
Max Temp 1	Min Temp 2	+ 0.65	< 0.001
Max Temp 1	Max Temp 2	+ 0.66	< 0.001
Max Temp 1	Wind 1	- 0.60	< 0.001
Max Temp 1	Rain 2	- 0.39	< 0.04
Min Temp 2	Max 2	+ 0.71	< 0.001
Min Temp 2	Wind 2	- 0.43	< 0.02
Min Temp 2	Rain 2	- 0.56	< 0.002
Max Temp 2	Wind 1	- 0.47	< 0.01

however, there is a large degree of divergence from a standard ratio of wing length to body weight among and between the various families of Lepidoptera. Thus in studies involving a wide taxonomic diversity, wing length/span may not be the best measure of size. Choosing either body or wing metrics for this study does unfortunately introduce certain biases. Differences in moth wing size would likely be most affected by wind (McGeachie 1989), and differences in body size would most likely be influenced by temperature (Heinrich 1993).

Environmental variables. Moon. The role of moon illumination on light trap captures of moths has been well documented in many studies (e.g., Bowden 1984; Yela & Holyoak 1997). In simple terms, the brighter the moon illumination, the less visible to moths is light from a trap, leading to reduced numbers of captures. In the present study, the amount of moon illumination was not correlated with any of the other environmental variables (Table 5). Moon illumination, however, did become a 2nd order variable in explanatory models for numbers of moths captured (Table 6).

Rain. Because sample nights were chosen based on the likelihood of no rain, it is not surprising that during the sampling periods there were no significant correlations between rain and other environmental variables or numbers and sizes of moths captured. The well-known depressive effect of rainfall on ambient temperature (Rosenberg *et al.* 1983) is confirmed in this study, as the occurrence of rain in the six days prior to sampling periods was significantly correlated (negative) with the minimum temperature during that period and with the maximum temperature of the subsequent sampling period (Table 5). In explanatory models for sizes and numbers of moths captured, rain was a 3rd order variable for the entire set of captures and a 1st order variable for several size classes (Table 6).

Wind. Both during and before the moth sampling periods, wind was significantly correlated (negative) with minimum and maximum temperatures (Table 5). Wind would be expected to lower temperatures, due both to increased evaporative cooling and the association with changing weather conditions. Given that the trap location was in a reasonably protected location, wind would not be expected to have a significant impact on numbers of moths captured. The location of the wind-monitoring equipment at the nearby Experiment Station, however, was in a more exposed location, producing wind values that when applied to the trap location, over-emphasized the potential impact of wind. Although wind was not a 1st order variable in explanatory models for numbers and sizes of moths captured, it was a 2nd or 3rd order

TABLE 6. The number of moths captured in each size class in 29 sampling periods regressed against nine environmental variables, producing best explanatory models based on one or two or three variables (variable followed by the number '1' represents events occurring while the light trap was in operation; the number '2' represents events occurring the preceding six days).

Size (mm)	Best 1 variable	R ²	Prob >F	Best 2 variables	R ²	Prob > F	Best 3 variables	R ²	Prob > F
<6	Min Temp 1	0.22	0.012	Min Temp 1 Rain 1	0.32	0.004 0.068	Min Temp 1 Rain 1 Moon	0.43	0.001 0.031 0.041
6–10	Max Temp 1	0.28	0.004	Max Temp 1 Moon	0.33	0.002 0.178	Min Temp 1 Rain 1 Wind 2	0.40	0.030 0.025 0.042
11–15	Rain 2	0.14	0.051	Wind 2 Rain 2	0.18	0.255 0.042	Rain 1 Rain 2 Wind 2	0.27	0.105 0.189 0.093
16–20	Rain 2	0.25	0.007	Rain 2 Moon	0.31	0.003 0.145	Rain 1 Rain 2 Moon	0.37	0.148 0.004 0.109
21–25	Max Temp 1	0.29	0.003	Max Temp 2 Max Temp 1	0.35	0.139 0.001	Max Temp 2 Max Temp 1 Min Temp 2	0.40	0.067 0.024 0.172
26–30	Max Temp 1	0.35	0.001	Max 1 Wind 1	0.41	0.001 0.100	Wind 1 Max Temp 1 Max Temp 2	0.48	0.044 0.019 0.082
Total	Max Temp 1	0.23	0.009	Max Temp 1 Moon	0.33	0.002 0.061	Max Temp 1 Rain 1 Moon	0.39	0.002 0.153 0.049

variable in several specific size models (Table 6).

Temperature. Minimum temperatures before and during sampling periods were significantly correlated with maximum temperatures before and during sampling periods, as well as with wind and rain (Table 5). Moth activity occurred throughout the range of observed temperatures (4 to 38°C), though the extremes of temperature may have inhibited flight somewhat. Minimum temperatures during the sampling periods were a 1st order explanatory variable only for the smallest (<6 mm) size class. This was not unexpected, given that a small object has more surface area for its volume than a larger one, leading to the smaller object losing heat faster (Calder 1984). Thus the smallest moths were most likely to not be flying at the lowest temperatures. Although there are some small winter-active moths that can fly continuously at ambient temperatures of 5°C (Heinrich 1987), they are uncommon and do not occur in Georgia (Schweitzer 1974).

Body size. At the start of this study, it was thought that the use of body length rather than wing length or wing span as a measure of moth size would probably have an effect on the relative importance of temperature; that is, body length would probably be more sensitive to variables affecting body metabolism, such as temperature. It is well established that there is

minimal heat transfer to and from the wings and the body of lepidopterans (Kammer & Brachi 1973), indicating the key role of the body in both generating heat necessary for body functions and as the primary portion of the complete organism most affected by environmental temperature. If wing length or wing span had been used as the size metric, rather than body length, the results of this study would probably have been different. Small moths tend to have relatively larger wings than large moths, primarily due to their difficulty in maintaining sufficiently high thoracic temperatures necessary for flight; larger wings compensate for smaller mass (i.e., low wing-loading) and allow flight at the necessarily lower thoracic temperature (Bartholomew & Heinrich 1973).

The size distribution illustrated by Table 1—decreasing abundance as individual size increases—is the same pattern found in many animal assemblages (e.g., Blackburn *et al.* 1993). What is not typically seen is the relation of size to temperature. Minimum temperature during sampling periods best explains the occurrence of the smallest moths, and maximum temperatures during sampling periods best explains the occurrence of the largest moths, but temperature has no explanatory value for the occurrence of the intermediate-sized moths (Table 6). The effect of temperature may also be involved in the variability of

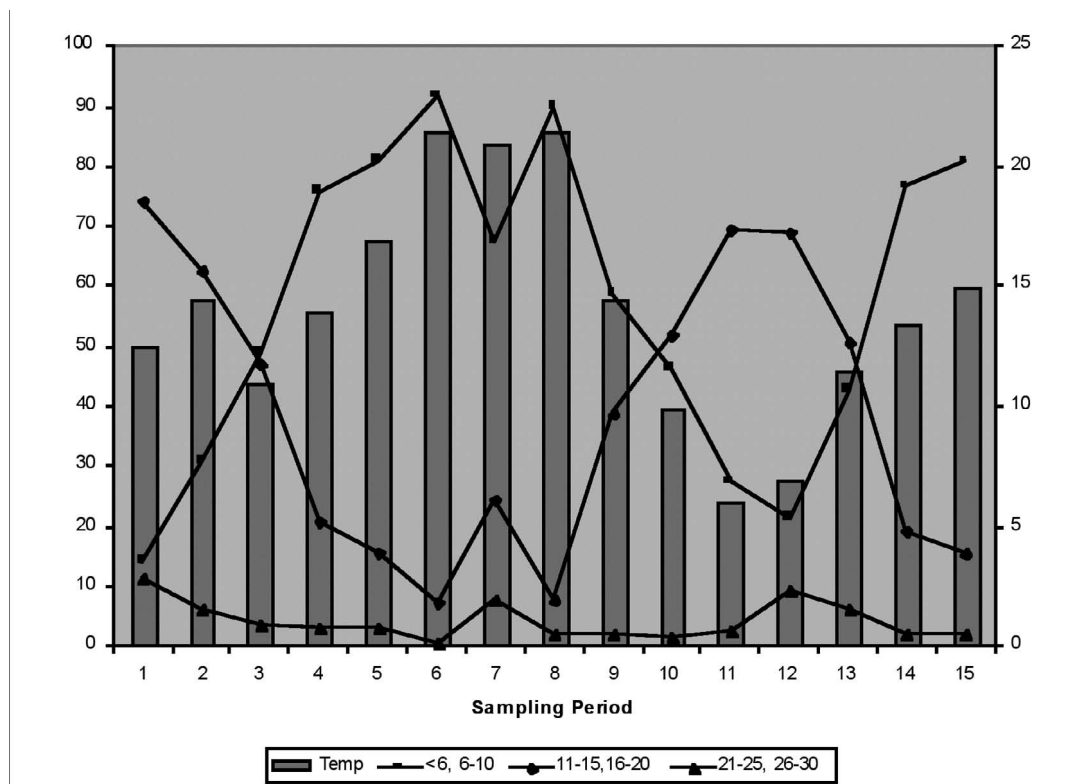


FIG. 1. Percentage of moths captured in three size categories in 15 sampling periods, with concurrent minimum temperatures.

capture numbers within a size category. The smallest- and largest-sized moths have the greatest range of capture numbers during the sampling periods and the intermediate-sized moths have the least variability in capture numbers (Table 3). This suggests that the intermediate-sized moths have, through time, a relatively constant population size, and/or a population relatively unaffected by changes in the various environmental conditions that were monitored. The order-of-magnitude difference in capture number variability between the smallest-sized (<6 mm) moths and all other sized moths (Table 3) suggests that the smallest-sized moths are more affected by environmental variables than any of the other sizes.

Does this study indicate that there is an optimal size for “successful” moths at this location? Yes and no. If success is defined as the largest population, then the smallest moths are the optimal size. If success is defined as the most stable population through time, and thus perhaps the group least affected by environmental variables, then the intermediate-sized moths are the optimal size.

When the six size categories are consolidated into three, and a plot is created of sampling period versus percentage of the size class in each sampling period (Fig. 1), the smallest moths are most abundant in the

warmer periods of the year and the intermediate-sized moths are most abundant in the cooler periods. The largest size class never exceeded 12 percent of the total moths captured in any period, whereas the smallest size class peaked at 91 percent and the intermediate size class peaked at 74 percent. Figure 1 also illustrates the impact that rain can have on the capture of moths in a light trap, and on the subsequent analyses. Although there was a deliberate attempt to avoid sampling periods in which rain might occur, this was not possible for the 31 July–2 August period. The occurrence of rain both before and during that sampling period depressed the capture frequency of the smallest-sized moths and increased that of the intermediate-sized moths (Fig. 1). These two periods were sufficiently important in the entire 13 month study for rain to become the most important parameter in the explanatory models for the two intermediate-size categories (Table 6).

In general, the results of this study are compatible with the pioneering study in England of C.B. Williams (1940), who demonstrated that temperature in winter (November to April) was the most important factor affecting insect capture (of all sizes) at light traps, and that rainfall in summer (May to October) was the most important factor. Other trends demonstrated by numerous studies (e.g., McGeachie 1989) are also

supported, to include (1) increases in mean illumination and mean wind speed are associated with a decreased light-trap catch of moths (of all sizes), and (2) increases in mean temperature are associated with an increased catch.

Without knowledge of each species and its relevant biology included in this assemblage, it is merely conjecture to outline the relationships between various environmental parameters and the individual size of groups of moths captured. This study, though not specifically addressing the metabolic characteristics of the various sizes of moths captured, does support the general conclusion that the smallest sized moths would be most affected by environmental temperatures lower than about 30°C, and that there may be an optimum size of moth best suited for a particular set of environmental variables (Heinrich 1993).

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Please see Appendix A & B on the next two pages

APPENDIX A. Light trap capture data, 28 March 1981–7 May 1982, Tifton, Tift Co., GA.

Sample Dates	TrapNights	<6 mm	6–10 mm	11–15 mm	16–20 mm	21–25 mm	26–30mm	Total
28 Mar–30 Mar 81	2	1	7	17	13	3	1	42
4 Apr–6 Apr	2	0	13	43	37	9	4	106
11 Apr–13 Apr	2	3	36	62	27	12	3	143
18 Apr–20 Apr	2	33	62	153	31	12	2	293
25 Apr–27 Apr	2	43	50	119	26	7	2	247
2 May–4 May	2	49	130	90	27	10	2	308
9 May–11 May	2	165	103	95	16	14	0	393
16 May–18 May	2	185	106	38	7	6	2	344
23 May–25 May	2	713	260	107	44	25	6	1155
30 May–1 Jun	2	298	96	89	25	17	4	529
15 Jun–17 Jun	2	242	170	15	11	6	3	447
30 Jun–2 Jul	2	876	143	61	31	3	0	1114
16 Jul–18 Jul	2	122	237	109	35	34	12	549
31 Jul–2 Aug	2	138	220	77	40	34	4	513
16 Aug–18 Aug	2	90	97	14	15	29	5	250
1 Sep–3 Sep	2	878	526	100	10	5	2	1521
15 Sep–17 Sep	2	27	39	30	11	3	0	110
30 Sep–2 Oct	2	454	428	488	97	29	3	1499
17 Oct–19 Oct	2	45	141	128	28	4	1	347
4 Nov–6 Nov	2	8	49	67	50	4	0	178
18 Nov–20 Nov	2	4	13	14	12	2	0	45
24 Dec–26 Dec	2	0	2	19	3	0	0	24
20 Jan–22 Jan 82	2	0	9	6	2	2	0	19
18 Feb–20 Feb	2	3	9	43	17	7	0	79
11 Mar–13 Mar	2	4	11	43	17	4	1	80
1 Apr–3 Apr	2	33	97	83	29	13	4	259
14 Apr–16 Apr	2	183	92	57	26	7	1	376
28 Apr–30 Apr	2	166	89	33	19	7	2	316
5 May–7 May	2	407	159	68	41	22	4	701
Totals		5180	3394	2268	747	330	68	11987

APPENDIX B. Environmental values, 28 March 1981–7 May 1982, Tifton, Tift Co., GA (temperature = degrees centigrade; rainfall = centimeters, total amount in period; wind = mean meters per day; moon = 0 - new, 1 - full; identification numbers with letter 'S' represent sample periods when light trap was operating).

