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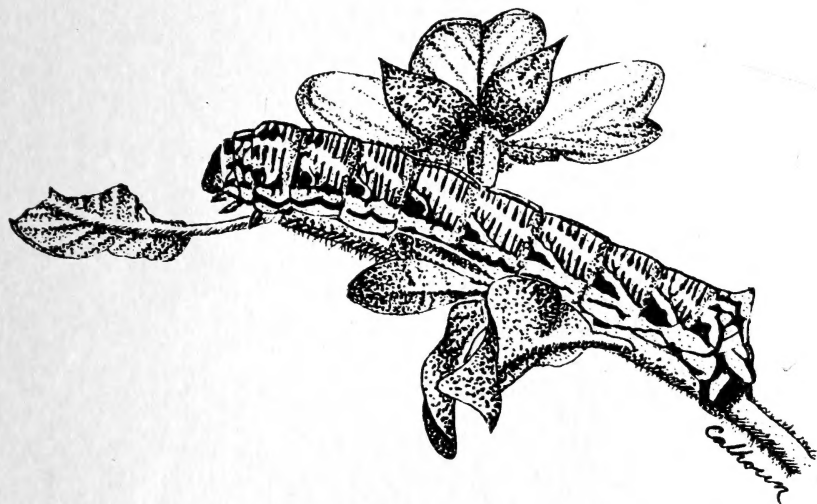
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Cover illustration: Mature larva of *Eumorpha fasciata* Sulzer (Sphingidae) feeding on *Ludwigia* sp. (Jussiaea) in southern Florida, where this hawk moth is generally found throughout the year. Original drawing by Mr. John V. Calhoun, 382 Tradewind Ct., Westerville, Ohio 43081, USA.

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THE BUTTERFLY FAUNA OF BARTON CREEK CANYON ON THE BALCONES FAULT ZONE, AUSTIN, TEXAS, AND A REGIONAL LIST

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ABSTRACT. Diversity of substrate, topography and water supply, and climate and vegetation account for the occurrence of 74% of the regional fauna along a 1.1 km stretch of Barton Creek. Monthly mean weather records for 40 years are analyzed on a bioclimagram and the modes matched with habitat types. 172 species are listed for the ten counties around Austin, and range, habitat, abundance, and residency are indicated for the 127 found at the study site. Faunal history is interpreted as a sequence of colonization events followed by episodes of habitat restriction. These are related to regional patterns of climatic change inferred from the 22,000-year paleontologic record of sphagnum bogs 70 km to the east and southeast. No species listed is endangered by collecting. Several restricted species of special habitats are threatened by potentially careless land use.

Barton Creek rises in Hays Co. on the Edwards Plateau and flows east into Travis Co. to enter the Colorado River at Austin below the Balcones Fault Zone. Most of the basin contains juniper and live-oak woodland, with cedar-elm more frequent towards the east. Post oak savanna occurs on higher hills near the headwaters, including Shingle Hills at 460 m. Madrone (*Arbutus xalapensis* H.B.K.), associated with sacahuista-grassland (*Nolina lindheimeriana* (Scheele) Wats. and *N. texana* Wats.) is found on the divides. Dwarf palmetto (*Sabal minor* (Jacq.) Pers.) and bald cypress (*Taxodium distichum* (L.) Rich.) are found in the deepest canyon in the middle part of the drainage (Correll & Johnston, 1970). In terms of biotic diversity, the most interesting area is the lowest portion of the canyon where it crosses the spring zone of the Balcones Faults. Here, since 1971, have been taken 127 species and an additional 10 subspecies in overlap. This is 74% of the total butterfly fauna known from the 10-county area around Austin (Llano, Burnet, Blanco, Hays, Travis, Williamson, Lee, Bastrop, Cald-

well, and Fayette) or within approximately 90 km (Fig. 1). Factors accounting for this biotic diversity include: features of substrate; topography and water supply; and climate and vegetation.

Substrate. Bedrock is a hard gray Cretaceous limestone (Rodda et al., 1970); the upper three members of the Edwards Formation, with the softer Georgetown Limestone capping hills north and south of the study area. The uppermost member of the Edwards is cavernous with rapid sink-in of rainfall, leading to development of rather xeric microhabitats. Next below is the major cliff-forming member. Residual soils on these limestones are dark-brown and gray-brown granular with limestone fragments and are of the Tarrant soil group (Werchan et al., 1974). On steeper slopes occurs colluvium of broken limestone of the Brackett soil group. At approximately 170 m there are deposits of the Capitol Terrace of reddish-brown chert pebbles and clay on which are developed soils of the Speck group. This terrace was deposited during or before the Yarmouth Interglacial, two to three hundred thousand years ago, when the gradient of the Colorado River and its tributaries was raised in adjustment with the interglacial rise in sea level. At approximately 150 m there is the Sixth Street Terrace of brown-red silty clay on which is developed soils of the Altoga group. This terrace deposit accumulated during the Sangamon Interglacial between 125,000 and 40,000 years ago. Insect microfossils in this deposit indicate a climate as warm as, or warmer than, present. At 140 m there is the First Street Valley Fill of brown fine sandy loam on which is formed soil of the Hardeman group. This deposit, which contains extinct horse and mastodon remains, was formed during the major pluvial stage in the late Wisconsin Glacial between 15,000 and 9000 years ago. Insect microfossils in this deposit indicate a climate cooler and more moist than present. Four lower levels of valley fill occur to the east of the study site, deposited during later Wisconsin and post-glacial pluvial episodes. The present bed load of Barton Creek consists of gray silt with limestone boulders, which are accumulating since the damming and modification of the creek channel at Barton Springs swimming pool.

Topography, land use and water supply. The collecting site extends from 1.2 km above the mouth of Barton Creek at the upper end of the swimming pool at 144 m elevation to 2.3 km SSW of the mouth at 157 m elevation above the rapids above Campbell's Hole. In the channel there is a small perennial spring at 145 m and two usually perennial pools at 147 m, the uppermost of which has been known for 100 years as Campbell's Hole. There is a sloping meadow at 150 to 155 m in the northeastern third of the area, upstream from which the canyon narrows. The top of the bluffs stands at approxi-

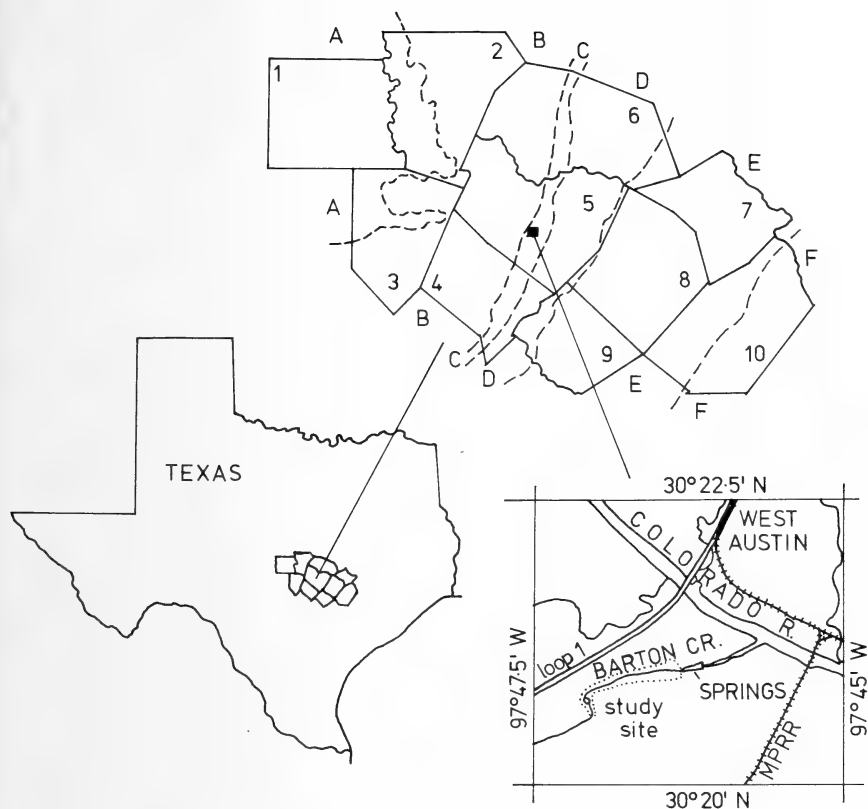


FIG. 1. Location of study site, with counties in the Austin area: 1. Llano, 2. Burnet, 3. Blanco, 4. Hays, 5. Travis, 6. Williamson, 7. Lee, 8. Bastrop, 9. Caldwell, 10. Fayette; and substrate: A. Llano Uplift (Precambrian shield and Paleozoic limestones), B. Lower Cretaceous limestone plateau and canyons, C. Balcones Fault Zone (canyons and springs), D. Upper Cretaceous limestones (with black rendzina soils and prairie), E. Paleogene sandstones and shales (with barren sands, podsoles and peat bogs), F. Neogene sands and clays (with coastal plain prairie).