Please see Appendix B on the next page

Appendix B. Environmental values, 28 March 1981–7 May 1982, Tifton, Tift Co., GA

I.D. No.	Sample Period	Temperature Min–Max	Rainfall	Wind	Moon
1	23 Mar–28 Mar	3 - 23	0.02	35	
1S	28 Mar–30 Mar	12 - 24	0.28	130	0.50
2	30 Mar –4 Apr	9 - 33	3.63	61	
2S	4 Apr–6 Apr	13 - 22	0.30	90	0.00
3	6 Apr–11 Apr	8 - 31	0.00	55	
3S	11 Apr–13 Apr	14 - 31	0.00	39	0.50
4	13 Apr–18 Apr	12 - 33	0.00	49	
4S	18 Apr–20 Apr	15 - 32	0.00	49	1.00
5	20 Apr–25 Apr	10 - 30	1.45	72	
5S	25 Apr–27 Apr	12 - 29	0.00	36	0.50
6	27 Apr–2 May	11 - 32	0.00	48	
6S	2 May –4 May	10 - 27	0.00	45	0.00
7	4 May–9 May	11 - 31	2.74	48	
7S	9 May–11 May	15 - 26	0.00	72	0.50
8	11 May–16 May	8 - 30	0.00	71	
8S	16 May–18 May	13 - 32	0.00	45	1.00
9	18 May–23 May	10 - 34	0.00	68	
9S	23 May–25 May	16 - 32	0.00	48	0.50
10	25 May–30 May	16 - 33	1.75	65	
10S	30 May–1 Jun	18 - 33	0.00	40	0.00
11	1 Jun–15 Jun	23 - 35	2.51	55	
11S	15 Jun–17 Jun	23 - 35	0.20	29	1.00
12	17 Jun–30 Jun	16 - 36	0.41	52	
12S	30 Jun–2 Jul	20 - 32	0.30	42	0.00
13	2 Jul–16 Jul	19 - 37	3.30	40	
13S	16 Jul–18 Jul	23 - 38	0.00	42	1.00
14	18 Jul–31 Jul	20 - 37	4.37	46	
14S	31 Jul–2 Aug	19 - 32	3.78	35	0.00
15	2 Aug–16 Aug	20 - 33	5.36	34	
15S	16 Aug–18 Aug	22 - 34	2.16	39	1.00
16	18 Aug–1 Sep	17 - 32	8.03	39	
16S	1 Sep–3 Sep	21 - 34	0.00	28	0.25
17	3 Sep–15 Sep	18 - 35	2.82	28	
17S	15 Sep–17 Sep	17 - 27	2.77	43	1.00
18	17 Sep–30 Sep	9 - 33	0.00	36	
18S	30 Sep–2 Oct	12 - 31	0.00	27	0.25
19	2 Oct–17 Oct	9 - 30	1.88	51	
19S	17 Oct–19 Oct	7 - 29	0.00	66	0.75
20	19 Oct–4 Nov	8 - 26	3.60	63	
20S	4 Nov–6 Nov	13 - 23	0.43	48	0.50
21	6 Nov–18 Nov	2 - 26	5.08	47	
21S	18 Nov–20 Nov	6 - 27	0.00	65	0.50
22	20 Nov–24 Dec	-8 - 27	12.73	60	
22S	24 Dec–26 Dec	6 - 20	1.63	75	0.00
23	26 Dec–20 Jan	-13 - 27	13.41	66	
23S	20 Jan–22 Jan	10 - 23	0.00	36	0.25
24	22 Jan–18 Feb	-5 - 27	12.73	71	
24S	18 Feb–20 Feb	4 - 25	0.00	82	0.25
25	20 Feb–11 Mar	-2 - 28	2.87	56	
25S	11 Mar–13 Mar	9 - 29	0.00	29	0.75
26	13 Mar–1 Apr	4 - 34	2.82	65	
26S	1 Apr–3 Apr	14 - 31	0.00	70	0.50
27	3 Apr–14 Apr	2 - 27	4.75	59	
27S	14 Apr–16 Apr	15 - 30	0.00	48	0.50
28	16 Apr–28 Apr	9 - 29	3.51	80	
28S	28 Apr–30 Apr	12 - 22	0.00	76	0.50
29	30 Apr–5 May	14 - 27	0.00	35	
29S	5 May –7 May	15 - 28	0.00	48	1.00

THE LIFE CYCLE OF *MESOSEMIA MEVANIA* (HEWITSON 1857) (RIODINIDAE) IN A LOWER MONTANE HUMID FOREST IN COLOMBIA

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Abstract. The life cycle and behavior of *Mesosemia mevania* from eggs to adults in a lower montane humid forest in the Parque Ecológico Piedras Blancas (Antioquia, Colombia) are described and illustrated. For each stage, morphological characteristics are described as well as average size and development time. The average duration of the life cycle was 77.3 days. The host plant was *Notopleura macrophylla* (Rubiaceae) (Ruiz & Pav.) C. M. Taylor.

Additional key words: immature stages, *Notopleura macrophyll*

Immature stages of riodinid butterflies are not well known, with host plants and first stadia morphology having been described for only 13–15 % of species (DeVries *et al.* 1992; DeVries 1997; Hall *et al.* 2004). Detailed life cycles have only been published for a handful of species: *Anatole rossi*, by Ross (1964); *Juditha molpe*, by Callaghan (1982); *Stalachtis susana*, by Callaghan (1985); *Synargis brennus*, by (Callaghan 1986); *Nymphidium lisimon attenuatum*, *Phaenochitona sagaris satnius* and *Metacharis ptolomaeus*, by (Callaghan 1988); *Metacharis ptolomaeus* and *Napaea nepos orpheus*, by Callaghan (1991); *Theope guillaumei cecropia*, by DeVries & Hall (1996); *Dodona egeon*, *Dodona eugenes*, *Dodona dipoea*, by Callaghan (1997); *Juditha caucana*, by Hall & Harvey (2001) and *Calydna sturnula*, by Hall *et al.* (2004).

The genus *Mesosemia* (Hübner 1819) contains approximately 130 Neotropical species (Callaghan & Lamas 2004) distributed from Mexico to South America, but especially diverse in lowland forest habitat in the Amazon (DeVries 1997). Although it is one of the most frequently observed genera among the riodinids (DeVries 1997), its biology and immature stadia are not well known (DeVries *et al.* 1992; DeVries 1997; Hall *et al.* 2004).

Mesosemia mevania (Hewitson 1857) is commonly found in forest understory in the Andean region in Colombia, Ecuador, Peru and Venezuela. In Colombia it is found in all three Andean Cordilleras, on the Pacific

coast and in the Magdalena and Cauca valleys, at altitudes ranging from 800 to 2400m (García-Robledo *et al.* 2002). Host plants include species of Rubiaceae: *Psychotria poeppigina*, *P. macrophylla* and *Palicourea angustifolia* (Valencia *et al.* 2005).

This article describes and illustrates immature stages of *Mesosemia mevania*, representing the second detailed description of the life cycle of a species belonging to this genus after Stichel (1924).

MATERIALS AND METHODS

The study was carried out between April and September 2005 in the Parque Ecológico Piedras Blancas nature reserve (Antioquia, Colombia) (6° 8' 20" N - 75° 30' 20" W), at an altitude of 2300 to 2400m, which has an average temperature of 15°C and average annual rainfall of 1965mm (IDEAM 2003). Immature individuals (eggs and larvae of different instars) were collected in the field and reared in laboratory until adult. Some of the eggs were collected immediately after oviposition events by females. Behavioral observations of immature individuals were made in the field and in the laboratory.

Rearing in the laboratory. Laboratory rearing was carried out at an average temperature of 16.7°C (max: 23.5 and min: 10.3) and a relative humidity of 76.7% (max: 100 and min: 51.1). Eggs were held in plastic containers until eclosion, after which they were separated at first instar and monitored individually

throughout their life cycle. Larvae obtained in the field were reared as a group, conserving the same number of individuals found on the host plant. Some of these were reared on host plants grown in plant pots in order to observe group behavior.

To determine the development time for the eggs, only those collected immediately after observing the oviposition event were taken into account (for which the date and time of oviposition was known). Development time for larvae, from first instar until chrysalis, was established from all the eggs collected, whether or not the oviposition event was observed.

For each individual for each of the five larval instars we recorded development time, initial and final larval size, width of head capsule and pupal size. Lengths were measured with millimeter lined paper under a stereo microscope. These data were used to calculate minimum, maximum, average and standard deviation values for each instar.

Larvae from each instar were killed in hot water and initially fixed in Kahles solution and finally transferred to 80% alcohol (Borror *et al.* 1989; Holloway *et al.* 1992). These specimens, as well as the adults, were deposited in the Piedras Blancas Entomological Museum (MEPB- National Collections Register No. 147) and the Entomological Collection of the Universidad de Antioquia (CEUA National Collections Register No. 036). The host plant was identified and deposited at the Herbarium of the Universidad de Antioquia (HUA # 147845).

RESULTS

Description of immature stages. *Eggs* (Fig. 1a). Echinoid-shaped eggs, 0.6mm long and 0.8mm in diameter ($n = 132$). Viewed under a stereomicroscope, the chorion has diminutive round cells, surrounded by smooth crests with hairlike structures. The surface surrounding the micropyle is smooth and slightly concave. Eggs are yellow in color for the first few days after oviposition and gradually become clearer until eclosion. Eggs take an average of 17 days to hatch (16–18 days, $n = 17$).

First instar (Fig. 1b). Average length at the beginning of the instar: 2.2mm ($sd = 0.4$; $n = 103$) and 3.6mm at the end ($sd = 0.6$; $n = 64$). The body is trapeze-shaped, with small lateral, rounded lobes at the base of segments T2 to A8, covered with dorsal chalazae with long feathery setae. T1 is higher than other segments, with a fleshy lobe or verruca on each side with seven divergent chalazae, most of which are dark; some point cephalad, covering the head. From T2 to A8, two dorsal chalazae are present per segment. In T2–A1 and A8, one lies close to the midline, the other below. From A2 to A7, one is anterior, the other posterior, further dorsad. The closest chalazae to the midline on T2 and A1 are white, the others are dark; on T3 both are dark; on A8 both are white. On A2 to A7, the anterior chalaza is white, the posterior is dark. On A9 and A10, there are three dorsal setae, the two anterior are white and the posterior is dark. The posterior edge of A10 has three dark setae which point caudad. On each side of A8, dorsally posterior to the spiracle, there is an extrusible tentacle, similar to the nectary organs present on myrmecophilous riodinid larvae described by DeVries (1997). T1 has two lateral setae per side, there are three on T2 and T3, one of which is shorter; on A1 to A7, there is a group of four infraspicular setae, one of which is shorter and points dorsad.

On A8, there are six or eight infraspicular setae, one is shorter and points dorsad. On T1 to T3, there are two setae on each leg and two on each proleg of A10. Initially, larvae are transparent and become green after feeding. Spiracles are circular and white, located more ventrally and posterior on the prothorax than on the abdomen. The head is visible at rest; it is round, transparent yellow with transparent long and short setae. The head capsule measures 0.5mm in width on average ($n = 26$), with black ocelli and light brown mandibles. Average duration of the stage is 7.3 days (5–12 days, $n = 64$).

Second instar (Fig. 1c). Initially 4.9mm in length ($sd = 1.5$; $n = 62$), final length 6.7mm ($sd = 1.5$; $n = 59$). The body is green with a shape similar to the previous instar, covered with small spinules and chalazae. These are greenish-aquamarine at their base with feathery black setae. Each verruca on the prothorax has numerous divergent chalazae as well as white setae on the anterior edge of the segment extending cephalad and covering the head. On each side of the dorsal part of T2, T3 and A1, there are three or four chalazae, joined at the base, two anterior and one or two posterior. On A2 to A7, there are two dorsal chalazae, joined at the base; one is close to the midline, the other below; there are also one or two posterior chalazae, joined at the base. A8 has two chalazae joined at the base, and like the previous stadium, there is an extrusible tentacle posterior (dorsal) to the spiracle and surrounded by long, thick setae. A9–A10 has numerous black setae dorsally and white setae on the posterior edge. A sclerotized or well-differentiated anal shield was not observed. There is a short seta on and anterior to the spiracle from A1 to A7, as well as a longer one, posterior (dorsal) to the spiracle. These are white and elliptic in shape. There are more abundant lateral lobes, barbed setae and chalazae present on T2 to T8 than in the previous stadium. Over the first pair of legs, there is a verruca with a tuft of setae. The head capsule is on average 0.8mm in width ($n = 27$). Average duration of the stage is 7.2 days (4–10 days, $n = 59$).

Third instar (Fig. 1d). Initial length 8.9mm ($sd = 2.0$; $n = 59$), final length 11.2mm ($sd = 1.5$; $n = 58$). The body has a shape similar to the previous instar with a green aquamarine mid-dorsal stripe, extending from T2 to A8, bordered by a thick line interrupted at the middle of each segment. The chalazae are the same color as in the previous stadium. The head, lateral lobes of each segment and ventral region are lime green. The position of the dorsal chalazae on T1 to A1 is the same as the second instar. There are two anterior chalazae on A2 to A7, joined at the base, one closer to the midline, the other below. There also two posterior chalazae, joined at the base, one anterior and above the other. A8, like in the previous instar, has an extrusible tentacle (Fig. 1e). A9 to A10 have numerous dorsal chalazae and setae, as well as on the edge of the segment. There are lateral setae as in the previous stadium. In addition to the dorsal chalazae, there are also smaller, thick, black setae on each segment. The head capsule has an average width of 1.1mm ($n = 45$). Average duration of the stage is 5.8 days (3–9 days, $n = 59$).

Fourth instar (Fig. 1f). Initial length 13.2mm ($sd = 2.0$; $n = 58$), final length 16.5mm ($sd = 2.3$; $n = 58$) (Table 2). Body shape, position of setae and chalazae same as previous instar. The color varies slightly, on the dorsal, central region, from T2 to A8 there are three thin aquamarine longitudinal lines. Viewed dorsally, the head is hidden under the prothorax. There are verrucae on top of the last pair of prolegs, with setae hidden by the anal shield. A8 is the same as in previous instar, with an extrusible tentacle. The head capsule averages 1.4mm in width ($n = 9$) (Table 2). Average duration of the stage is 4.2 days (3–7 days, $n = 58$).