mately 185 m. The present boundary of Zilker City Park protects the north canyon wall almost to the top, but the south canyon wall lies outside the park, where it is not developed because a city regulation prohibits building on floodplains. Development in the form of apartment complexes and single family houses has, in the past 5 years, used up almost all land bordering the collecting site. In the early 1960's a major sewer line was laid along the northern border of the creek channel. Construction of this line cracked limestone ledges which formerly held ephemeral pools, the habitat of an endemic crustacean, *Eulimnadia antlei* Mackin, known elsewhere only from Okla-

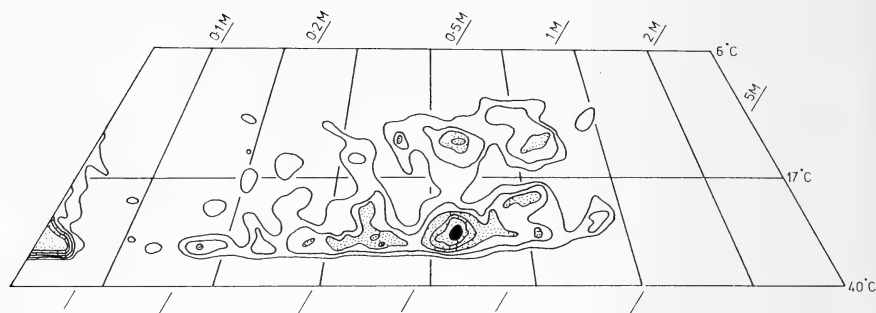


FIG. 2. Bioclimagram for Austin, Texas, based on monthly means of temperature and rainfall from 1931 to 1970, summarized by point density contouring to locate modes. Apparent rainfall is monthly rainfall $\times 12$.

homa. Published plans for future development of the study area include a "Barton Creek Hike and Bikeway" trail over the sewer line and wide enough for a standard patrol car to extend from Barton Springs to a major highway 3.5 km to the southwest.

Climate and vegetation. Monthly rainfall and temperature records for Austin, covering the years 1931 to 1970 were plotted as points on a diagram similar to that of Holdridge et al. (1971). Points were standardized as if for yearly averages and then point density was contoured to locate the positions of climatic modes found throughout the year (Fig. 2). The interpretive overlay of Holdridge was originally calibrated empirically for equatorial climates of small annual amplitude. A new overlay (Fig. 3) has been calibrated empirically for strongly seasonal climates, using as labels the habitats selectively favored under each condition. In order of decreasing frequency of occurrence, our summer (hotter than 16°C, 63°F) bioclimates are for dry forest (sabinal), warm desert, warm arid forest (encinal), with minor modes at warm thorn scrub, warm thorn woodland (including chaparral), warm mesic forest (2 modes), and warm moist forest. Our winter bioclimates are moderate park woodland (2 modes) and moderate groved meadow. Because the annual bioclimate is an oscillation between modes, now one, then another, community best adapted for particular modes is at a selective advantage. The cumulative result of such historical selection is a mosaic or patchy environment in which diverse communities coexist side by side in sharp discontinuity with boundaries maintained by small, but decisive, edaphic and topographic differences. Winter temperatures run some 1.5°C higher, and in summer, some 2.5°C lower in the canyons than the published records from the prairie site at the airport (U.S. Dept. Commerce, NOAA-EDS, 1970).

On Barton Creek there is sabinal or *Juniperus ashei* Buchh. wood-

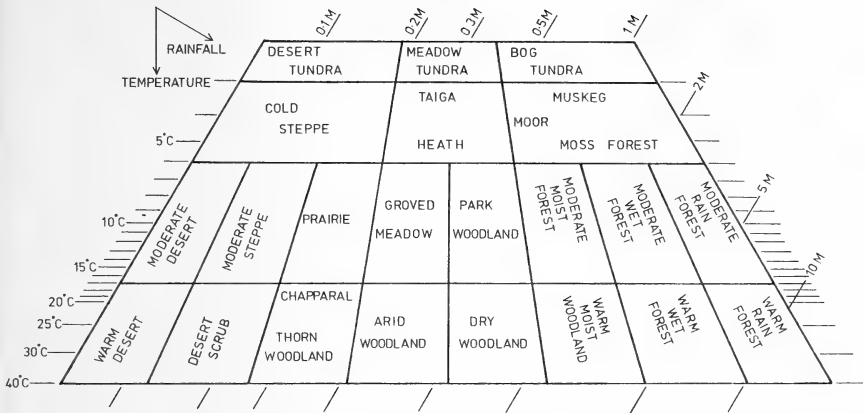


FIG. 3. Key diagram showing optimal community types for various temperatures and apparent rainfall figures based on data from a large number of North American stations.

land on the divides. Oak (*Quercus fusiformis* Small) and elm (*Ulmus crassifolia* Nutt.) woodland occurs on deeper^a dry soils. Oak (*Q. sinuata* Walt.) and elm (*U. americana* L.) woodland occurs on mesic colluvial pockets. Oak (*Q. texana* Buckl.), redbud (*Cercis canadensis* L.), red buckeye (*Aesculus pavia* L.), hop tree (*Ptelea trifoliata* L.), and monilla (*Ungnadia speciosa* Endl.) woodland occurs on steeper shade slopes. Pecan (*Carya illinoensis* (Wang.) K. Koch) and ash (*Fraxinus americana* L.) woodland occurs on alluvial soil. Cottonwood (*Populus deltoides* Marsh), willow (*Salix nigra* Marsh), plane tree (*Platanus occidentalis* L.), and indigo bush (*Amorpha fruticosa* L.) occur along the stream channel. On sunslopes there is a chaparral of evergreen sumac (*Rhus virens* Gray), ebony (*Diospyros texana* Scheele), stretch berry (*Forestiera pubescens* Nutt.), oreja de raton (*Bernardia myricaefolia* (Scheele) Wats.), christmas bush (*Eupatorium havanense* H.B.K.), china (*Sapindus saponaria* L.), lotebush (*Ziziphus obtusifolia* (T. & G.) Gray), cenizo (*Leucophyllum frutescens* (Berl.) I. M. Johnst.), granjeno (*Celtis pallida* Torr.), mescal bean (*Sophora secundiflora* (Ort.) DC.), kidney wood (*Eysenhardtia texana* Scheele), catclaw (*Acacia roemeriana* Scheele) and many other shrubs. The grassland of cleared areas is richly herbaceous and is returning rapidly to shrubland under pioneering jara dulce (*Baccharis neglecta* Britt.), mesquite (*Prosopis glandulosa* Torr.), huisache (*Acacia smallii* Isely), and retama (*Parkinsonia aculeata* L.), and to savanna with coma (*Bumelia lanuginosa* (Michx.) Pers.) and hackberry (*Celtis laevigata* Willd. and *C. lindheimeri* Engelm.). The herbaceous and small shrub flora is very rich, particularly on the limestone cliffs

where nectar sources are found in all seasons. During moist periods there is a proliferation of herbs and vines on the woodland floor, including suitable larval foodplants for many of our periodic tropical colonists. In cedar thickets in autumn, drying plants of *Heliotropium tenellum* (Nutt.) Torr. are attractants for *Danaus* spp.