Fifth instar (Fig. 1g). Initial length 19.2mm ($sd = 2.5$; $n = 58$), final length 20.7mm ($sd = 1.6$; $n = 58$). Body is similar to previous instar, but with numerous clear blue spots on all segments. The width of the prothorax is reduced to almost the width of the head capsule, which is an average of 3mm ($n = 58$). A8 is the same as in the previous instar, with an extrusible tentacle. Average development time until prepupal stage is 4 days (2–7 days, $n = 58$). After the fourth day, the larva begins the prepupal stage (Fig. 1h), becoming dark brown with fine yellow lines bordering the segments and a yellow mid-dorsal line with lateral emerald green spots parallel to this. The prepupa is suspended with the head pointing down, and is adhered to the substrate by the

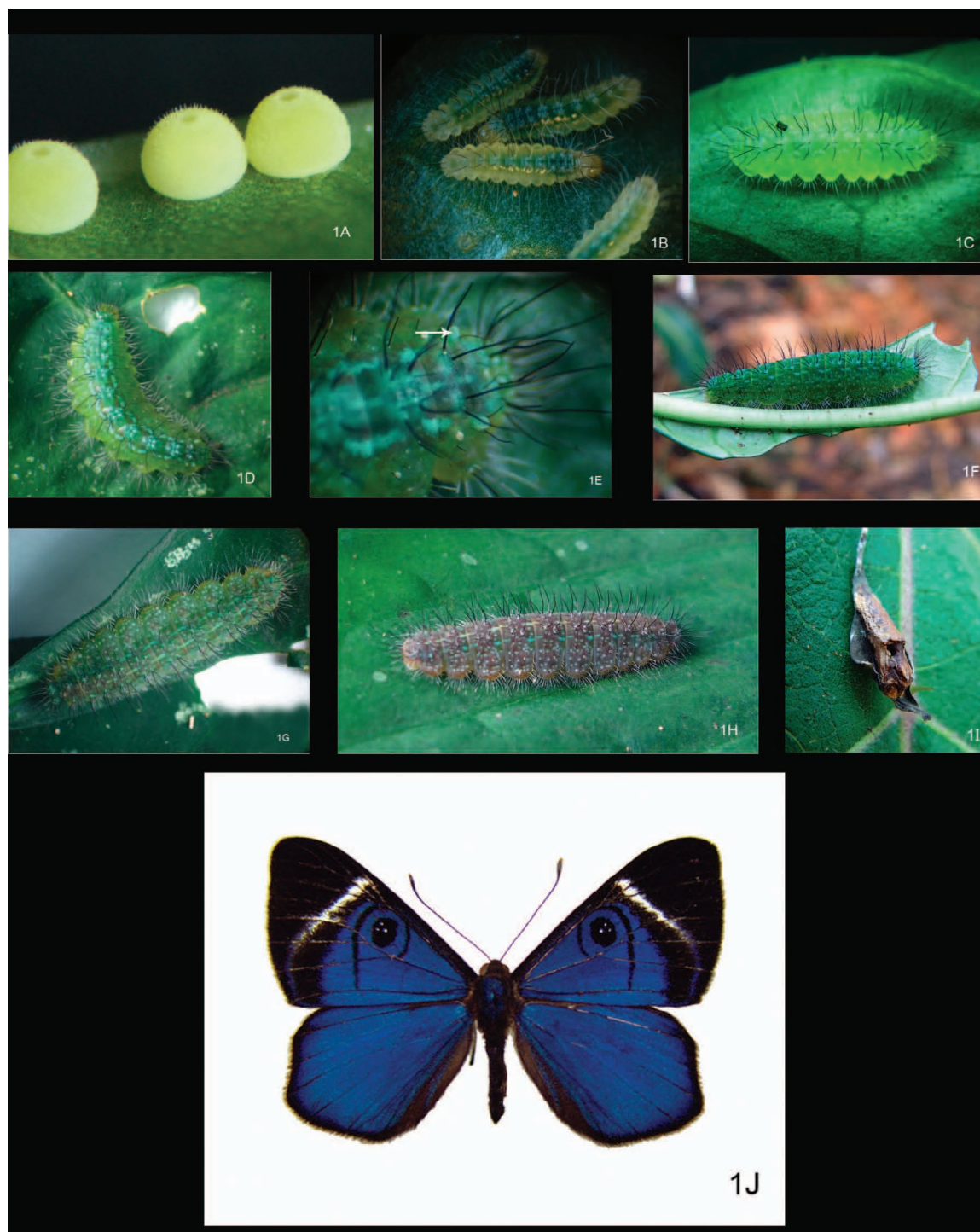


FIG 1. Immature stages and imago: **a)** Egg, **b)** First instar, **c)** Second instar, **d)** Third instar, **e)** Third instar, arrows show extrusible tentacle on A8, **f)** Fourth instar, **g)** Fifth instar, **h)** Prepupa, **i)** Pupa, **j)** Dorsal view, adult male.

cremaster which is surrounded by a silk pad. Average length 19.5mm (sd = 1.3; n = 58). The prepupa takes an average of 3.5 days to transform into the pupa (1–6 days, n = 58). Total development time is 7.5 days (n=58).

Pupa (Fig. 1i). Length 19mm, width 5.9mm, on average (n = 58). Pupa is suspended with the head pointing downwards and attached to the substrate by means of a large and flattened cremaster as well as a very thin silk thread, which passes dorsally over the second abdominal segment. Shape and coloration of the body is very cryptic, resembling a dry leaf or the face of an animal. Laterally, the body appears ventrally flattened; the first abdominal segment is depressed with a pair of dark marks. A2 is greater in height and has two crests on either side of the midline, with a line of hairs which look like eyebrows; two black marks join those on A1, giving the appearance of eyes. The mesothorax resembles a nose with two small protuberances with tufts of hairs on either side of the dorsal midline. On abdominal segments A3 to A6, there is an interrupted dorsal midline and lateral black marks. The body is covered with small, white setae, denser nearer the head. The A3 spiracle is hidden. The imago (Fig. 1j) emerges after 28.4 days on average (25–32 day; n = 56).

Biological observations. All eggs and larvae of *M. mevania* were observed on *Notopleura macrophylla* (Ruiz & Pav.) C.M. Taylor (Fig. 2), generally on plants between 20 and 60cm in height. A total of 132 eggs were collected on 40 plants, 17 immediately after observing oviposition events by three females. The remaining 115 were collected without recording the time of oviposition. Eggs were distributed in clusters of two to eleven eggs per leaf (one group per plant, 40 groups in total), and only three eggs were found by themselves. Larvae were only present on four of the 40 plants where eggs were found. Generally, each group of eggs was found on the edge of the underside of the leaf, organized in a line, separated by a few millimeters between each egg or in contact with one another.

The complete life cycle of *M. mevania* requires an average of 77.4 days (n = 58) from the egg to the emergence of the adult. The instar requiring most development time is the pupa, with 28.4 days on average, followed by eggs with 17 days. When the larvae hatch, they make a circular hole at the apex of the egg and do not feed on the chorion. In the field, observations showed that larvae of different instars fed on very young plants with succulent stalks and leaves. During the first three stages, larvae are semi-gregarious; two to five individuals were found on the underside of a leaf on each plant. In general they are active both by day and by night, feeding at the same time as each other on the leaves, from the central vein outwards on the underside. In the fourth and fifth instars only one or two larvae were found per leaf, with a maximum of three larvae per plant (field observations). They are active mainly at night, a common trait in many species of riodinids (DeVries 1997). Larvae prefer the upper side of the leaf and feed from the edges inwards, until the whole leaf has been eaten.

In the laboratory, the prepupae generally moved away

from the food plant to fix themselves to the walls of the container and form a chrysalis. In the cases where larvae were reared together on the host plant in a plant pot, they often pupated on the edges of the pot.

Adults were frequently observed in the understory at less than 2m in height, or in clearings, up to 5m above the ground. They flew from one plant to another, where they perched on the leaves with their wings half open. The adults were certainly found where there were immature larvae.

Parasitoids. Only 2.3% (n=3) of the 132 eggs collected in the field had been parasitized by *Telenomus* sp (Hymenoptera: Scelionidae). Parasites were not observed in any other stadia.

DISCUSSION

Habitat and food plant. The study area is principally made up of large pine plantations surrounding small fragments of native forest, dominated by *Quercus humboldtii*. This area corresponds to the lower montane moist forest (Im-MF) life zone (Holdridge 1987).



Figure 2. *Notopleura macrophylla*, host plant of *Mesosemia mevania*.

The host plant, *Notopleura macrophylla* (Ruiz & Pav.). C.M. Taylor (Rubiaceae), previously cited as *Psychotria macrophylla* Ruiz & Pav, is a shrub reaching a maximum height of 2.20m. Plants are distributed in small groups, along streams or in humid, shady areas and exclusively in native forest.

Oviposition behavior and behavior in larvae.

The host plant of *M. mevania* in Parque Ecológico Piedras Blancas belongs to the Rubiaceae family, the same host family as the majority of species of *Mesosemia* (Beccaloni *et al.* 2008). Females oviposit in clusters, on young plants and generally where oviposition has not taken place previously. Although an oviposition event was only observed in three females, it is likely that each of the 40 groups of eggs collected came from a single female. Observations showed that eggs within each group generally hatched on the same day and had been placed very close together on the leaf, in a similar fashion to those observed in oviposition events.

According to DeVries *et al.* (1992), DeVries (1997) and Stamp (1980), the majority of riodinids lay isolated eggs. Semi-gregarious behavior of the larvae or oviposition in small clusters has not previously been reported for any species of Mesosemiini. Among the riodinids, semi-gregarious larvae have only been reported for Eurybiini, Riodinini, Helicopiini, Emesiini, Lemoniini and Nymphidiini (DeVries *et al.* 1992), Stalachtis (Callaghan 1985), whereas females of *Ancyluris*, *Emesis*, *Thisbe*, *Theope* and *Nymphidium* oviposit in small clusters or individually, depending on circumstances (DeVries *et al.* 1994). Stamp (1980) states that oviposition behavior depends on the structural and ecological characteristics of the host plant and proposes that a grouped distribution of the host plant, as is the case in *N. macrophila* in the study zone, favors clustered oviposition because it reduces time spent searching for host plants by the female. It is probable that a female of *M. mevania* oviposits on several nearby host plants, given that several plants within a patch are often found to contain eggs. However, this could be a disadvantage to *M. mevania* with regard to predators and parasitoids, although results show that rates of parasitism were very low.

The cryptic appearance may be a factor in avoiding parasitism as suggested by Eisner & Meinwald (1965) and Damman (1986). The yellow color of the eggs resembles that of the leaf underside and the slightly flattened larvae are a very similar green to that of the host plant. The pupae resemble dry leaves. Additionally, IV and V stadia larvae have another apparent method of defence in the form of a green secretion produced when they are disturbed, possibly to repel predators.

Courtney (1984) suggests that oviposition tactics

depend principally on fecundity in species laying groups of eggs, fecundity is high, even though some females may increase the number of eggs depending on the density of the host plant. In the case of *M. mevania*, the limiting factor on number of eggs laid per plant may be the size of the host plant. In the laboratory, observations of the groups of larvae in the containers showed that when they reach instar IV or V, two individuals are completely capable of consuming a whole plant before pupating. It is probably for this reason that larvae go from being semi-gregarious in the first instar to solitary in the last instar. Despite larvae being able to eat a whole plant before pupating, cannibalism was never observed.

In the field, when larvae enter the prepupal stage, it is probable that they move away from the host plant to form a chrysalis close to the ground. This was observed in the laboratory with the larvae reared on plants grown in plant pots.

Morphological notes. With regard to larval morphology, the appearance and coloration of the larvae is similar to that of *M. rhodia* (Stichel 1924). The pupa is similar to *Leucochimona vestalis*, illustrated by DeVries (1997). The imago emerges after 28.4 days on average, a shorter time than *Mesosemia rhodia*, which has a 45 day duration (Stichel 1924).

One of the most interesting observations was that of structures similar to tentacle nectary organs located at the same place as in *Synargis brennus* (Callaghan 1986), (Ross 1966) and other myrmecophilous riodinids (DeVries 1997). However, unlike in these species, the body of *M. mevania* is covered by numerous setae. There are bearded setae and chalazae on the lateral lobes, and the tentacles themselves are surrounded by setae, which would make them rather inaccessible to ants. In the field we observed no ants associated with the larvae, no secretions were detected from these organs, and the larvae did not have a reflex of rolling around when disturbed, a behavior to which myrmecophilous larvae are prone (DeVries 1997).

This is the second report on the presence of these structures in *Mesosemia* and Mesosemiini. Stichel (1924) described similar structures for *M. rhodia* on A8. Since Mesosemiini are not known to be myrmecophilous (DeVries 1997), the presence of these organs in *M. mevania* and *M. rhodia* suggests that more detailed field observations on larval behavior and more detailed studies on other species of *Mesosemia* and Mesosemiini would be very interesting.

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NEW PROTOCOL FOR MEASURING LEPIDOPTERA WING DAMAGE

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ABSTRACT. Lepidoptera may acquire damage to their wings throughout their lifespan. The ability to quantify the accumulated damage is relevant when studying the impact of wing damage on territorial behavior, mating systems, predation, or assessing relative age of the insect, but unfortunately, methods for accurate insect wing damage quantification are scarce. The purpose of this paper is to introduce a new protocol that provides a simple method for accurately quantifying wing damage of live Lepidoptera, without the removal of them from the field. Using a combination of Adobe Photoshop® and Scion Image®, 3 photographs of wild *Papilio (Pterourus) homerus* butterflies with wing damage were analyzed and compared to an older method of visually estimating wing damage. Of the 12 individual wings analyzed, 7 were significantly different ($p \leq 0.05$), and the new protocol yielded precise results. The newly described protocol is an inexpensive and accurate method for determining percent wing damage on insects without having to harm or remove them from the wild.

Additional key words: wing area, *Papilio homerus*, wing assessment, predation, territoriality

It is not unusual for Lepidoptera to acquire damage to their wings. Wing damage can accumulate from multiple factors such as conspecific territorial behavior (Pinheiro 1990; Freitas *et al.* 1993; Monge-Najera 1998), mating (Anderson & Keyel 2006), predation (Benson 1972; Shapiro 1974; Bowers *et al.* 1985; Mallet & Barton 1989; Lyytinen 2003; Langham 2004), and weather and daily wear (Carter 1992). Insect wing damage is commonly used as an indicator for age (Watt *et al.* 1977; Hayes *et al.* 1998; Kemp 2000; Pitts & Wall 2004) and to study predation associated with the evolution and development of eyespots and wing appendages in Lepidoptera, such as the False-head Hypothesis (Robbins 1981; Tonner *et al.* 1993). Severe wing damage can potentially hinder flight performance, impinging on mate-locating behavior and tactics (Koenig & Albano 1985), acquisition of food sources (Higginson & Barnard 2004), and predator evasion (Robbins 1981).

The combination of digital cameras and visual software has led to improved quantification systems for measuring damage to biological entities, such as leaf area associated with multiple insect-plant interactions (James & Newcombe 2000; O'Neal *et al.* 2002) including host plant resistance and the effect of pesticide application (Hoy & Hall 1993). Although this technology has progressed in many different fields of study, there are few new applications for quantifying Lepidoptera wing damage. Previous methods of estimating wing damage were limited to categorical rankings (i.e., #1 = freshly emerged, no wing damage; #2 = slight wing damage; etc.) (Watt *et al.* 1977), nominal rankings (i.e., tears, missing areas, or notches) (Burkhard *et al.* 2002), or the use of a grid system or sectioning the wing to determine wing area (Tonner *et*

al. 1993). The purpose of this paper is to introduce a simple protocol for the assessment of wing damage of Lepidoptera. This new protocol is an adjustment from a protocol described by O'Neal *et al.* (2002). To demonstrate the accuracy of the described protocol, it will be compared to the results of a survey where percent wing damage was visually estimated.

Study Organism. The Homerus Swallowtail, *Papilio (Pterourus) homerus* Fabricius, 1793 (Papilionidae), is the largest swallowtail butterfly in the Western Hemisphere and is endemic to Jamaica (Emmel & Garraway 1990). *Papilio homerus* is protected as an Appendix I species by CITES and is listed by the IUCN as an endangered species, serving as a flagship species for the island's natural wildlife heritage (Collins & Morris 1985). Photographs of wild *P. homerus* were taken within the Cockpit Country while estimating population size using mark-recapture protocol (Lehnert 2008). Wing wear (not associated with capturing technique) was noticed on captured and recaptured specimens, encouraging a study of wing wear analysis methods.

MATERIALS AND METHODS

Photographs of *Papilio homerus* were taken in the field using a Nikon Coolpix 8700 digital camera. The 8 mega-pixel camera was set to the highest resolution of 3264 × 2448 pixels. It was not necessary to have a camera with large mega-pixel capabilities, but a higher resolution gave more accurate results. Photographs were then transferred to a computer and opened in Adobe Photoshop® 6.0 as JPEG images. The images used for analysis are shown in Fig. 1. Each wing was individually cut using the Lasso tool and pasted into a new file. In the new file, the Erase tool was selected and



FIG. 1. Photographs of *Papilio homerus* used for image analysis. From left to right, photograph #3889, 4060, and 3794.

used to outline the wing as the presumed shape of an undamaged wing while erasing the remainder of the background. The image was cleaned using the Erase tool so that only the wing remained for analysis. Photographs of undamaged wings were used as a template when outlining the presumed shape of an undamaged wing on a wing with damage. The image was then saved as an undamaged wing JPEG file as a high quality image (10) with the format option set as baseline standard. The undamaged wing file was reopened and the Erase tool was used to outline the actual damaged wing, which was then saved as a damaged wing JPEG file. Both images were grayscale by selecting the Image tab, then choosing the Mode option, which leads to the Grayscale option. The grayscale images were saved as TIFF files.

The undamaged wing TIFF file was opened in Scion Image® for analysis from the File menu. The Options menu was selected to ensure that the Grayscale tab was checked and the Threshold tab was also checked. The Threshold tab converted the image to black and white. The Map Box was opened from the windows menu and used to adjust the image so that the area used for analysis was completely black with a white background. If the area of the image needed for analysis was not becoming completely black on a white background or additional black spots appeared outside of the wing, the Paint tool and/or the Eraser tool was selected from the tools menu to adjust the image accordingly. The Wand tool was then selected and clicked on the black image (the wing) to highlight the area for analysis. If the image for analysis looked correct, the Measure option was chosen from the Analyze menu to reveal a pixel count of the image. The pixel count was given as the area in the Info Box and recorded. If the pixel count was not shown, it was then selected from the Set Scale option in the Analyze menu. The damaged wing TIFF file was then placed through the same procedure to retrieve the area (pixel count) of the image and recorded. By simply dividing the damaged wing area (pixels) by the undamaged wing area (pixels) and multiplying by 100,

the percent wing area remaining was revealed. This number was subtracted from 100 to give the percent wing damage. The process is illustrated in Fig. 2. Each of the four wings in each photograph was analyzed 10 separate times to determine the efficiency of the described protocol.

For comparison, a survey portraying each original photograph was given to ten people. Each person was asked to visually estimate the percent wing damage of every wing (left forewing (LFW), left hind wing (LHW), right forewing (RFW), and right hind wing (RHW)) in each photograph. A paired-sample t-test using SPSS 16.0 software was used for comparing differences in accuracy and precision of the results from Scion Image® analysis and the survey.

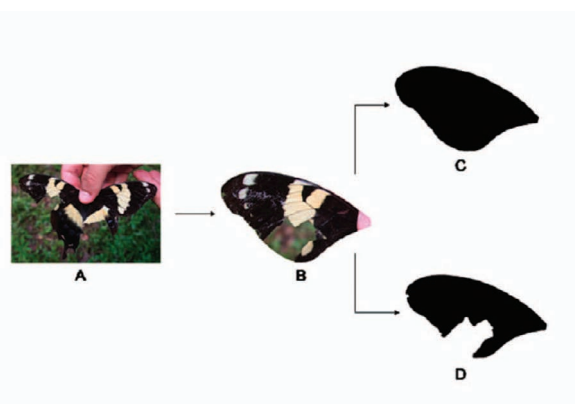


FIG. 2. Illustration of procedure used for wing analysis. In this example the left forewing (LFW) of individual 3889 is analyzed. The photograph on the far left (A) is the original picture opened as a JPEG file in Adobe Photoshop 6.0. The lasso tool was used to outline the LFW, which was saved into a new file. In the new file, the erase tool was selected and used to outline the presumed shape of an undamaged wing (B). The erase tool was used to then outline the damaged wing. Both photographs were grayscale and saved as TIFF files. Using Scion Image Analysis, the photographs were opened and converted to completely black images on an all white background (C = presumed undamaged wing, D = damaged wing). The analysis was performed issuing a pixel count (C = 310818, D = 259192). By using the equation listed in the methods, it was estimated that there was 16.6% wing damage on the LFW.

RESULTS

Only seven of the twelve pairs comparing Scion Image® analysis and the visual estimation of % wing damage were significantly different ($p < 0.05$) (Fig. 3). The pairs that involved analysis of wings with relatively extensive wing damage were significantly different in most of the cases, except one example, Pair 6. Fig. 3 clearly displays the precision of using Scion Image® for wing analysis when compared to visually estimating wing damage, as the standard error bars are too small to appear in the figure.

DISCUSSION

The new protocol utilizing Scion Image® for analysis appears much more precise than the visual estimation of % wing damage (Fig. 3). Although the Scion Image® analysis is more precise, wings with relatively little damage were not significantly different using these two methods. This lack of difference could be due to the sample size, or simply that the human eye is better at accurately assessing a small amount of wing damage since there is still an extensive amount of wing area remaining; it is easy to estimate wing damage when there is little difference between a damaged wing and an undamaged wing.

Analysis of wings with extensive damage was much more accurate and significantly different using Scion Image® for analysis rather than the visual estimation of % wing damage (Fig. 3). The only instance when there was a large amount of wing damage and no significant difference is Pair 6. It is unclear why there is a lack of a significant difference between these two methods in this particular case.

According to O'Neal *et al.* (2002), a methodology is typically chosen based upon three different characteristics: cost, expediency, and quality. Scion Image® is free downloadable software (http://www.scioncorp.com/pages/scion_image_windows.htm); therefore, the only expense to the user is to have image manipulation software, such as Adobe Photoshop®, to clean raw JPEG images and to convert them to TIFF format.

It is a tedious task to properly clean images to reveal the presumed undamaged and damaged wings. While cleaning the image, the eraser tool has to be minimized to a small pixel size in order to carefully go around small wing tears and fragments to appropriately portray the exact wing shape. It sometimes took greater than 10 minutes to successfully clean one image, but once an image was cleaned, it took less than 3 minutes to use Scion Image analysis to acquire the pixel count.

Comparison of Scion Image analysis and visual estimation
mean % wing damage

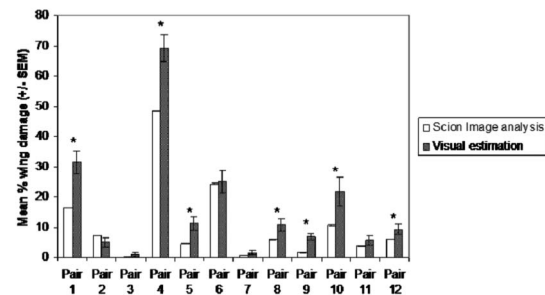


FIG. 3. A comparison of the mean and SEM of the newly described protocol (white bars) and the results from the visual estimation survey. Pairs 1–4 correspond to the comparison of the LFW, LHW, RFW, and RHW, respectively, of Photograph 3889. Pairs 5–8 refer to the LFW, LHW, RFW, and RHW, respectively, of Photograph 4060. Pairs 9–12 refer to the LFW, LHW, RFW, and RHW, respectively, of Photograph 3794. An * was placed above the Pairs with a significant difference ($p < 0.05$).

Precise quantification is the most impressive characteristic when comparing Scion Image® analysis to visually estimating wing damage. The described protocol allows the user to accurately quantify percent wing damage. The results suggest that visually estimating wing damage is not precise, probably because it is a subjective measure. The use of a categorical ranking system for determining wing wear also has flaws because it relies on a range of arbitrary descriptive characteristics. Another important facet of the described protocol is that it does not require the removal of specimens from their habitat, such as during a mark-release-recapture study of live Lepidoptera. Removal of an individual may add stress, thus altering its behavior.

The author suggests that researchers using wing wear to determine age in Lepidoptera should use a combination of the described protocol to assess wing damage with a categorical ranking system dedicated to the presence or absence of scales. Wing damage alone cannot be used as an indicator of age. For example, a freshly eclosed butterfly may be more likely to acquire wing damage from a predator before the wings fully expand than a butterfly that is capable of flight. Scion Image® analysis of wing wear is accurate enough, though, to quantify the frayed edges of Lepidopteran wings known to accumulate over time.

Although the described protocol provides a more accurate method for assessing wing damage to Lepidoptera, it is not flawless. The most noticeable problems associated with this study are that each wing is not entirely exposed in each photograph and that there is no way of knowing exactly the original appearance of

the undamaged wing. The new protocol was arranged after the field work was accomplished, which is why the wings are not fully exposed in every photograph. Future studies that have intentions of examining wing wear using the new protocol should take the necessary steps for photographing wings in their entirety. In this study, photographs of undamaged wings were used to determine the presumed shape of the damaged wings in each photograph. An improvement to this method would be to have an original photograph of the perfect individual before the wing damage is accumulated in order to provide accurate results. This would also set up an interestingly precise study to quantify wing damage of the same individual over time, such as in a mark-release-recapture study.

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FIRST REPORT OF *ECPYRRHORRHOE PURALIS* (SOUTH) (PYRALOIDEA: CRAMBIDAE: PYRAUSTINAE) IN NORTH AMERICA: A NATURALIZED EXOTIC PYRAUSTINE FROM ASIA FEEDING ON *PAULOWNIA* SIEBOLD & ZUCC.

Additional key words: Crambidae, Pyraloidea, *Paulownia*, invasive, China, *Yezobotys*.

In 2001, while sampling for the Great Smoky Mountains All Taxa Biodiversity Inventory at the Cosby Ranger Station, BGS collected a single specimen of a large, yellow pyraustine (Figs. 1, 2). Subsequent searches at other institutions and contacts with other lepidopterists documented other specimen records (see below). In addition, Doug Tallamy at the University of Delaware submitted two adults to MAS for identification that were reared on *Paulownia tomentosa* (Thunb.) Steud. (Scrophulariaceae) by DHF in West Grove, Chester Co., Pennsylvania (voucher specimens deposited at the National Museum of Natural History, USNM, Washington, D.C.).

In the U.S. this species most resembles members of the genus *Hahncappsia* Munroe, but it is significantly larger (female forewing length 12.8mm (n=14); male forewing length 12.5mm (n=10)), and the male genitalia are very different. Briefly, the uncus of *Hahncappsia* is broad at its tip while in the new moth the tip is thin (Fig. 4). The valvae of *Hahncappsia* have a complex sella and no fibula, but the new moth has a prominent non-scaled fibula (Fig. 4). The penis of *Hahncappsia* is not armed, and, in the new moth, is prominently armed (Fig. 5).

In 2008 MAS, with Michael Shaffer, identified the moth as *Pionea puralis* South (1901), originally described from central China, based on comparison to the male type specimen at The Natural History Museum (BMNH) in London. The male genitalia of the type specimen lacked the uncus, but the valvae were quite distinctive (Fig. 4). Mutuura (1954) placed *P. puralis* in *Pyrausta*, but it was evident that it did not belong in this genus. In addition, we discovered that it was similar to *Yezobotys ainualis* Munroe & Mutuura (1969) from Japan. The female genitalia (BMNH genitalia slide #19693) are similar, but the antrum is clearly different in *P. puralis* (Fig. 3). The BMNH card catalog also indicated that *Pyrausta dissimilis* Yamanaka (1958) was similar to *Y. ainualis* and *P. puralis*, and indeed Inoue *et al.* (1982) had synonymized *dissimilis* with *ainualis*. Zhang *et al.* (2004) revised *Ecpyrrhorrhoe* in China, described three new species, and transferred *Pionea puralis* South and *E. rubiginalis* (Hübner), known to feed on Labiatae, into this genus.