Most years have minimum temperature no lower than -5°C (23°F) during the second week of January. New growth of chamaephytes begins in February. The mean last frost date is 3 March with rare chance of near frost as late as mid-April. The first rainy season peaks in May and is separated in most years by a more or less severe dry season in June, July, and August from the second rainy season in September. Rarely the first frost occurs as early as late October or as late as January, with the mean first frost date on 28 November. A few butterfly species are adult only during, just before, or just after the first rainy season. These are *Erynnis juvenalis*, *Megathymus coloradensis kendalli*, *Satyrium calanus falacer*, *Callophrys solatus*, *Fixsenia ontario autolytus*, *Megisto cymela*, and *Anthocharis midea annickae*, and all are single brooded. Other numbered species on the list are two or more brooded per year and may be found during or following both rainy seasons, or all year long. Periodic tropical colonists are usually not found before late August in normal years. In years of moist spring, when there is abundant rainfall in the Rio Grande Valley between Sabinas Hidalgo and San Antonio, they may reach our area in May or June. In rare years of exceptionally mild winter, some of these tropical colonists may survive the cold. Neck (1978) has given an introduction to the periodicity of this phenomenon. Empirically, the greatest diversity or number of synchronic species occurs in mid-October, and the greatest population or number of individual butterflies on the wing occurs in late September. There is a smaller diversity peak in June and population peak in May. Diverse collecting often persists well into November and occasionally into December. Taxa of temperate distribution enter hibernation during October, possibly in response to change in day-length. This stops the emergence of new adults of these species, freeing niche space and nectar sources for the periodic tropical colonists. From mid-October through December the greater part of the adult population is composed of species with predominantly tropical distribution, a few endemic taxa, and a few adult hibernators. One species of the sacahuista-grassland association, not yet known from the study site but occurring on the left divide 11 km to the northwest, is *Hesperia woodgatei*. This species has a single autumn brood flying from mid-October into early November. The 27 species indicated (*) may be found dur-

ing warm weather in mid-winter. In dry years, more species can be found in January than in July.

Biogeographic notes. The subspecies is chosen as the working taxon for biogeographic analysis because it is the primary occupant of the niche (Durden, 1969). Different subspecies have slightly different habitat requirements and accordingly their ranges are determined by the distribution of such habitats. At this locality there are 6 pairs and 2 triplets of syntopic subspecies. These are, however, rarely synchronic or competitive. They have different overall ranges, different habitat requirements, and are only found together during episodes of mutual dispersal.

By habitat preference our butterflies are 53% of woodlands, 26% of desert and grassland, 12% of brushland, and 9% of arid woodland and thorn scrub. Geographically they are 39% in midrange, 41% at or near the northern boundary, 18% near the eastern boundary, 17% at the southern or southwestern boundary, and 7% at the western boundary. Range groups, position within range, frequency, and residency status are indicated in the list by the following symbols:

Range groups. A—wide-ranged in dry disturbed sites (9) in midrange). B—Great Plains (8 in midrange, 4 at southern edge, 4 at eastern edge). C—warm temperate, subtropical and tropical in dry open sites (9 in midrange, 2 at eastern edge). D—subtropical arid thorn forest (1 in midrange, 3 at eastern edge, 3 at northern edge). E—eastern subtropical arid thorn scrub (2 in midrange, 2 at northern edge). F—Tamaulipan arid woodland (2 at northern edge). G—broad-ranged temperate and tropical woodland (1 in midrange). H—eastern deciduous forest and tropical woodland (1 at western edge). I—Gulf Coast and tropical woodland (9 in midrange). J—subtropical and southern Great Plains brushland (3 in midrange, 1 at eastern edge). K—eastern deciduous and subtropical montane woodland (2 in midrange). L—eastern deciduous woodland (5 in midrange, 5 at southwestern edge). M—Appalachian and Mississippi Basin woodland (4 at southern edge, 4 at southwestern edge). N—Gulf Coast woodland (7 at western edge). O—western deciduous and subtropical montane woodland (6 at eastern edge). P—*endemic taxa* of the Sierra Madre Oriental and Balcones Escarpment (4 at northern edge). Q—*endemic taxa* of central Texas and northern Coahuila (1 in midrange, 2 at eastern edge, 4 at northern edge). R—tropical woodland (4 in midrange, 11 within northern part of range, 15 at northern edge).

Position within range. n—at northern edge of range (30). nm—in the northern part of the range, rarely straying farther (11). m—in midrange (54). e—at eastern edge of range (18). w—at western edge of

range (8). s—at southern edge of range (8). sw—at southwestern edge of range (9).

Frequency. a—abundant, but may be periodically scarce, although frequently occurring in such abundance that a series may be taken in a day (84). u—uncommon, few specimens have been taken, several years are required to accumulate a series (27). s—scarce, one to five individuals have been taken in 10 years (26).

Residency status. p—periodic, strays appearing in our region after a moist spring or after dispersal by hurricane, usually raising one or more broods or persisting up to 9 years before extermination by severe winter freeze or by summer drought (46). r—permanent residents, known to have survived extreme drought or winter freeze of 25 to 100 year severity.

LIST OF THE BUTTERFLIES FOUND ON BARTON CREEK IN ZILKER PARK, AUSTIN, TEXAS, WITH ADDITIONAL SPECIES FOUND IN THE ADJACENT TEN COUNTIES

(Dates given for scarce species only; author was collector unless noted otherwise; footnotes 1–28 follow the List.)

PYRGINAE (HESPERIIDAE)

1. *Epargyreus clarus* (Cramer, 1775) subsp., O-e-a-r.
2. *Chioides albofasciatus* (Hewitson, 1867), R-n-s-p (14:x:72).
3. *C. zilpa zilpa* (Butler, 1874), R-n-s-p (29:ix:76).
Urbanus proteus (Linné, 1758), Bastrop Co. (Heiligbrodt, 1870's).
4. *U. dorantes rauterbergi* (Skinner, 1895), R-nm-s-p (1:x:72).
Achalarus coyote (Skinner, 1892), Travis Co. (Bull Cr.).
5. *Thorybes pylades* (Scudder, 1870), K-m-u-r.
T. confusus Bell, 1922, Bastrop Co., Travis Co. (Bull Cr.).
T. bathyllus (Abbot in Smith, 1797), Bastrop Co.
Cogia outis (Skinner, 1894), Travis Co. (Bull Cr.).
6. *Bolla clytius* (Godman & Salvin, 1897), R-n-s-p (2:x:77).
7. *Staphylus hayhurstii* (Edwards, 1870), L-m-u-r.
8. *Systasa pulverulenta* (Felder, 1869), E-n-a-r.
9. *Achlyodes mithridates tamenund* (Edwards, 1871), R-nm-u-p.¹
Gesta invisus llano (Dodge, 1903), Llano, Travis, Bastrop Co's.²
10. *Erynnis horatius* (Scudder & Burgess, 1870), L-m-a-r.
11. *E. meridianus* Bell, 1927, B-s-s-r (30:ix:76).
12. *E. juvenalis juvenalis* (Fabricius, 1793), M-s-u-r.
E. martialis (Scudder, 1869), Bastrop Co. (Sandy Cr.).
13. *E. funeralis* (Scudder & Burgess, 1870), C-m-a-r.
E. zarucco (Lucas, 1857), Travis Co. (Bull Cr.).
E. baptisiae (Forbes, 1936), Travis Co. (Bull Cr.).
E. burgessi (Skinner, 1914), Blanco Co. (Round Mt.; F. G. Schaupp).
- 14a. **Syrichtus (Tuttia) communis communis* (Grote, 1872), C-m-a-r.³
- 14b. *S. (T.) communis albescens* (Plötz, 1884), D-n-a-p.⁴
S. (T.) oileus (Linné, 1767), Travis Co. (Bull Cr.).
15. *S. (T.) philetas* (Edwards, 1881), E-m-u-r.⁵
16. *Heliopetes laviana* (Hewitson, 1868), R-n-s-p (13:x:71, 9:xi:72).
17. *Celotes nessus* (Edwards, 1877), E-m-a-r.

18. *Pholisora catullus* (Fabricius, 1793), M-s-a-r.
P. mejicana (Reakirt, 1866), Travis Co. (Bull Cr.).

HESPERIINAE (HESPERIIDAE)

19. *Megathymus coloradensis kendalli* Freeman, 1965, Q-e-u-r.⁶
M. coloradensis reinthali Freeman, 1963, Caldwell, Williamson, Lee Co's.
Ancyloxipha numitor (Fabricius, 1793), Travis, Lee Co's.
A. arene (Edwards, 1871), Llano Co. (Enchanted Rock).
20. *Copaeodes aurantiaca* (Hewitson, 1868), C-e-a-r.
21. **C. minima* (Edwards, 1870), L-m-a-r (with the genitally distinct winter f. *rayata* Barnes & McDunnough, 1913).
22. **Atalopedes campestris* (Boisduval, 1852), L-m-a-r (with a dark winter f.).
23. *Hesperia viridis* (Edwards, 1883), B-e-u-r.
H. woodgatei (Williams, 1914), Travis Co. (Fourpoints & U. Barton Cr.).
H. licinus (Edwards, 1871), Bastrop Co. (Heiligbrodt Cln.).⁷
H. meskei (Edwards, 1877), Bastrop Co. (Heiligbrodt Cln.).
H. attalus (Edwards, 1871), Travis Co. (U. Shoal Cr.).
24. *Polites (Polites) vibex brettoides* (Edwards, 1883), L-m-u-r.
P. (P.) themistocles (Latreille, 1824) subsp., Bastrop Co. (Paige).
25. *P. (Wallengrenia) otho otho* (Abbot in Smith, 1797), L-m-a-r.
Poanes (Poanes) viator viator (Edwards, 1865), Lee Co. (Patschke Bog).
26. *Hylephila phyleus* (Drury, 1773), L-m-a-r.
Atrytone (Atrytone) arogos iowa (Scudder, 1868), Travis Co.⁸
A. (A.) arogos arogos (Boisduval & LeConte, 1833), Fayette Co. (Swissalp).
27. *A. (A.) delaware lagus* (Edwards, 1881), B-s-u-r.
A. (A.) mazai Freeman, 1969, Travis Co. (U. Shoal Cr.).
28. *Euphyes vestris osyka* (Edwards, 1867), L-m-a-r.
29. *Amblyscirtes nysa* Edwards, 1877, B-e-u-r.
A. aenus aenus Edwards, 1878, Travis Co. (Bull Cr.).
A. erna Freeman, 1943, Travis Co. (Bull Cr.).
30. *A. eos* (Edwards, 1871), B-e-u-r.
31. *A. celia* Skinner, 1895, F-n-a-r.
A. alternata (Grote & Robinson, 1867), Bastrop, Lee Co's.
32. *Lerodea eufala* (Edwards, 1869), L-m-a-r.
33. *Calpodes ethlius* (Stoll, 1782), R-m-u-p.
34. *Panoquina ocola* (Edwards, 1863), L-m-a-r.
35. *Nastra julia* (Freeman, 1945), Q-m-a-r.
36. *Lerema accius* (Abbot in Smith, 1797), L-m-a-r.

RIODININAE (LYCAENIDAE)

37. *Calephelis nemesis australis* (Edwards, 1877), Q-n-a-r (with a winter form approaching typical *nemesis*).⁹
38. *C. perditalis* (Barnes & McDunnough, 1918), P-n-u-r (with darker angulate-winged winter form).
39. *C. guadeloupe* (Strecker, 1878), Q-n-a-r (with summer f. *rawsoni* McAlpine, 1939).¹⁰
40. *C. sinaloensis nuevoleon* McAlpine, 1971, P-n-s-r (16, 21, 28:x:71; 10:ix:72).
Apodemia mormo mejicanus (Behr, 1865), Bastrop, Travis Co's.¹¹

LIPHYRINAE (LYCAENIDAE)

41. *Feniseca tarquinius* (Fabricius, 1793), M-sw-s-r (24:ix:79).

LYCAENINAE (LYCAENIDAE)

- Chlorostrymon simaethis sarita* (Skinner, 1895), Williamson Co. (Salado Cr.).
Phaeostrymon alcestis alcestis (Edwards, 1871), Williamson, Travis Co's.
42. *Satyrrium calanus falacer* (Godart, 1824), M-s-u-r.

43. *Calycopis isobea* (Butler & Druce, 1869), J-m-a-r (with a dimorphic form or possible sibling species).
44. *Callophrys (Mitoura) gryneus gryneus* (Hübner, 1819), L-m-a-r.¹²
C. (M.) gryneus auburniana (Harris, 1862), Bastrop Co. (Sandy Cr.).
C. (M.) gryneus × *sweadneri*, Travis Co. (3 in hundreds of the parents).
45. *C. (M.) sweadneri* (Chermock, 1944) subsp., Q-e-a-r.¹³
46. *C. (Incisalia) solatus* (Cook & Watson, 1909), Q-n-a-r (with a var. with green scales ventrally).¹⁴
C. (I.) henrici turneri (Clench, 1943), Llano, Travis Co's.
47. **Atlides halesus estesi* Clench, 1942, D-m-a-r.
48. *Fixsenia ontario autolytus* (Edwards, 1871), B-m-a-r.
49. *Panhiades m-album m-album* (Boisduval & LeConte, 1833), L-sw-u-r.
- 50a. **Strymon melinus franki* Field, 1938, C-e-a-r (with a dark winter f.).¹⁵
- 50b. *S. melinus melinus* Hübner, 1818, N-w-u-r.
- 51a. *S. alea* (Godman & Salvin, 1887), P-n-a-r (with a dark winter f.).¹⁶
- 51b. *S. alea* × *columella* (1 in 75 specimens of parent species).
52. *S. columella istapa* (Reakirt, 1866), R-n-s-p (14:x:71; 2:x:72; 7, 9, 10:xi:72).
53. *Hemiargus ceraunus zachaeina* (Butler & Druce, 1872), D-e-u-p.
54. *Echinargus isola alce* (Edwards, 1871), C-m-a-r (with dark winter f.).
55. *Celastrina ladon ladon* (Cramer, 1780), M-s-s-r (6:viii:72).¹⁷
56. *Zizula cyna* (Edwards, 1881), R-n-s-p (2:xi:71).
57. *Brephidium exilis exilis* (Boisduval, 1852), B-e-s-r (22:x:71; 2, 4:xi:71).
58. *Everes comyntas comyntas* (Godart, 1824), H-w-u-p.
59. *E. texana* Chermock, 1944, Q-n-a-r.¹⁸
60. *Leptotes cassius striatus* (Edwards, 1877), R-n-s-p (17:v:72).
61. *L. marinus* (Reakirt, 1868), D-e-u-p.

PAPILIONINAE (PAPILIONIDAE)

62. *Papilio polyxenes curvifasci* Skinner, 1902, B-m-a-r.
P. rudkini f. *clarki* Chermock & Chermock, 1937, Travis Co. (Turkey Bend).¹⁹
Pterourus (Pterourus) troilus troilus (Linné, 1758), Travis Co. (Bull Cr.).
63. *P. (Jasniades) glaucus glaucus* (Linné, 1764), L-sw-u-r.
64. *P. (J.) multicaudatus* (Kirby, 1884), O-e-u-r (with large dark summer f.).
65. *Heraclides (Heraclides) cresphontes* (Cramer, 1777), G-m-a-r.
H. (H.) thoas autocles (Rothschild & Jordan, 1906), Travis Co. (L. Austin).
66. **Battus philenor philenor* (Linné, 1771), C-m-a-r.
B. polydamas polydamas (Linné, 1758), Travis Co. (Austin).

LIBYTHEIDAE

- 67a. *Libytheana bachmanni bachmanni* (Kirtland, 1851), L-sw-u-p (with wet season f. *kirtlandi* (Field, 1938)).²⁰
- 67b. **L. bachmanni larvata* (Strecker, 1878), D-n-a-r (with wet season f. *streckeri* (Field, 1938)).
68. *L. carinenta mexicana* Michener, 1943, R-n-s-p (3:v:73; 24:ix:79; 2:x:80; 11:xi:80).