Zhang and colleagues proposed the following classification for Chinese species, and we also include the finding by Maes (1994) that *Harpadispas* Agenjo is a synonym of *Ecpyrrhorrhoe* Hübner and its type species, *Botys diffusalis* Guenée:

Ecpyrrhorrhoe Hübner, [1825], 1816

Harpadispas Agenjo, 1952

Pyraustegia Marion, 1963

Yezobotys Munroe & Mutuura, 1969, **new synonym**

E. biaculeiformis Zhang, Li, & Wang, 2004

E. diffusalis Guenée, 1854 (synonyms not listed here)

E. digitaliformis Zhang, Li, & Wang, 2004

E. dissimilis Yamanaka, 1958, **new combination**

E. ainualis Munroe & Mutuura, 1969

E. ruidispinalis Zhang, Li, & Wang, 2004

E. puralis South, 1901

E. rubiginalis Hübner, 1796

Based on collection and observation records, *E. puralis* was introduced into the eastern United States probably in the 1990s, and spread quickly over much of the range of its introduced host, *P. tomentosa*. This species is commonly known as the Princess or Empress tree, among other names. It was introduced to the eastern U. S. around 1840, probably by using its seeds as packing material for porcelain from China. More recently, it has been planted as an ornamental and now occurs from New York and Massachusetts south through Florida and west to Texas, Missouri and Illinois, and in Oregon in the northwest (Williams 1993). The species is invasive primarily in the Appalachians from Pennsylvania to Georgia (Langdon & Johnson 1994), but the National Park Service notes that it is now found in over 25 states (<http://www.nps.gov/plants/alien/fact/pato1.htm>). Although *Paulownia* is invasive in the Appalachian Region, it is highly prized for its wood, which is exported, and the species is used in reforestation efforts in various other parts of the world. For example, the American *Paulownia* Association (www.paulowniatrees.org) is dedicated to its culture and encourages its marketing, and the "Peace Portal" touts it as "the fastest growing Hardwood Tree on the planet"



FIGS. 1–5. **1.** Dorsal view of pinned adult, photo by B. Scholtens. **2.** Dorsal view of live adult, photo by Rich Healy, Hart. Co. Kentucky, 9 Aug 2006. **3.** Ventral view female genitalia, photo by M. Metz. **4.** Ventral view male genitalia, photo by M. Metz. **5.** Penis, photo by M. Metz.

(<http://peaceportal.mobi/home/>).

Ecpyrrhorrhoe puralis records reflect the invasive range of the tree; the moth is known from Mississippi and Georgia to Maryland and Pennsylvania. The following are known records of *E. puralis* from eastern North America. ALABAMA: Jackson Co./Hollytree/Bingham Mtn. area/9 May 2008, 20 Jun 2008, 18 Jul 2008, 19 Sep 2008/ Howard Grisham (4 specimens)/ Howard Grisham collection; GEORGIA: Gordon Co./Calhoun (346 Sunset Dr. SE)/at lights/18 Jul 2000, 23 Jul 2000, 10 Sep 2001, 26 Apr 2002, 29 Jun 2002, 12 May 2003, 6 Sep 2003, 8 Sep 2003, 14 Aug 2005, 8 Sep 2005, 11 Sep 2005, 24 Apr 2006, 2 Aug 2007, 5 Aug 2007/James K. Adams (16 specimens) /James Adams collection; Whitfield Co./Carbondale, exit 326 off I-75/at lights/14 Sep 2005/James K. Adams/James Adams collection; Whitfield Co./Rocky Face ridgeline, Co. Rd. 202 (Hurricane Rd)/crest of Doug Gap Battle Rd./SW of Dalton/19 Aug 2003/James K. Adams/James Adams collection; KENTUCKY: Hart Co./ 9 Aug 2006/ Rich Healy/photo record; MARYLAND: Anne Arundel Co./Smithsonian Env. Res. Ctr., Edgewater/8 Sep 2000/D.C. Ferguson, J.D. Glaser/USNM collection; Prince George's Co./ Bowie/22 Jun 2004, 18 Jun 2005/ Bob Patterson/photo records on Moth Photographers Group (MPG); MISSISSIPPI: Tishomingo Co./J.P. Coleman St. Pk./20 Jul 2004/Ricky Patterson/Mississippi State collection; PENNSYLVANIA: Chester Co./Goat Hill Nat. Conser./Nottingham/20 Aug 2005/Samuel R. Smith; Chester Co./Wert Grove/captured Sep 2005/ Dave Funk /lab reared on *Paulownia*, eclosed 10 Apr 2006 and 22 May 2006/ USNM collection; Dauphin Co./Middletown/7 Sep 2003/Samuel R. Smith; Lancaster Co./Mountville/31 Aug 2005/Matthew Roth/ photo record on MPG; SOUTH CAROLINA: Greenville Co./17 Aug 2004/John A. Snyder/Furman Univ. collection; TENNESSEE: Cocke Co./Cosby Ranger Station/16 May 2001/Brian Scholtens/College of Charleston collection; WEST VIRGINIA: Boone Co./Fork Creek WMA/2.5 miles NW, Nellis/29 Aug–1 Sep 2003/Steve Johnson (2 specimens)/ Jim Vargo collection. The species appears to be at least double brooded in the south, with adult records from April through September in Georgia. In the north, all records are from August and September. We expect the moth will spread throughout the range of *Paulownia* in the United States.

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A NEW LARVAL FOOD PLANT, *COLLINSIA CONCOLOR*, FOR THE ENDANGERED QUINO CHECKERSPOT, *EUPHYDRYAS EDITHA QUINO*

Additional key words: *Antirrhinum*, *Plantago*, *Cordylanthus*, *Castilleja*, diapause

Before the Quino checkerspot, *Euphydryas editha quino* (Behr), was placed on the federal endangered list, larvae of this checkerspot were only known to feed on erect plantain, *Plantago erecta* E. Morris (Plantaginaceae) (Emmel & Emmel 1973, Mattoni et al. 1997, Osborne & Redak 2000). Recently, *Plantago patagonica* Jacq. (Plantaginaceae), *Antirrhinum coulterianum* Benth. (Scrophulariaceae), *Castilleja exserta* (A. A. Heller) (Scrophulariaceae), and *Cordylanthus rigidus* (Benth.) Jepson (Scrophulariaceae) were added as ovipositional food plants for this checkerspot (Pratt et al. 2001). *Plantago patagonica* and *A. coulterianum* were identified as major prediapause and postdiapause larval food plants at elevations higher than 1,300m, seven kilometers south-southwest of Anza, Riverside County, California. It appears that *A. coulterianum* is the preferred ovipositional food plant where both *P. patagonica* and *A. coulterianum* co-occur, but during drought years, when *A. coulterianum* does poorly, *P. patagonica* becomes the main food plant (Pratt et al. 2001).

Observation numbers of prediapause larval clusters vary with plant species. There have been hundreds of clusters observed on *Plantago erecta* at many locations, over 50 on *Plantago patagonica*, and over 130 on *Antirrhinum coulterianum* (Pratt et al. 2001). Yet only two larval clusters have been observed on *Castilleja exserta* and five clusters on *Cordylanthus rigidus* in a region ten to thirteen kilometers west of Tecate, San Diego County, California (Pratt et al. 2001). Since *C. exserta* and *C. rigidus* are abundant at Quino checkerspot occupied sites, it is surprising that more checkerspot larval clusters have not been observed on these plants. So far, *C. rigidus* is used as a prediapause food plant only where *P. erecta* is present for postdiapause larvae. The advantage of *Cordylanthus* in these areas is that *P. erecta* is often a poor prediapause food plant since it dries out early in the season, while *C. rigidus* continues to grow well into summer.

Although Quino checkerspot larvae have been found on larval food plants below 900m (the upper elevation range for *Plantago erecta*) and above 1,300m, no larval food plants are known between 900 and 1,300m. While searching for ovipositional and prediapause food plants on 13 April 2008, twenty kilometers southwest of Anza,

Riverside County, California, at 1,050m elevation, Pratt observed a female Quino checkerspot crawling over the ground with its abdomen curled under. Even though no known food plants were observed in the area, this observation was believed to be an ovipositional search behavior. Upon closer examination, Pratt observed numerous tiny *Collinsia concolor* E. Greene plants forming a ground cover. These plants were a reddish brown color blending with the soil surface. Pratt searched the nearby *Collinsia* and found a large, partially hatched egg cluster under a *Collinsia* leaf (Figure 1). Freshly eclosed larvae were found on a nearby leaf.

When Pratt and Pierce returned to the area on 19 April 2008 they found approximately 20 prediapause Quino checkerspot larval clusters at elevations that ranged from 1,050 to 1,075m. These larvae were in first to third instar. Despite extensive searching, no larval clusters were observed on nearby *Castilleja exserta* and *Antirrhinum coulterianum*.

After observing prediapause larval clusters on *Collinsia concolor*, Pratt was able to locate additional clusters on this plant species at other locations. At eight kilometers south-southwest of Anza at 1,366m on 5 May 2008 a prediapause Quino checkerspot larval cluster was found on a *C. concolor* plant at the northern open edge of one large *Collinsia* patch on a north facing slope (Figures 2 & 3). Over 40 additional larval clusters were found on *Collinsia* also on north facing slopes at eight kilometers south of Anza at 1,270m on 6 May 2009. Despite extensive searching of neighboring *Antirrhinum coulterianum* plants, no larval clusters were found on this snapdragon, even though larval clusters were common on *Antirrhinum* at 8.5km south-southwest of Anza on south facing slopes on 5 May 2008.

Quino checkerspot females oviposit in nature upon *Plantago erecta*, *Plantago patagonica*, *Collinsia concolor*, *Antirrhinum coulterianum*, *Cordylanthus rigidus*, and *Castilleja exserta*. Although *C. rigidus* and *C. exserta* are placed in the Scrophularaceae along with *C. concolor* and *A. coulterianum*, recent DNA studies show that *Plantago* species in the Plantaginaceae are more closely related to *Collinsia* and *Antirrhinum* than they are to *Castilleja* and other parasitic members of the



FIGS.1-3. **1.** Partially hatched Quino checkerspot egg cluster on *Collinsia concolor* twenty kilometers southwest of Anza, Riverside County, California. **2.** *Collinsia concolor* plant eight kilometers south-southwest of Anza, Riverside County, California with first instar Quino checkerspot larvae. **3.** First instar Quino checkerspot larvae at the base of a *Collinsia concolor* plant.

Scrophularaceae (Olmstead et al. 2001). *Cordylanthus* is a parasitic member of the Scrophularaceae (Hickman 1993). Olmstead *et al.* (2001) place the parasitic members of the Scrophularaceae in the Orobanchaceae and *Antirrhinum*, *Collinsia*, and *Plantago* in the Veronicaceae. Searches for Quino checkerspots should occur in areas that have sufficient quantities of these plants to support larval development to adults. The only exceptions are *C. rigidus* and *C. exserta*, which may require extensive stands of other food plants to support complete larval development.

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LEE DENMAR MILLER (1935–2008): HIS LIFE AND A BRIEF HISTORY OF THE ALLYN MUSEUM OF ENTOMOLOGY

Dr. Lee D. Miller, a life member of the Lepidopterists' Society, passed away on 5 April 2008 at his home near Gainesville, Florida, after a long illness. He was 72 years old. He is survived by his wife, Jacqueline Y. Miller, and two daughters, Kathryn Lee Angeli of Saratoga, California, and Laura Sue Langford of New York, New York, and one granddaughter, Rowan Langford.



FIG. 1. Lee Miller, Allyn Museum collections in 1998.

Born on 1 June 1935 in Des Moines, Iowa, Lee was the son of a lawyer, Guy Denmark Miller and a hospital administrator, Anabel Lee Smith. He grew up and attended schools in Des Moines, Iowa. Lee attended Iowa State University and worked with Dr. Jean L. Laffoon, who was a professor in the Departments of Zoology and Entomology. Dr. Laffoon served as the curator of the Iowa State Entomology Collection, a specialist in systematics of fungus gnats and was also involved in mosquito control. Active in the Entomological Society of America and Iowa Academy of Science, among other scientific organizations, he was an excellent mentor and had a major impact on Lee's life. It was here that Lee began to consider a possible career in Entomology. However, Lee had multiple scientific interests, and later transferred to the University of Iowa where he had a triple major in Geology, Biology, and English, until three days prior to graduation. Since he was required to choose only one, Lee selected and graduated with a degree in Biology in 1960. Lee began his graduate program at University of Pittsburgh while

also working at the Carnegie Museum of Natural History in the then Section of Insects and Spiders (now Invertebrate Zoology). Lee completed his M. S. degree (1963) on a review of the genus *Osmodes* Holland (Lepidoptera: Hesperidae) (1964a). In 1965, he completed his Ph. D. dissertation entitled: *The Higher Classification, Phylogeny, and Zoogeography of the Satyridae (Lepidoptera)* with publication in 1968.

During his professional career, Lee served as a Research Assistant Professor and Assistant Professor (1965–1968) at the Department of Biology, Catholic University of America, Washington, D.C. He was subsequently the Curator of Allyn Foundation, Inc. (1968–1972), later the Allyn Museum of Entomology (1972–1981). When the Director, Arthur C. Allyn, donated the collection, facilities and property to the Florida State Museum (now Florida Museum of Natural History) in 1981, Lee served as a Curator in the Department of Natural History, Florida Museum of Natural History, Allyn Museum of Entomology, University of Florida (1981–2004) (Fig. 1). With the development of the McGuire Center of Lepidoptera and Biodiversity, the Allyn Museum collections were moved to the new Center in 2004. Lee served as the Allyn Curator of Lepidoptera in the McGuire Center at the Florida Museum of Natural History from 2004 until his death. He was also an Adjunct Professor in the Departments of Zoology (1981–2008) and Entomology and Nematology (1995–2008) at the University of Florida. In addition to the above, Lee was a Visiting Associate Professor in the Department of Biology, University of Florida, Tampa (1973–1977) and a Research Scholar and Adjunct Faculty Member in the Division of Natural Sciences, at New College of Florida (State Honors College), University of South Florida, Sarasota (1995–2004), where he taught Entomology, Zoogeography and Phylogenetics. A Research Associate of the Department of Zoology-Entomology, Field Museum of Natural History, Chicago, Illinois (1971–1979), Lee was also appointed as a Research Associate of the Section of Invertebrate Zoology, Carnegie Museum of Natural History, Pittsburgh, Pennsylvania (1965–2008). Lee taught courses and seminars, including three workshops on the collection and identification of insects at the College of the Bahamas, Nassau, Bahamas (1988–1993) along with Mark Simon and me.

Over the years Lee served the Lepidopterists' Society in various capacities, including: Zone Coordinator, Season Summary (1964–1968); Secretary-elect (1971); Secretary (1972–1976); Editor, Supplements of the Lepidopterists' Society (1971–1973); Member, Editorial Committee, *Journal of the Lepidopterists' Society* (1972–1995); Editor, Clench Memorial issue (vol. 37 (2) 1980); President-elect (1982–83); President (1983–84); and Immediate Past-President (1984–1985). He served as a Member at Large on several occasions. Lee conceived and implemented the idea for the Karl Jordan Medal honoring and recognizing lepidopterists for publication of original research of exceptional quality on morphology, taxonomy, systematics, zoogeography and "natural history." He was also a member of the Association for Tropical Biology, Inc., The Society for the Study of Evolution, Society of Systematic Biology, The American Entomological Society, Entomological Society of America, Southern Lepidopterists' Society, Willi Hennig Society, Fellow, Royal Entomological Society (London), and a Fellow, Linnean Society (London). He was the Editor of the *Bulletin of the Allyn Museum* (1971–2007), during which he oversaw the development, external review, and production of this series, which now numbers more than 160 issues and is still in production at the McGuire Center. He also served as an Associate Editor of the *Journal of Research on the Lepidoptera* (1971–1978). In addition to the above, Lee was an accredited judge of the American Orchid Society, and served as Judges Co-training Coordinator, Florida North Central Judging Center in Tampa (1986–1996).