NYMPHALINAE (NYMPHALIDAE)

69. **Euptoieta claudia claudia* (Cramer, 1776), C-m-a-r (with winter dwarfs).
70. *E. hegesia hoffmanni* Comstock, 1944, R-n-s-p (16, 21:x:71).
71. *Polygonia (Polygonia) interrogationis* (Fabricius, 1869), K-m-a-r (with summer f. *umbrosa* (Lintner, 1869)).
72. *P. (Grapta) comma* (Harris, 1842), M-sw-s-r (with summer f. *dryas* (Edwards, 1870)), (24, 26:ix:79).
73. *Nymphalis (Euvanessa) antiopa lintnerii* (Fitch, 1856), O-e-s-r (6:ix:76).
74. **Vanessa (Vanessa) atalanta rubria* (Fruhstorfer, 1916), A-m-a-r.
75. **V. (Cynthia) cardui* (Linné, 1758), A-m-a-p.
76. **V. (C.) virginensis* (Drury, 1773), A-m-a-r (with winter f. *fulvia* (Dodge, 1900)).

77. **Precis (Junonia) coenia coenia* (Hübner, 1822), C-m-a-r (with dark wet season f., and winter f. *rubrosuffusa* Field, 1936).
78. *P. (J.) nigrosuffusa* (Barnes & McDunnough, 1916), D-n-u-p.²¹
- 79a. *P. (J.) genoveva genoveva* (Stoll, 1782), R-n-u-p.
- 79b. *P. (J.) genoveva zonalis* (Felder & Felder, 1867), R-n-s-p (2:x:71; 2:xi:71; 1:vii:72).
80. *Anartia jatrophae jatrophae* (Johansson, 1763), R-nm-s-p (18:x:71).
Siproeta (Victorina) stelenes biplagiata (Fruhstorfer, 1907), Travis Co. (Austin; R. Neck).
81. *Heliconius charitonius vazquezae* Comstock & Brown, 1950, R-nm-a-p (with var. with orange scaled disc).
Eueides isabellae zorcaon (Reakirt, 1866), Travis Co. (Austin, R. Neck).
82. *Dryas iulia moderata* (Riley, 1926), R-nm-a-p (with dark wet season f.).
Dione (Dione) moneta poeyi (Butler, 1873), Travis Co. (Bull Cr.; P. Horde).
83. **D. (Agraulis) vanilla incarnata* (Riley, 1926), B-m-a-r (with winter dwarfs).
84. *Mestra hypermnestra amymone* (Ménétriés, 1857), R-m-a-p (with wet season dark f.).
Biblis hyperia aganisa Boisduval, 1836, Travis Co. (Austin).
Chlosyne (Chlosyne) janais (Drury, 1782), Travis Co. (Bull Cr.).
85. *C. (C.) lacinia adjutrix* Scudder, 1875, J-m-a-r (with dry season light f. cf. *saundersi* (Doubleday, 1848), and var. black, var. black and white).
86. *C. (Charidryas) gorgone carlota* (Reakirt, 1866), B-s-s-p (5:iv:78; 29:ix:79).
87. *C. (C.) nycteis* (Doubleday, 1848), M-sw-a-r (with wet season f. cf. *drusius* (Edwards, 1884)).
Thessalia theona bollii (Edwards, 1877), Burnet Co. (Pangle).
88. *Texola elada ulrica* (Edwards, 1877), E-n-a-r (with wet season f. *senrabii* (Barnes, 1900)).
89. **Phyciodes phaon* (Edwards, 1864), L-m-a-r (with summer f. *aestiva* (Edwards, 1878)).
90. **P. tharos distincta* Bauer, 1975, O-e-a-r (with winter f. ventrally brown).
91. **P. vesta* (Edwards, 1869), J-e-a-r (with winter f. *boucardi* Godman & Salvin, 1878).
92. **Anthanassa texana texana* (Edwards, 1863), J-m-a-r (with summer f. *smertis* (Hewitson, 1864), and var. black & white).
93. *Marpesia (Euglyphus) chiron* (Fabricius, 1775), R-nm-s-p (29:ix:75).
94. *Limnitis (Limnitis) bredowii eulalia* (Doubleday, 1848), O-e-a-p.²²
- 95a. *L. (Basilarchia) archippus archippus* (Cramer, 1776), B-s-a-p.
- 95b. *L. (B.) archippus watsoni* (dos Passos, 1938), N-w-a-r (with var. orange, a Batesian mimic of *Danaus eresimus* v. orange).²³
96. *L. (B.) astyanax astyanax* (Fabricius, 1775), L-sw-u-r.
Dynamine dyonis Geyer, 1837, Travis Co. (Bull. Cr.).

APATURINAE (NYMPHALIDAE)

97. *Asterocampa celtis alicia* (Edwards, 1868), N-w-a-r.
98. *A. antonia antonia* (Edwards, 1877), B-m-a-r.
99. *A. leila cocles* (Lintner, 1884), F-n-a-p.
100. *A. clyton texana* (Skinner, 1911), B-m-a-r (with light dry season f.).
101. *A. louisa* Stallings & Turner, 1947, P-n-u-r.
102. **Anaea (Anaea) andria andria* Scudder, 1875, L-m-a-r (with winter f. *andriaesta* Johnson & Comstock, 1941).
103. **A. (A.) aidea* (Guerin, 1844), R-nm-a-p (with winter f. *morrisonii* (Edwards, 1883)).

SATYRINAE (NYMPHALIDAE)

104. *Cercyonis pegala texana* (Edwards, 1880), B-m-a-r (with var. dark).
Cyllopsis gemma gemma (Hübner, 1808), Lee Co. (Patschke Bog).
Neonympha (Hermeuptychia) hermes (Fabricius, 1775), Travis Co.

105. *N. (H.) sosybius* (Fabricius, 1793), N-w-a-r.²⁴
 106. *Megisto cymela cymela* (Cramer, 1777), B-m-a-r (with var. smeared silver).
 107. *M. rubricata rubricata* (Edwards, 1871), B-m-a-r (with var. obsolescent eye-spots).

DANAINAE (NYMPHALIDAE)

108. *Danaus (Danaus) plexippus plexippus* (Linné, 1758), A-m-a-p (with var. dark apex forewing).
 109. **D. (Anosia) gilippus strigosus* (Bates, 1864), C-m-a-r (with var. cf. *bernice* (Cramer, 1780), var. *gilippina* Hoffmann, 1940, and var. orange Müllerian mimic of *D. eresimus* var. orange).
 110. *D. (A.) eresimus montezuma* Talbot, 1943, R-n-a-p (with var. dark maculate, and var. orange).

PIERINAE (PIERIDAE)

111. *Anthocharis (Paramidea) midea annickae* dos Passos & Klots, 1969, M-sw-a-r.
 112. *Artogeia rapae rapae* (Linné, 1758), A-m-a-p (exotic introduction).
 113. **Pontia protodice* (Boisduval & LeConte, 1829), A-m-a-r (with winter f. *vernalis* (Edwards, 1864)).
 114. *Ascia (Ascia) phileta phileta* (Fabricius, 1775), R-nm-s-p (16:x:71).²⁵
 115. *Appias (Glutophrissa) drusilla poeyi* (Butler, 1872), R-nm-s-p (13, 18:x:71).
 116. **Colias (Colias) eurytheme eurytheme* Boisduval, 1852, A-m-a-r (with summer f. *amphidusa* Boisduval, 1852, and female var. *alba* Strecker, 1878).
C. (C.) philodice philodice Godart, 1819, Bastrop Co. (H. Duval Cln.).
 117. **Zerene cesonia cesonia* (Stoll, 1790), A-m-a-r (with winter f. *rosa* (M'Neill, 1889), and var. *stainkeae* Field, 1936).
Anteos maerula lacordairei (Boisduval, 1836), Travis Co. (N. Austin).
 118a. **Kricogonia lyside lyside* (Godart, 1819), D-e-a-p (with winter f. *unicolor* Godman & Salvin, 1889).²⁶
 118b. *K. lyside terissa* (Lucas, 1852), R-nm-a-p (with f. *lanice* Lintner, 1885).
 118c. *K. lyside fantasia* Butler, 1871, R-n-u-p.
 119. *Eurema (Eurema) mexicana* (Boisduval, 1836), O-e-a-r (with winter f. *rosa* Whittaker & Stallings, 1944).
E. (E.) दौरα दौरα (Godart, 1819), Travis Co. (Austin).
 120. *E. (Pyrristia) proterpia* (Fabricius, 1775), R-n-a-p (with winter f. *gundlachia* (Poey, 1851)).
 121. *E. (P.) lisa* Boisduval & LeConte, 1829, C-m-a-r (with summer f. *immaculata* Whittaker & Stallings, 1944, and female var. *alba* Strecker, 1878).
 122. *E. (P.) nise nelphe* (Felder, 1869), R-n-s-p (14:x:76; 11:xi:80).
 123a. **E. (Abaeis) nicippe nicippe* (Cramer, 1780), C-m-a-r (with winter f. ventrally orange, and female var. pale orange).
 123b. *E. (A.) nicippe flava* (Strecker, 1878), N-w-s-r (19:x:71).²⁷
 124a. *Phoebis (Callidryas) sennae eubule* (Linné, 1767), L-sw-a-p (with female var. *browni* Field, 1936).
 124b. *P. (C.) sennae sennae* (Linné, 1758), N-w-a-p.
 124c. *P. (C.) sennae marcellina* (Cramer, 1777), R-nm-a-p (with female var. *yamana* Reakirt, 1863).²⁸
 125. *P. (C.) philea* (Johansson, 1763), R-m-s-p (10:x:71; L. Gilbert).
 126. *P. (Phoebis) agarithe maxima* (Neumoegen, 1891), R-m-a-p (with female var. *albarithe* Brown, 1929).
Aphrissa statira statira (Cramer, 1777), Travis Co. (Northwest Hills).
 127. **Nathalis iole* Boisduval, 1836, A-m-a-r (with winter f. *viridis* Whittaker & Stallings, 1944).

FOOTNOTES TO LIST OF BUTTERFLIES ON BARTON CREEK

¹ *Hesperia tamenund* Edwards has been treated as a subspecies of *Papilio thraso* Jung, 1792 which is a junior homonym. *Papilio mithridates* Fabricius, 1793 is the oldest name for the species (H. Ebert, 1969, J. Lepid. Soc. 23, Suppl. 3: 38).

² *Nisoniades llano* Dodge, described from Llano Co., refers to the Central Texas populations which are subspecifically distinct from *Thanaos invisus* Butler & Druce, 1872 which ranges north to Tamaulipas and strays into the Rio Grande Valley.

³ Species allied to *Papilio oileus* Linné, fall outside the genus *Pyrgus* as revised by B. C. S. Warren (1926, Trans. Entomol. Soc. London, 74: 152). By genitalic structure they fit best in *Tuttia* Warren, 1926. This genus was sunk in *Muschampia* Tutt, 1906 (e.g., C. G. Higgins & N. D. Riley, 1970, Field Guide to the Butterflies of Britain & Europe, Boston) for which F. Hemming (1967, Bull. British Museum Nat. Hist., Entomology, Suppl. 9: 300) has shown the correct name is *Syrichthys* Boisduval, 1834.

⁴ *Pyrgus albescens* Plötz is distinguished genitalicly from *Syrichthys communis* Grote, as are occasional intermediates interpreted as hybrids. Genitalic determination of males is made in the field using a 20× Seibert emskop. A. W. Lindsey, E. L. Bell & R. C. Williams (1932, J. Sci. Lab., Denison Univ., 26: 46) are followed in recognizing subspecific status.

⁵ Specific distinctness of *Papilio oileus* Linné and *Pyrgus philetas* Edwards has been supported on structural, ecological and geographic grounds by J. M. Burns & R. O. Kendall (1969, Psyche, 76: 453).

⁶ H. A. Freeman (1969, J. Lepid. Soc. 23, Suppl. 1) reports different chromosome numbers (27) for *Megathymus coloradensis* (Riley, 1877) and (26) for *M. yuccae* (Boisduval & LeConte, 1833) and places *M. y. reinthali* Freeman, 1963 with *coloradensis* rather than with *yuccae*.

⁷ *Pamphila licinus* Edwards, 1871, described from Waco (Belfrage clr.) although recently treated subspecifically under *Hesperia metea* Scudder, 1863 by MacNeill (in Howe et al., 1975, Butterflies of North America, New York) is considered distinct following Lindsey, Bell & Williams (loc. cit.) until data is available from connecting localities.

⁸ This subspecies occurs on southern extensions of tall grass prairie developed as glades on fluvial terraces on and west of the Balcones Fault Zone. The next subspecies occurs on Fayette prairie, a facies of the Southeastern Coastal Plain prairies. The first is identified with *Hesperia iowa* Scudder (type locality: Denison, Iowa); the second with *H. arogos* Boisduval & LeConte (type locality: "North America," probably Georgia), determination and subspecific ranking following A. B. Klots (1951, Field Guide to the Butterflies, Boston) rather than MacNeill (loc. cit.).

⁹ Subspecific recognition follows W. S. McAlpine (1971, J. Res. Lepid., 10: 28) rather than the lumping of J. A. Powell (in Howe et al., loc. cit.). The allolectotype, fig. 6 of F. M. Brown (1968, Trans. American Entomol. Soc., 94: 130) is of the summer form.

¹⁰ Here the synonymy of Powell (loc. cit.) is followed with added recognition that *guadeloupe* was based on the winter form more easily confused with the summer form of *C. nemesis*. *C. rausoni* McAlpine, 1939 was based on the distinctive summer form of this species. Although convenient labels for ecologically important phenotypes, these names, when used for seasonal forms, are infraspecific and outside present zoological nomenclature.

¹¹ Specimens collected by Morgan Hebard, 23 miles east of Austin (Carnegie Museum Cln.) fall close to *mexicanus* and are the basis for this determination. One sight record (Travis Co., Austin, Northwest Hills, 13:x:68) resembled the Hebard specimens.

¹² W. T. M. Forbes (1960, Cornell Univ. Agric. Expt. Sta., Mem. 371: 133) is followed in recognition of subspecific distinctness of the northeastern entity associated with red cedar. Bastrop Co. material (associated with *Juniperus virginiana* var. *crebra* Fern. & Griseb.) was compared with series from Connecticut, New Jersey and North Carolina. This is distinct in color facies from the southern subspecies *gryneus* which is synonymous with *smilacis* Boisduval & LeConte, 1833. Texas material of this complex is routinely referred to *castalis* Edwards, 1871 (type locality: Waco) but the type seems indistinguishable from the summer form of southeastern *gryneus*. Our *gryneus* is associated both with *Juniperus silvicola* (Small) Bailey and with *J. ashei* Buchh. in lowland sites, perhaps favoring hybrid stands of these species.

¹³ Our other species of *C. (Mitoura)* is associated with the upland phenotype of *J. ashei* which resembles *J. monticola* Martinez. Specimens were compared with the type series of *C. sweadneri* with which our winter brood is in close agreement. One specimen of our summer brood at Carnegie Museum (Austin, an old collection, possibly by C. T. Brues or J. F. McClendon) was placed under *C. siva* which it superficially resembles. K. Johnson (1978, J. Lepid. Soc., 32: 3-19) has not recognized three taxa in Central Texas.

¹⁴ *Incisalia henrici* var. *solatus* Cook & Watson (type locality: Blanco Co., Texas) originally proposed as a "geographic variety" and formally accorded subspecific status by W. Barnes & J. H. McDunnough (1917, Checklist of the Lepidoptera of Boreal America, Decatur, Ill.) is here broadly sympatric, and often syntopic and synchronic with *C. henrici turneri* (Clench, 1943). The former normally utilizes buds, flowers and early pods of *Sophora secundiflora* as larval food, but when these are destroyed by late frost, it shifts to *Diospyros texanum*; the latter utilizes flowers and fruit of *Cercis canadensis* as larval food, with populations in Llano and Burnet Co. using *Lupinus texensis* Hook. Specific distinction is inferred from these differences and the lack of clearly intermediate individuals.