As a child, Lee was introduced to natural history at an early age as both of his parents were avid bird watchers and interested in native plants, insects, and mammals. Denmark had had a butterfly and moth collection as a child, and he and Lee collected in both Iowa and Minnesota throughout Lee's childhood. Denmark's collection was eventually donated to Lee's grade school in Des Moines. In addition, there was a group of boys in east Des Moines, the "35th St. Boys", who were pals and went fishing, hunting, and collected insects among other things. They included B. C. Johnson, Ron Royer, and Norris Young among others. Lee was the oldest, and taught them how to collect and prepare butterflies and moths. When his parents moved to Franklin and 39th St. in West Des Moines, these friends would still get together on occasion. They would often go collecting at various state parks including Pilot Knob State Park (Hancock Co.), and Waubesa State Park (Fremont Co.) in southwestern Iowa, in search of new additions to their collections. A couple of these trips culminated in Lee's first paper published in the *Journal*

(1962a) in which he reported observations on nine Iowa butterfly species, including four species new to the state. Later, Lee joined John Downey and others in revisiting a few of these sites (1975–1978), to see if some of the uncommon species were still extant, and contributed to the recently published *The Butterflies of Iowa* (Schlicht *et al.* 2007). Lee's personal collection was donated to the Carnegie Museum about the time that he completed his Ph. D. in May, 1965.

In addition to sharing their love for natural history, the Miller family also shared a passion for fishing and hunting. Summers were spent fishing along the Raccoon River near Des Moines or in lakes near their cabin or farm in Minnesota. Fall activities included collecting wild rice and cranberries, hunting ducks or grouse and watching the Springer Spaniels work the fields for birds. Of course, collecting and watching Lepidoptera were always part of these trips. Lee and Denmark coveted their Master Angler trophies for their



FIG. 2-3. (2) Lee with one of his Master Angler fish about 1974. (3) Lee and Denmark Miller upon Lee winning the Iowa State High School tournament in 1953.

fishing prowess in Canada (Fig. 2), but butterfly nets were always included with the fishing gear.

Lee and Denmar also shared a love for the game of golf. Denmar had won nearly all of the state's top titles and had represented the state of Iowa at the Western Open (1936–1939). Lee in turn was a competitive golfer in high school, won the Iowa State High School title in 1953 (Fig. 3), and went on to play golf at both Iowa State University and the University of Iowa. He once competed against Jack Nicklaus in a Big 10 tournament, but Nicklaus was a formidable competitor even then. However, golf took more of a recreational role later in Lee's life.

Following his graduation from the University of Iowa in 1960, Lee and his then wife, Susan, with daughter Kathryn, went to Casa Grande, Arizona, near Tucson, in search of employment as an entomologist. It wasn't long before Lee was out in the field and saw some *Megathymus*. These skippers seemed unusual compared to other Hesperidae that he had encountered in the Midwest. Soon after, Lee had the opportunity to meet Kilian Roever, who was then in the Department of Entomology at the University of Arizona. Kilian took him to some of his special collecting sites, and Lee had numerous opportunities to observe and collect immature *Megathymus*. He accumulated tents of seven species, some from two or more localities, and began a comparative study of their emergence patterns. When some potential job opportunities arose in Des Moines later that year, the family traveled back east with these immature *Megathymus* in the car. Lee immediately contacted "the 35 St. Boys" about the *Megathymus*, and they eagerly came to see these new treasures and caught up on their recent collecting experiences. Lee recorded the number of males versus females and made observations on other aspects of their emergence patterns. He later reported back to Kilian in a letter of "the megs emerging thick and fast for about a month." Thus began an exchange of information on skippers between Kilian and Lee, who shared a passion for all butterflies, especially Hesperioidea. Years later after moving to Sarasota in 1969, Kilian arrived unannounced the following spring to collect *Megathymus cofaqui* on Longboat Key and further south to Venice. At that time, Longboat was mostly undeveloped, and there were stands of *Yucca aloifolia* all along the key. Following visits to various spots in the Sarasota area, Kilian continued to collect *M. cofaqui* all the way up the Gulf coast into the Florida panhandle.

The last *Megathymus* from Arizona emerged in Des Moines early on 11 November 1960, the day that Lee and the family headed off to Meadville, Pennsylvania,

where he had secured a job as a plant pest control inspector for USDA (1960–1961). Prior to this trip, Lee had already corresponded with Harry Clench and took the opportunity to visit the Carnegie Museum of Natural History in Pittsburgh on several occasions. Here he met the Curator in the Division of Insects and Spiders, Dr. Richard M. Fox, who held a teaching appointment in the Department of Biological Sciences at the University of Pittsburgh. Following a successful collecting expedition to Liberia, Fox had recently taken this position at Carnegie. Given Lee's interest in Hesperidae, he was intrigued with Fox's Liberian material. Arthur W. Lindsey was already working on the skippers from Liberia, but due to his declining health, he needed some assistance in completing this portion of the proposed volume. Lee was also exploring the possibility of continuing his education and obtaining advanced degrees with Fox. In addition to completing the Liberian monograph, Fox was in the process of organizing a two month expedition to Baja California (October–December, 1961). This trip was financially supported by a distinguished scientist research fellow at the Academy of Natural Sciences, Philadelphia, Margaret J. Cary. Cary was a noted specialist on the Sphingidae and at that time, the southern half of the Baja peninsula was largely unexplored. There were excellent opportunities for studying the biodiversity and discovering new species in a number of phyla. Lee joined the expedition as an entomologist while arrangements were in progress for his admission to graduate school. For Lee, who until then had encountered such difficulty in trying to secure an entomological position, it was a surprising turn of events.

As is with such expeditions, not everything went as planned. Harry Clench (lepidopterist), Neil Richmond (herpetologist), and John Bauer (preparator) drove from Pittsburgh and met Lee at Richmond, Indiana. The itinerary scheduled the above personnel to travel and collect along the west coast of Mexico for two weeks in the newly acquired International Carryall and to meet Dr. Fox and his wife, Jean, in Mazatlan (Fig. 4a). However, the vehicle was soon nicknamed "Pariah" as the gas mileage was a little over 14 mi/gal., and within four days of starting the trip from Pittsburgh, the battery had died. The unexpected problems with the truck provided constant delays, immense frustration, and entertainment throughout the trip. The field team flew from Mazatlan into southern Baja on November 4, 1961, while the vehicle and other equipment arrived three days later by ferry. The group was separated into three field teams, who would collect herps, fossils, plants, and insects. With Lee on a horse and Harry on a

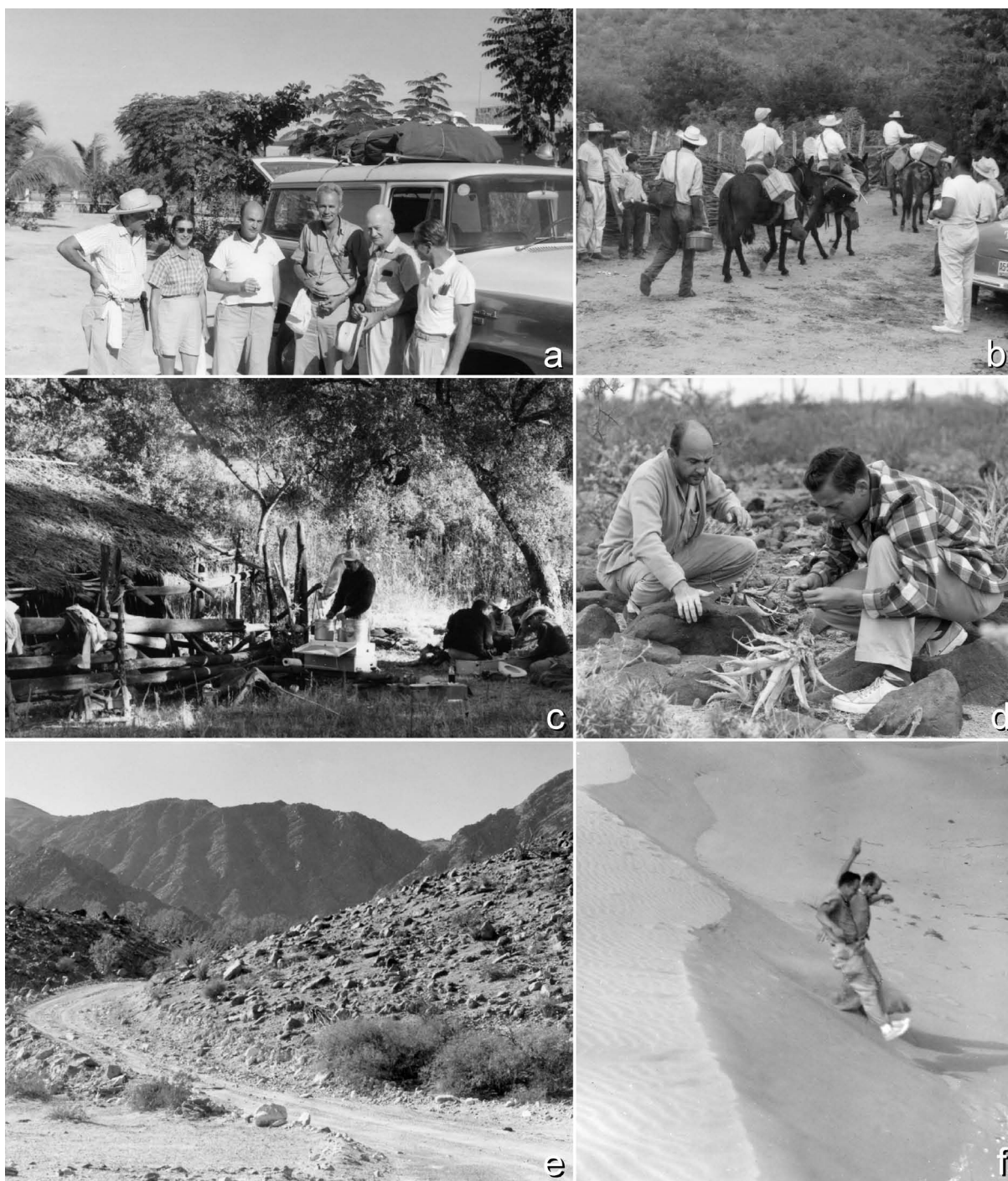


FIG. 4. Margaret J. Cary field expedition to Baja California, October-November, 1961: **a)** Field team at Guaycura, La Paz (left to right), Lee Miller, Jean Fox, Harry Clench, Neil Richmond, Richard Fox, and John Bauer; **b)** Harry and Lee heading up into the Boca de la Sierra; **c)** Camping area in La Cienaga I, Sierra Laguna; **d)** Lee and Harry examining Agave for *Megathymus* larvae near San Ignacio; **e)** Rocky road about 30 mi. north of Bahia, S. L. Gonzaga; **f)** Sand dunes approximately 29 mi. N. of San Felipe with Lee and Harry (two future presidents of the Lepidopterists' Society) hard at work celebrating the end of the trip.

mule, they headed up into the Boca de la Sierra for a week of collecting and camping (4b, 4c). After the first day, Lee decided that he would rather walk and collect than ride. A few days later, Harry's mule fell down a hill.

In the end, both animals carried gear, and Lee and Harry walked out of the forest.

Once the surveys had been completed in southern Baja, Dick and Jean Fox flew directly back to

Pittsburgh. The rest of the crew drove the 600 miles north to Tijuana, collecting along the way over the primitive trails and “rocky roads” (Fig. 4e) into a variety of habitats (4f). Lee was heavily involved in the collecting of insects during this expedition, especially Lepidoptera and primarily the Hesperioidea (4d). His efforts resulted in a collaboration with Don MacNeil and the description of two new subspecies, *Polites sabuleti margaretae* and *Cogia hippalus peninsularis* (1969). This experience was the impetus for taking four additional collecting trips to continental Mexico with an emphasis on different states (1966–1973) (Tamaulipas, Veracruz, Morelos, Guerrero, Chiapas, Michoacan, Sinaloa, Nayarit, Durango), and has provided a historical timeline and background for the more thorough biodiversity surveys in progress and completed by Jorge Llorente, Amando Luis, and other members in their working group at Universidad Nacional Autónoma de México (UNAM) in addition to Carmen Pozo De la Tijera, El Colegio de la Frontera Sur (ECOSUR).

Following the Baja trip, Lee entered graduate school in the Department of Biological Sciences, University of Pittsburgh in January, 1962. He was a member of the first Organization of Tropical Studies class at La Selva in 1963 where he met Dan Janzen and Jay Savage and made new friendships that would last throughout his life. It was also here that his interest in all aspects of the Neotropics and the associated fauna and flora intensified. During his stay, Mount Irazú, the tallest volcano in Central America, erupted. Lee took pictures of this natural event and noted how the insects attempted to adapt to the situation. For a geologist/biologist, Lee continued to have a keen interest over the years on the succession of plants and insects following such catastrophic events and the associated evolutionary changes.

Following the completion of his Ph. D., Lee accepted a position as a Research Assistant Professor in the Department of Biology at Catholic University of America in Washington, D. C. in 1965. There he developed and taught five courses in addition to mentoring more than six graduate students in just three years. In late 1967, Lee was presented with an opportunity to curate a private Lepidoptera collection. He interviewed in November with Arthur C. Allyn, an avid collector, private businessman, and co-owner of the Chicago White Sox. Allyn had recently acquired the W. J. Kaye collection, an international collection that contained a number of types. Mr. Allyn wanted someone to fill this position immediately, but Lee had already signed a teaching contract and had three graduate students, who were in the process of trying to

finish degrees. So he turned down the position with regret. Allyn then placed an advertisement in *Science* and received more than 300 applications for the position. Following Christmas vacation, there was message from Allyn requesting that Lee return his call. However, when he attempted to do so, there was some confusion with another Miller, the representative for the baseball players' union. In the end, Allyn reoffered the curatorial position to Lee and said that he was willing to wait until July 1, 1968, for him to begin. Lee gladly accepted Allyn's offer, but with a few caveats. Allyn stated that the position would be finite and last for seven years, but he had a long list of things that he would like to see accomplished during this period. To fulfill these requirements and initiate a state of the art scientific collection, Lee would need a curatorial assistant for preparation of specimens, general collection maintenance, etc. Lee and I had met at the University of Pittsburgh and had worked together on various courses at Pitt and at Catholic University. Neither of us could deny the natural compatibility and magic behind what would become the “Miller team.” Mr. Allyn was supportive of an assistant position which I accepted along with Lee's proposal.