¹⁵ As well as obviously seasonal variation, a suite of apparently genetically determined phenotypes occurs in our area. The most frequent of these is identified as *S. m. franki* (type locality: Lawrence, Kansas), and the next most frequent as *S. m. melinus* (type locality: coastal Georgia). The former is associated with drier and prairie sites; the latter with streamside herbaceous stands, particularly with *Hypericum* sp.

¹⁶ H. K. Clench (1966, J. Lepid. Soc., 20: 65-66) is followed for treatment of our material. There is still not enough west Mexico topotypical material to resolve the need or not for recognition of *Callicista laceyi* Barnes & McDunnough, 1910 as eastern subspecies, queried by Clench.

¹⁷ The correct name for this entity, formerly known as *Argus pseudargiolus* Boisduval & LeConte, 1833 has been clarified by H. K. Clench & L. D. Miller (1980, J. Lepid. Soc., 34: 103-119) who resurrect the same opinion of A. G. Butler (1900, Canadian Entom., 32: 91).

¹⁸ This entity is not a subspecies of *E. comyntas* which also occurs this far and farther south. It is probably conspecific with *E. herri* (Grinnell, 1901) but not with *E. amyntula* (Boisduval, 1852) but this remains to be properly demonstrated.

¹⁹ The correct name for this entity is uncertain. Edwards (1877, Trans. American Entomol. Soc., 6: 10) was probably correct in considering Arizona material conspecific with *P. americanus* Kollar, 1850. *P. coloro* Wright, 1906 may refer to the California subspecies currently called *P. rudkini* J. A. Comstock, 1935. All material seen from east of the continental divide and north of latitude 30° is of *f. clarki*. *P. americanus stabilis* Rothschild & Jordan, 1906, which more closely resembles *P. coloro*, ranges north from eastern Mexico to Bexar and Comal Co.'s. in Texas. Brown's (1942) *f. pseudoamericanus* is an aberrant *P. polyxenes asterius* quite unrelated to the entity in question.

²⁰ These three *Libytheana* taxa have been frequently confused (e.g., Howe, 1975, loc. cit.: 258, pl. 47, f. 14, 15,

presents *L. bachmanni larvata* as *L. carinenta mexicana*). Heitzman & Heitzman (1972, J. Res. Lepid., 10: 284) give good figures for determination of the North American mainland species.

²¹ Thorne (1971, J. Res. Lepid., 9: 101) is followed in treatment of the *P. coenia* complex and all males were genitally determined. Work by Clench, continued by Harvey suggests that *P. evarete* (Cramer, 1780) is an additional species distinct from our three. Infrequent intermediates between *P. g. genoveva* and *P. g. zonalis* suggest conspecificity; *genoveva* occurs south of, and *zonalis* east of our area. De Lesse (1952, Bull. Soc. Ent. France, 57: 74) is followed in recognition of *Junonia* but only at the subgeneric level.

²² By genitalia and venation *L. bredowii eulalia* is close to the type species of *Limenitis*, *L. populi* (Linné, 1758). As demonstrated by G. D. H. Carpenter & B. M. Hobby (1944, Trans. Royal Entomol. Soc. London, 94: 311-346) it is not an *Adelpha*, that genus being closer to *Parthenos*. Species related to *L. astyanax* (Fabricius, 1775) have been separated generically from *L. bredowii* (e.g., dos Passos, 1964, Lepid. Soc. Mem. 1) but the available name *Basilarchia* Scudder, 1872 is here used subgenerically.

²³ *L. a. archippus* is the plains and northeastern subspecies which ranges south to the Rio Grande in West Texas. *L. a. watsoni* is the Gulf Coast subspecies which ranges west to the Rio Grande, meeting *archippus* in Travis and Zapata Co's. Here populations of one or the other wax and wane with little intergradation.

²⁴ *Neonympha* Hübner, 1818: 8 (type species: *Papilio areolatus* Abbot in Smith, 1797) is senior by page to *Euptychia* Hübner, 1818: 20 (type species: *E. mollina* Hübner, 1818). W. Forster (1964, Veröffentlichungen der Zoologischen Staatssammlung, München, 8: 88-89) is followed in specific distinction of *hermes* and *sosybius*, although his genus *Hermeuptychia* seems no more than subgenerically distinct from *Neonympha*.

²⁵ C. Talbot (1928, Bull. Hill. Museum, 2: 195) pointed out that *Papilio monuste* Linné, with which our species has been identified, is actually *Udaina cyenis* Hewitson. *Papilio phileta* Fabricius, 1775 is the oldest available name.

²⁶ The entities *lysida*, *terissa*, and *fantasia* have geographically recognizable ranges that overlap only in northeast Mexico and Texas, and then only during migration. N. D. Riley (1972, J. Lepid. Soc., 26: 228) determined that *Papilio castalia* Fabricius, 1793 is a junior synonym of *P. drusilla* Cramer, 1777, and the entity that has been known as *castalia* (e.g., J. L. de la Torre y Callejas, 1958, Univ. de Oriente (Cuba), Dept. Ext. y Relac. Cult., 42: 24) should be referred to the appropriate senior available name, *Gonepteryx terissa* Lucas, 1852.

²⁷ Holland (1932, The Butterfly Book. New York) figures a male of this entity (pl. 37, f. 5). L. Harris (1972, Butterflies of Georgia. Norman, Oklahoma) reports three collections from Georgia, including three males and two females. Originally described as a species, in recent usage (e.g., C. P. Kimball, 1965, Lepidoptera of Florida. Gainesville) this name has been erroneously applied to the light var. of the orange female from which the true *flava* may be distinguished by the cold yellow tone resembling *E. boisduvaliana* Felder & Felder, 1865 with which it may be confused on the wing.

²⁸ Some years *eubule*, *sennae*, and *marcellina* are all absent. In other years a combination of one to rarely three are present. The low frequency of intermediates between *eubule* and the other two denies a clinal relationship and may ultimately prove specific distinction.

Faunal history. Micropaleontological studies in progress indicate that in this region, pluvial and interpluvial climates were out of phase with glacial and interglacial climates of the north. River terrace deposits (largely gravel) appear to represent interpluvial time. They were deposited when sea level stood higher than today and river gradients were adjusted upward. Accumulation took place during infrequent severe storms in a period of semiarid climate during later interglacial and early glacial times. Interpluvial times appear to have occupied much more of the Pleistocene Epoch than did pluvial times. The former were times of plains and desert communities in our area and of isolation of relict pockets of woodland biota. Pluvial times were brief episodes of dispersal between relict woodlands and influx of Sierra Madre montane and eastern deciduous forest elements during cool pluvial time, and tropical forest elements during warm pluvial time. Periodic colonists are of course in a state of flux, dependent upon minor climatic fluctuations of the recent past. Our resident species may be analyzed in terms of a tentative schedule of late Pleistocene episodes based on data published for Hershop, North Soefje, and Rutledge Bogs in Gonzales Co., Boriack and Patschke Bogs in Lee Co., South Gause and North Gause Bogs in Milam Co., and Franklin Marsh in Robertson Co. (Durden, 1979).