Initially our goals were to expand both the taxonomic and geographic representation of the collection worldwide, especially of butterflies and some moths. For the latter, we would focus on Saturniidae, Sphingidae, and Arctiidae as there were significant holdings in the W. J. Kaye collection. In addition, we also wanted to establish the Allyn collection as one of the most significant scientific research resources for future lepidopterists. Allyn was very open to these suggestions. In the interim, Mr. Allyn wanted Lee to represent him at an auction of Lepidoptera in Paris in early February, 1968. The auction included the LeMoult collection among others and was conducted by Claude Lemaire. Although Allyn was intrigued by the more showy *Morpho* and Papilionidae, Lee was interested in obtaining unprepared specimens, especially of the *Charaxes*, *Euphaedra*, and *Euriphene* (African Nymphalidae) and also in filling some major voids in Allyn's collection, especially in the Riodinidae, Hesperioidea, and Lycaenidae that were each represented by a single drawer. In addition to some types and a number of prepared specimens, Lee eventually purchased more than 300 “LeMoult” boxes of unprepared specimens.

Lee's interest in the African Lepidoptera expanded when we joined Arthur Allyn. Allyn was interested in a number of African genera, especially *Charaxes* and *Colotis* (Pieridae). Although the Carnegie Museum of Natural History and American Museum of Natural

History had significant African collections, we sought to increase holdings from other African countries that were not well represented in other U.S. collections. Fortunately, Allyn already had business interests in South Africa with excellent contacts. We supported a number of collectors in the field and obtained a number of collections during 1968–1977. In addition, Lee had purchased material earlier from Father Theo Maessen, a priest in Ghana, beginning in 1963, and this continued until Maessen left the country in 1987. Over the years Lee managed to make three trips into South Africa and one into Kenya. This provided him with additional information not only about the habitats and ecology of these butterflies but more insight concerning the historical geology and biogeography of this continent.

Another major geographic area of interest was, of course, the Neotropics due to Lee's research on the HesperIIDae and Nymphalidae, and in particular the Satyrinae. Lee was particularly interested in the higher altitudinal Satyrinae as there was more promise for obtaining endemic species and new taxa to be described. He had made contacts with a number of collectors and/or colleagues throughout the Neotropics. Through F. Martin Brown, who had conducted surveys various in countries in South America in the late 1920's and lived for some time in Ecuador, Lee contacted Rosario de Lafebre and the Velastigui family. In 1969, Rosario, her family, and their cadre of collectors were charged with collecting selected lepidopteran groups on all of the volcanic peaks in Ecuador. There were occasional forays into lower elevations, such as the Rio Coca, as opportunities for travel into some of these isolated areas for biodiversity surveys became available. Through Rosario, we also met Nadia Venedictoff, who had collected both butterflies and moths throughout Ecuador, often accompanied by Rosario. Nadia donated her large Lepidoptera collection to the Allyn Museum in 1985. Both of these collections among others were significant additions to the neotropical holdings as they not only provided new material for description but increased our taxonomic and geographic representations in the collection.

Due to the expansion of the collections, library and additional space for new equipment, the Allyn Museum soon outgrew the original Florida facilities at the Sarasota Bank and Trust building and was moved to a new 5500 square foot building on Bay Shore Road. We hosted the Lepidopterists' Society meetings there in 1973. Research visits to the collections increased markedly following the meetings, and a few of these visitors were attracted to the Sarasota area. In 1977, Steve Steinhauser moved to Sarasota to work in the collections on a regular basis, and he was soon followed

by Dale and Joanne Jenkins in 1979. Nadia Venedictoff also moved to Sarasota and worked there 1986–1991. Arthur Allyn had purchased a scanning electron microscope to enable his detailed morphological studies on Lepidoptera. Beginning in 1981, John Downey spent summers working and collaborating with Arthur Allyn on a number of butterfly ultrastructure studies using the SEM as well as morphological studies on immature stages and pupal sound production. John moved permanently to Sarasota in 1988. There were also a number of New College students, who worked on undergraduate theses, and others who assisted with the preparation of specimens. The Museum was a hub of activity with the integration of new specimens and revisionary and other studies in progress. Lee always enjoyed working in the collections with visitors. He had a humorous bent and was known for not only being able to discuss the systematics, biogeography and life history of various Lepidoptera but also for having a long list of the latest jokes. There was never a dull moment at the Allyn Museum; however, the combination of Steve Steinhauser and Lee made for a truly comical team. Together there was always some bizarre occurrence, interesting puns or new humor to be shared.

It is difficult to summarize all of the significant highlights of Lee's life and accomplishments as a lepidopterist here. Some are listed above, but a few additional accounts are noteworthy. Over a number of years, F. Martin Brown had located, documented, and designated type specimens originally described by William Henry Edwards and published these for separate taxonomic groups. In 1974, Brownie enlisted Lee to assist him with the Hesperioidea to complete the project. Over the next six years, they visited various museums throughout the U. S. and Canada and published four papers (1975, 1977, 1980, 1987) and in all, designated 53 Lectotypes and 23 Neotypes. In addition to the above, Lee and Brownie co-authored *A Catalogue/Checklist of the Butterflies of America North of Mexico* published by the Lepidopterists' Society in 1981. Initially they reworked the original dos Passos checklist and updated the nomenclature including the higher classification, which has been subsequently refined. There were many discussions between the authors about generic versus subgeneric designations, and often these resulted in compromise. In order to keep costs down and through the kindness of Jack Serbin, Serbin Printing Inc., we were allowed to typeset some of the volume on his new electronic equipment on the weekends or at night. The Lepidopterists' Society benefited from this effort as the volume sold well and the original publication investment was returned within five years.

In 1980, Dr. David Spencer Smith, who I had met at the University of Miami Medical School in 1965, visited the Allyn Museum along with Dennis Leston and Barbara Lenczewski. They were actively working on variation in *Eurema daira*, especially *palmira*, in south Florida. David was also a friend of Mark Simon, and he knew that Lee and Mark had been collecting in the Bahamas on a regular basis. David was interested in Bahamian butterflies and had also been collecting there along with Dennis Knowles. Over the next few years, we developed a potential project on the Caribbean butterflies, which culminated in *The Butterflies of the West Indies and South Florida*. At the time, David was the Hope Professor at Oxford University Museum and a Professor in the Department of Zoology. He approached Oxford University Press about their potential interest in the project, and we obtained a contract in 1987. Although the text was initiated in 1988, there were so many voids in our knowledge, especially of the butterfly fauna of the Virgin Islands and Lesser Antilles. Thus, we initiated surveys over the next six years making several trips each year in order to obtain current information on the butterfly biodiversity of these islands. We did not want this work to be based solely on specimens in museum and private collections. Along with the superb illustrations of Richard Lewington and through the assistance and kindness of many colleagues, the volume was finally published in 1994 after years of editing, annotations, and descriptions of new taxa.

Lee's primary research interests included the systematics, taxonomy, and biogeography of Lepidoptera, especially the Hesperidae, Nymphalidae, and Lycaenidae. He was an authority on the Satyrinae worldwide and published a number of revisionary studies on the group. His dissertation work on *The Higher Classification, Phylogeny, and Zoogeography of the Satyridae (Lepidoptera)* (1968a) represents a seminal work within the field, and his studies on *Pindis*, *Megisto*, and *Paramacera* set the standard for future revisionary studies. He had initiated several revisionary treatments of the Euptychiina, especially the genus *Taygetis*; these unfinished studies are in progress and will be completed by various collaborators in conjunction with me in the future. Lee had also continued his interest within the Hesperidae and was especially enamored with the African fauna (Miller & Collins, 1997; Douglass & Miller 2003) and the close alignment with certain taxa in the Neotropics. Our studies in the West Indies further fueled Lee's interest in the historical biogeography and relative age of Lepidoptera and are summarized in three papers (1989, 1998, 2001).



FIGS. 5–6. (5) Lee sharing some humorous moments at the Hope Museum in 1986. Left to right: Lee Miller, Chris O'Toole, and David Spencer Smith; (6) Collecting in the Sierra Maestre in eastern Cuba, 1995. Left to right: Mark Simon, Lee, and Jackie Miller.

In Lee's opinion, one of his greatest accomplishments was the implementation of a phylogenetic arrangement for museum Lepidoptera on a worldwide basis. Lee realized that such an arrangement provided researchers and students with the opportunity to review higher level taxa in one place as opposed to curating taxa according to a biogeographic region. He believed that natural history collections are not only a historical document but also an evolutionary learning tool. Amateurs and professionals can learn the characteristic appearance or gestalt of a group through such an arrangement.

However, with all of these interests and accomplishments, Lee would probably state here that his greatest contribution was his interaction with students of Lepidoptera at every level and especially with amateurs in the field. The Lepidopterists' Society has always been a very unique organization in the respect that it includes both amateurs and professionals

and provides the opportunity for both to interact, learn, and collaborate with one another. Lee's Presidential address in 1984 was a tribute to the amateur lepidopterist during which he recounted the accomplishments of a number of well known amateur lepidopterists through time, including Pieter Cramer, Dru Drury, Jacob Hübner, Frederick DuCane Godman, Osbert Salvin, Walter Rothschild, James Joicey, William Barnes, Lionel Higgins, Cyril F. dos Passos, Roy and Connie Kendall, Dick Dominick, Arthur C. Allyn, and today, Lee would have added William McGuire. These individuals, among nameless others, were or are amateurs, who worked in other occupations but have enjoyed the sense of discovery and learning about all aspects of Lepidoptera. Lee always had time to talk with amateurs, professionals, and students at all levels of their careers, review specimens with them in the collection, and discuss various topics. Together, we followed the careers of a number of students, some from middle school through their graduate degrees and into their professional careers. Over the years, Lee was proud of the accomplishments of so many students, perhaps best exemplified by Ron Royer, now at Minot State University, who was one of the original "35th St. Boys" from Des Moines, and with whom he had spent so many enjoyable trips in the field as a teenager. As Ron Royer so aptly stated about Lee, "he has given countless others such indelible memories to cherish as he gave us (the 35th St. Boys)." To Lee, this was always time well spent, as these efforts were repaid with the enthusiasm which comes with new discoveries, long-term friendships, and sometimes, even new additions to the Museum collections. For Lee, life was to be enjoyed, and he felt that he was one of the luckiest people in the world – working on Lepidoptera and actually getting paid for it!

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- phila lunus* (= *Atrytonopsis lunus*) (Edwards), Neotype, *Hesperia deva* (= *Atrytonopsis deva*) (Edwards), Neotype, *Hesperia vialis* (*Amblyscirtes vialis*) (Edwards), Lectotype, *Hesperia eos* (= *Amblyscirtes eos*) (Edwards), Neotype, *Hesperis comus* (= *Amblyscirtes eos*) (Edwards), Lectotype, *Amblyscirtes nysa* Edwards, Lectotype, *Hesperia wakulla* Edwards (= *Amblyscirtes aesculapius* (Fabricius), Neotype, *Hesperia nemoris* Edwards (= *Amblyscirtes hegon*) (Scudder), Lectotype, *Amblyscirtes aenus* Edwards, Lectotype, *Amblyscirtes cassus* Edwards, Lectotype, *Amblyscirtes simius* Edwards, *Pamphila arabus* (= *Lerodea arabus*) (Edwards), Neotype, *Hesperia eufala* (= *Lerodea eufala*) (Edwards), Neotype, *Hesperia maculata* (= *Oligoria maculata*) (Edwards), Neotype or Lectotype, *Hesperia ocola* (= *Panoquina ocola*) (Edwards), Neotype, *Hesperia ophis* (= *Panoquin panoquin*) (Scudder), Lectotype, *Megathymus neumoeogeni* (= *Agathymus neumoeogeni*) (Edwards))
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The study of Lepidoptera is steeped in the “history” of this unique insect order, from the study of systematics to observations on and the first publication of that special life history of a particular species. In essence, lepidopterists are a composite drawn from their life experiences in the field and with people whom they have met and shared information along the way. This obituary is a historical retrospect and features some, but not all, of Lee's contacts over the years. There are numerous stories and events, but it would have been impossible to have included everyone and every detail here.

I would like to thank Drs. Deborah L. Matthews, Andrew D. Warren, and Rebecca B. Simmons for providing comments on this manuscript, many of which have been incorporated into the final version. I would like to especially thank Dr. Matthews for her invaluable assistance in helping me organize materials for this work and to Dr. Ron Royer for providing me with additional insight into Lee's early life as a collector in Des Moines. I would also like to thank here the hundreds of lepidopterists, colleagues, and friends throughout the world who phoned, sent e-mails, or cards with personal messages and remembrances upon Lee's death. He was a very private person and would have been somewhat taken aback by all of your kind words.

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THE BUTTERFLIES OF VENEZUELA, PART 2: NYMPHALIDAE II (ACRAEINAE, LIBYTHEINAE, NYMPHALINAE, ITHOMIINAE, MORPHINAE). By Andrew F.E. Neild, 2008; 275 pages, 84 color plates, hardcover. Meridian Publications, London. ISBN 978-0-9527657-1-4. Available directly from the author at <http://thebutterfliesofvenezuela.com/>, price £ 110 plus shipping, charged through PayPal. Also available at <http://www.nhbs.com/> for £ 134 plus shipping.

Skillfully composed and beautifully illustrated, *The Butterflies of Venezuela* Part 2 provides 196 species accounts for butterflies classified in 55 genera and five nymphalid groups. Both the plates and the text are printed in glossy paper, a beautiful presentation indeed. This book maintains the format, style and classification used in the first volume of this four-part series. Although justified given the everlasting instability of nymphalid systematics, readers should bear in mind that the classification used in this series will be obsolete by the time the fourth volume goes to press. Part 2 departs from Part 1 by having invited contributors. Phil DeVries wrote a foreword, Angel Vilorio provided a general introduction, Francisco Romero co-authored the species accounts for *Actinote*, Niklas Wahlberg and Andrés Orellana wrote introductions to the Nymphalinae and the tribe Antirrheini, respectively. This gave *The Butterflies of Venezuela* Part 2 a hint of spice.

Among the 196 species accounts, eight are descriptions of new species: *Actinote ballettae* Neild & Romero, *Actinote alberti* Neild & Romero and *Actinote romeroi* Neild & Costa (Acraeinae), *Oleria boyeri* Neild, *Pagyris renelichyi* Neild, *Pteronymia alicia* Neild, *Pteronymia peteri* Neild and *Greta clavijoi* Neild (Ithomiinae). Ninety-one new subspecies are described, too many to list here, and one neotype and six lectotypes are designated. Species and subspecies descriptions follow the same format as in Part 1, and line drawings of genitalia are given for all new species and some new subspecies. Two small technical comments might be in order. First, in contrast to all other aspects of this book, the genitalia drawings seem overly simple and without much detail. Second, for general accessibility and convenience I prefer to see the descriptions of new taxa published in primary literature. For a minimal cost researchers often use library services to request articles that include species descriptions where text and photographs of type specimens appear on sequential pages. In this book the specimen photographs in the plates are widely

separated from the description, thus making it a little more difficult to order a complete species description through library services.

The text provides a measure of the author's growth between Parts 1 and 2. It is clear that in addressing tricky groups such as acraeines and ithomiines Neild was especially conscientious of the groundwork required for species identifications (examining series of specimens in several museums, making genitalic preparations, consulting with experts, etc). The species accounts in Part 2 are detailed and more maturely composed than in Part 1, and include personal reports and numerous literature citations dating back to the 1800's; true scholarship revealed. For instance, within three and a half pages, the account for *Morpho telemachus* (Linnaeus, 1758) discusses the Venezuelan subspecies *liliana* and *iphichus*, their variation, ranges, and differences between them and the nominal subspecies from the Guianas. It compares also their genitalia to similar species, and provides illustrations. One and a half pages are devoted to the habits and host plants of *telemachus*; to my knowledge the most detailed account ever written for this species. At the other end of the spectrum lies *Patricia deryllidas* (Hewitson, 1864) with its 16 line-long species account. Do not fret: in few words Neild provides the means for identification of this species, starting simply with the descriptor "unmistakable". We then find that little is known about *deryllidas*, and a call for further studies is left between the lines.

The color plates are impeccable. Multiple life-size illustrations are used to show dorsal and ventral color patterns of males and females, color variation, and transparency when appropriate. The 1,451 photographs have been processed extremely well, nicely organized and beautifully printed. This is particularly important for the identification of difficult groups such as acraeines or ithomiines. Photographs of type specimens are marked with red acronyms (e.g., HT, for holotype) making them easily recognizable. All plates were prepared with economy of space, even the largest of the *Morpho* species, which are tastefully staggered in plates 44–48.

Andrew Neild's series, *The Butterflies of Venezuela*, opens windows into this biologically rich country, and presents the reader with life-size photographs (almost as good as having a specimen in hand) and a wealth of information on butterflies. The series is testimony to Neild's dedication to fieldwork, interactions with researchers and enthusiasts, visits to museums and

private collections, photography, and countless hours spent studying and writing. It gives one pleasure to consult *The Butterflies of Venezuela* series because both volumes have been prepared with great care. In the 13-year gap between the publication of Parts 1 and 2 we have seen increasing demand for more numerous, shorter, and more rapidly published contributions at the expense of detail and scholarship. *The Butterflies of Venezuela* series does not bend to such demand. On the contrary, it emulates the best of the traditional

catalogs, yet it is modern. Clearly Neild's efforts were focused on making Part 2 as thorough and complete as possible. It shows. This outstanding book should be on every lepidopterist's shelf.

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THE HAWK MOTHS OF NORTH AMERICA: A NATURAL HISTORY STUDY OF THE SPHINGIDAE OF THE UNITED STATES AND CANADA by James P. Tuttle. 253 pages + XVIII pages, 23 color plates of larvae and adults. ISBN 978-0-9796633-0-7. Hardbound 29 cm X 22 cm. Published by the Wedge Entomological Research Foundation, Washington D.C. in 2007. Available from distributors for US\$90.00.

The sphinx moths are familiar to entomologists and lay people alike, certainly known even to prehistoric Americans as the horned worms that plagued their tobacco and tomato gardens, or as the great moths hovering silently in the dusk—like crepuscular hummingbirds above deep, sweet-scented flowers of the night. Their powerful flight has always presented us with the exciting prospect of finding rare strays at our collecting lights.

For years, I heard rumors of James Tuttle's endeavor to rear all of the known species of sphingids occurring in the United States (and, de facto, Canada) and photograph them himself. The story was a nearly epic one for sphingid aficionados like me. I asked myself, "How could he do that?" One would be lucky to see some species even once in a lifetime within the United States, but find their larvae, as well? Eventually, I reviewed his sections on *Proserpinus* and related genera. It was then that I discovered the promise of his work and knew that its final result would not suffer that oft' heard refrain: "But they did not consult the western collectors!" Jim acknowledges the help of many in realizing his field objectives, intensely peer reviewing and refining his work. I find none of the sloppy errors of identification common in many books treating regional faunas in Lepidoptera!

This book functions as a current incarnation of *The Moths of America North of Mexico*, *Sphingoidea*

(Hodges 1971), but covers more species (some lately discovered) with much greater depth and detail, especially with respect to aspects of life history. It provides accounts of 127 species for the study area, up from the 115 species treated by Hodges. Overall, and understandably, Jim's book follows the format of *The Wild Silk Moths of North America* (Tuskes, Tuttle, & Collins 1996). We find introductory chapters on biogeography, morphology, biology, ecology, collecting, and rearing.

The bulk of this work is devoted to species accounts, for each giving distribution maps and commentary on distribution, adult diagnosis, variation, habitat, adult biology, immature stages (usually treated extensively), and rearing notes. Throughout the text, Jim meticulously and copiously credits all sources, whether from literature or personal communication, listing some 476 references in the literature cited. For many species, detailed drawings of pupae are presented. Where the taxonomic status of populations is uncertain (the troublesome *Euproserpinus* and *Hemaris* are good examples), Jim lets us see the reasoning behind his opinions and makes clear where further work is needed. The resurrection of *Lintneria* from the ashes of *Sphinx* came from careful consideration of larval, pupal, and adult morphology. In fact, Jim actually used adult morphological characters of as-yet-unstudied species to make predictions and test his hypothesis with larvae he would only see later.

I enjoyed the color plates of adult specimens, artistically arranged in a Victorian era fashion reminiscent of Holland's *The Moth Book* (1903). The plates of larvae, with locality data, are composed of photographs showing the lateral aspect of ultimate instars for all species obtainable in the reasonable course of years Jim could devote. Missing are the larval images of only a few, mostly rare, stray species. The

larval plates alone would have been an important scientific contribution and worthy of purchase. They are a great accomplishment and a fitting centerpiece of this book. Many of these larvae are depicted for the first time; some were completely unknown previously. Appended are parasitoid associations (with citations), lists of collections referenced, an entomological/animal index, and a botanical index.

Whereas Hodges depicted extensive adult variation with exemplar series, Jim shows only some. For documentation of the larvae, I would like to have seen color depictions of dorsal views for some larvae shown only in lateral view. Though an added expense, the work would also have benefited by additional color images exemplifying geographic and within-population

variation of larval color and pattern (rampant for example in *Euproserpinus*), perhaps utilizing the blank reverse side of Plate 23. These minor comments, and Jim has my name wrong in the acknowledgements(!), cannot eclipse the fact that for all biologists interested in sphingids, whether occurring in North America or not, this book will be indispensable. In quality, it stands unsurpassed among the many faunal treatments that line my bookshelves.

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BIOLOGY, DISTRIBUTION AND DIVERSITY OF TINEID MOTHS, by Gaden S. Robinson. 143 pages, 16 color plates with 512 figures, 210 x 295 mm, hardbound. ISBN 978-983-40053-9-9. Southdene Sdn Bhd, P.O. Box 10139, 50704 Kuala Lumpur, Malaysia; email: hsbar@pc.jaring.my. © Natural History Museum, London, 2009. £40 (~ \$64).

This global review of the family Tineidae conveniently summarizes much that the author and others have learned about the clothes moths and their relatives, a biologically interesting group on which Gaden Robinson (1949–2009) had devoted much of his professional life. It is likely that the author realized while completing this volume that it would be his final major work. Sadly he was not able to view its publication, which appeared just a few weeks after his death, following a nearly two year decline of his health. An obituary and brief biography of the author is included as a preface to the text.

Basically this volume brings together, within a geographical framework, much of the essential information about Tineidae that has appeared in Robinson's web-based world catalogue of the Tineidae [Global Taxonomic Database of Tineidae (Lepidoptera); <http://www.nhm.ac.uk/entomology/tineidae/index.html>], Robinson, *et al.*, Lepidoptera host plant database [Hosts – a Database of the World's Lepidopteran Hostplants; <http://www.nhm.ac.uk/research-curation/research/projects/hostplants/>], and his excellent review with E. S. Nielsen on the Tineid Genera of Australia (Robinson & Nielsen 1993).

Early in the introduction, Robinson proposes the whimsical query “Why Tineidae—why pick on me”. To this he responds, with typical Robinsonian humor “Because you're cute little moths. I think it's the hair that does it – Jimi Hendrix taken to extremes, but well-kempt, admittedly. And facial hair to match.” Following this popular approach, the text becomes strictly business, first providing a family diagnosis (How Tineidae are defined), followed by a detailed discussion of the 16 currently recognized subfamilies (Classification within Tineidae). Under the latter section Robinson summarizes not only their morphological characteristics, but also major biological attributes within each subfamily, and the number of genera and species currently recognized within each subgroup tallied by biogeographical region. Unfortunately, no morphological illustrations nor taxonomic keys have been included, which otherwise would have assisted in recognizing subfamilies. Possibly these would have been provided had the author been provided more time to devote to this review. A major feature of this work are the 500 color figures of adults and 12 of larval cases, primarily sampled from the collections of the Natural History Museum, London (BMNH). Although many of the images appear poorly defined against a rather dark background, they do provide a ready means to identify many of the more distinctive species. Several species are represented by holotypes and many have never been illustrated before. A number of specimens are unspread or damaged, reflecting the need for much more collecting in this

poorly surveyed family. The author was able to illustrate representative species for 272 of the 341 known tineid genera. Robinson reports that of these 341 genera, 106, or 31%, are currently unassigned to any subfamily. It should be pointed out that the names of two color figures, *Dryadaula terpsichorella* and *Opogona harpalea*, have been mistakenly switched on the back cover (but not in the text). This minor error undoubtedly occurred after the author had any opportunity to correct it.

The following section—2. Distribution, biology, and diversity—constitutes nearly 70% of the volume, wherein the biology and diversity of most of the world's genera and representative species are summarized according to geographical regions, beginning with major island groups of the Pacific, Indian, Atlantic Oceans, and the subantarctic islands of the southern ocean. Next the standard biogeographical regions are treated, starting with the Nearctic and progressing through the Neotropical, Palearctic, Afrotropical, Oriental, and Australian Regions. Within each regional treatment, taxa are summarized according to

subfamilies, as defined in the introduction. The advantage of this approach, of course, being that one can find all diagnostic information included for each region. Unfortunately, it also requires repeating basic information about widespread taxa sometimes for several regions.

This book will provide an excellent introduction to future studies on the Tineidae for any major region of the world. Together with his very usable world catalogue for the family, and the review of the Australian genera with E. Nielsen (1993), Robinson has greatly enabled future work on this family. It is significant to mention that for these latter contributions and others, Gaden Robinson received the prestigious Jordan Award from the Lepidopterists' Society in 2007.

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A PHOTOGRAPHIC FIELD GUIDE TO THE BUTTERFLIES OF THE KANSAS CITY REGION. By Betsy Betros. 407pp. ISBN 978-1-933466-86-6. \$24.95 US. 5.5" x 8.5" softbound, lavishly illustrated with over 1100 color photographs. Kansas City Star Books, Kansas City, MO. Date of publication August 2008.

This is an incredibly well-researched book, as evidenced by the very first two names under Acknowledgements: Richard Heitzman, and Floyd & June Preston. The book is aimed at everyone from brand-new beginner to serious, long-time students and should satisfy both groups admirably.

Beginning sections include: Butterfly or moth?; Parts of a butterfly; Names and nomenclature; Common and Latin names; Stages of a butterfly's life; Butterfly predators, disease, parasitoids; What do caterpillars & adults eat?; How butterflies spend the winter; Monarchs—extreme overwintering; Rearing caterpillars; Gardening for butterflies (with tables of adult nectar plants and caterpillar host plants); and many other topics, including good coverage of field equipment and photography.

The species accounts are the meat-and-potatoes of this book, treating 100 species of the Kansas City Region plus another 31 rare species and strays from

adjacent areas. The species accounts are arranged by family and include upper- and underside views, where possible, of both sexes and occasional color variants. Larvae and chrysalides are given for a number of species as well.

The vast majority of the photos are of live, perched specimens, but some spread material is also included for comparison of "look-alike" species (using white circles or lines to elucidate important differences). It also includes extensive coverage of the skippers and has a comparison key for the upper- and undersides of their wings.

On each page facing the photos of a given species are a series of charts indicating habitat (7 categories), adult nectar sources (6 categories), larva nests (Y, N), winter stage (none, egg, larva, pupa, adult, or migrant), # of broods (1–4, unknown), courtship (patrol, or perch), adult flight (by months), egg laying (singly, cluster, + six substrate choices), and status (resident, migrant, immigrant, stray).

In addition to the concise information given in the boxes, the facing page also includes: distributional data for Missouri, Kansas, Greater Kansas City, and general range; similar species; larval food; variants; other names; and other information.

As if this wealth of data weren't enough, there are

also many interesting facts and personal anecdotes given in the captions for most images.

The book concludes with references used for butterflies, plants, and gardening; additional selected reading; two-plus pages of websites; two page essay on “developing an interest in butterflies;” and 16+ pages of plant species referenced in the book. If only every major population center could have such an excellent resource !

To order the book, call StarInfo at 816-234-4636 and say “operator,” or go to www.TheKansasCityStore.com.

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MANUSCRIPT REVIEWERS FOR 2009 (VOLUME 63)

Manuscript reviewers are anonymous contributors to the scientific rigor, clarity, and quality of text and illustrations in the papers published by the Journal of the Lepidopterists' Society. The reviewers' input is invaluable and always welcomed by authors, editors and readers. We hope their careful work continues to allow the Journal to increase quality and readership. On behalf of all the authors and the editorial staff of the Journal, respectful acknowledgement is given to the reviewers for contributions published in Volume 63.

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