For the last 4000 years our regional fauna has probably been much the same as present under moderate and dry climate with reduction of periodic colonists from the south during the "Little Ice Age". From 6000 to 4000 years ago the climate was moderate and not quite so dry. A few periodic colonists may have assumed resident status. From 8000 to 6000 years ago the climate was moderate and nearly as dry as present, with presumably almost the same fauna. From 9200 to 8000 years ago the climate was moderate and moist, with probable resident status for a few of our southern and eastern periodics. From 9700 to 9200 years ago the climate appears to have been hot and dry. The Austin regional fauna at this time probably resembled that of the lower Rio Grande Valley with 270 or more species of butterflies. Our relict populations of species with Tamaulipan (Durdin, 1974) affinities probably date from this time. These include *Systasea pulverulenta*, *Ancyloxipha arene*, *Apodemia mormo mejicana*, *Strymon alea*, *Thessalia theona bollii*, *Texola elada ulrica*, *Phyciodes vesta*, *Asterocampa louisa*, and *Neonympha hermes*. The Travis Co. (Turkey Bend) population of *Papilio rudkini* f. "clarki" probably arrived from the Chihuahuan and Sonoran Deserts at the same time. From 11,500 to 9700 years ago the climate was warm and arid, and some of the previously mentioned species may have established residency this early. From 12,800 to 11,500 years ago the climate was cooler than the present and dry. Our resident species of Gulf Coastal prairie and savanna distribution probably date from this episode. These include *Thorybes confusus*, *T. bathyllus*, *Erynnis zarucco*, *Hesperia meskei*, *Atrytone arogos arogos*, *Amblyscirtes alternata* and *Cyllopsis gemma gemma*. Species of Great Plains distribution probably date largely from this time also. These include *Pholisora catullus*, *Copaeodes aurantiaca*, *Hesperia viridis*, *H. attalus*, *Atrytone arogos iowa*, *A. delaware lagus*, *Amblyscirtes nysa*, *A. eos*, *Phaeostrymon alcestis*, *Strymon melinus franki*, and *Brephidium exilis exilis*. From 14,000 to 12,800 years ago the climate was warm and very wet. We appear to have no tropical species surviving here from this episode, but some of the Gulf Coast swamp-woodland species may go back this far. These include *Syrichtus oileus*, *Strymon melinus melinus*, *Limenitis archippus watsoni*, *Asterocampa celtis alicia*, and *Eurema nicippe flava*. At this time dwarf palmetto reached Barton Creek where it is now disjunct some 100 km from the nearest Coastal Plain stand down river. From 15,000 to 14,000 years ago the climate was moderate and wet. From 16,000 to 15,000 years ago and possibly as early as 22,000 years ago the climate was cool and moist. This appears to be the episode from which date both our relicts of Virginian distribution and of Sierra Madre montane

distribution. The former include *Thorybes pylades*, *Erynnis meridianus*, *E. juvenalis juvenalis*, *E. martialis*, *E. baptisiae*, *Ancyloxipha numitor*, *Polites themistocles*, *Poanes viator*, *Feniseca tarquinius*, *Satyrium calanus falacer*, *Callophrys gryneus auburniana*, *C. henrici turneri*, *Panhiades m-album*, *Celastrina ladon*, *Pterourus troilus*, *P. glaucus*, *Polygonia comma*, *Chlosyne nycteis*, *Limenitis astyanax*, *Neonympha sosybius* and *Anthocharis midea annickae*. The latter include *Epargyreus clarus* subsp., *Achalarus coyote*, *Cogia outis*, *Gesta invisus llano*, *Hesperia woodgatei* subsp., *Amblyscirtes aenus*, *A. erna*, *A. celia*, *Calephelis guadeloupe*, *C. sinaloensis nuevoleon*, *Callophrys sweadneri* subsp., *C. solatus*, *Pterourus multicaudatus*, *Nymphalis antiopa lintneri*, *Siproeta stelenes biplagiata*, *Phyciodes tharos distincta* and *Eurema mexicana*. However, many of these appear to have persisted in our area over several interglacials, as have such species of similar affinities as *Megathymus coloradensis kendalli*, *M. c. reinthali*, *Hesperia licinus*, *Calephelis nemesis australis*, *C. perditalis* and *Everes texana*. Before 22,000 years ago there appear to have been long episodes of climate much cooler than present and rather arid. Some of our species of Great Plains affinities may go back this far, but the only one that certainly dates from this time is the Blanco Co. (Round Mountain) population of *Erynnis burgessi*. Our fauna at that early and mid-glacial time must have been impoverished, resembling that of the Davis or Guadalupe Mountains with their montane endemic elements represented by our own canyon relicts.

The butterfly fauna of the Austin area is the result of opportunistic colonization under each changed climate, with the persistence of relict populations in reduced habitats through subsequent unfavorable climatic episodes. Our endemic taxa, most of which are shared with the mountains of northern Coahuila, Mexico, are the few lineages that have persisted through much of the Pleistocene and probably longer. The community to which they belong includes relict plants such as *Berberis swaseyi* Buckl. which find their roots in the Oligocene biota of Florissant, Colorado.

Potentially threatened or endangered taxa. None of the species that occur in the study area appear to be threatened by normal collecting for scientific or recreational purposes. The greatest hazard to all species of exacting habitat requirements is destruction of habitat. One of the six known stations for *Calephelis sinaloensis nuevoleon* in the United States is now an apartment complex and parking lot with no butterflies. This species with only two known additional stations in Mexico should be watched closely. The study site on Barton Creek is a protected station that should be preserved by non-development of the brush and chaparral where *Eupatorium hava-*

nense, the presumed larval food plant, grows. *Bernardia myricaefolia*, the larval foodplant of *Strymon alea*, is equally vulnerable to habitat destruction. The grassland species, *Hesperia woodgatei* and *Everes texana*, are susceptible to loss of foodplant through grazing. One colony of the latter in Travis Co. (Bull Creek) is gone through overgrazing by horses.

ACKNOWLEDGMENTS

This project was stimulated by work with Harry Clench at Powdermill Nature Reserve of Carnegie Museum from 1965 to 1968. Harry was responsible for addition of a species to this list during a visit in 1972 (*Artogeia rapae!*). Lawrence E. Gilbert, Raymond Neck, Roy O. Kendall, William W. McGuire, Pete Hord, and Donald J. Harvey have provided information and field company on occasion. Determinations, habitats and ranges were discussed with all these colleagues but the data presented here is the sole responsibility of the author. Systematic descriptions are in preparation for a few new taxa indicated but not named here. A phenography or calendar of adult flight times will be published shortly at Texas Memorial Museum.

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EPILOGUE. Since May 1980 *Thessalia theona* has been taken at the study site and *Pterourus palamedes* (Drury, 1770) has been seen in Austin, raising the known local fauna to 128 species and the regional fauna to 173 species. Development adjacent to the study site has caused silting of the waterholes, massive bacterial contamination of the springs, and loss of cliff habitat replaced by condominium projects.

THE LARVA AND STATUS OF *CATOCALA PRETIOSA*
(NOCTUIDAE), WITH DESIGNATION OF
A LECTOTYPE

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ABSTRACT. A lectotype is designated and illustrated for *Catocala pretiosa* Lintner (1876) and the larva is described, illustrated, and compared with that of related species. The status of this taxon as distinct from *C. mira* Grote and *C. crataegi* Saunders is confirmed. However, its relationship to *C. texarkana* Brower (1976) is unresolved. The known present and former range of *C. pretiosa* is documented. Larvae were reared on *Prunus maritima*, a likely foodplant in New Jersey. However, no larvae could be located in the field.

Catocala pretiosa Lintner (1876) was described from "three examples . . . captured by me at sugar, at Schenectady, N.Y., last year." Dates given are 8 and 10 July (males), 16 July (female). The New York State Museum (NYSM) has a male in its type collection (as of December 1979) with three labels: 1) "Schenectady, N.Y. July 10, 1874. Lintner Coll."; 2) "pretiosa Lintner 3966 ♂"; 3) "J. A. Lintner collection." An enlarged photograph of the labels shows that the first printed label originally read 1875 but that a 4 was written in ink over the 5. The U.S. National Museum also has two specimens with the same locality and collector dated 15 July 1874 (female) and 8 July 1875 (male). These labels are printed in the same style as that on the "type" and the 4 on the female's label is similarly written over a printed 5.

It is quite possible that the manuscript was written in 1875 and that "last year" referred to 1874. It is also possible that Lintner was mistaken about the years. At any rate, there can be virtually no doubt that the above NYSM specimen was among Lintner's three specimens. Unfortunately, no mention of any types is made in the original description. McCabe & Johnson (1980) listed this specimen as a syntype. I hereby designate this specimen, illustrated in Fig. 3, as Lectotype for *Catocala pretiosa* Lintner and will have an appropriate label affixed.

Catocala pretiosa Lintner has remained a little known taxon since its description. Some authors (e.g., Barnes & McDunnough, 1918) have treated it as a form of *C. crataegi* Saunders. Forbes (1954) treated it as a species. Sargent (1976) reached no definite conclusion regarding its status. One of the major problems faced by taxonomists has been a shortage of specimens, especially recent ones. Quite a few old specimens lack data.

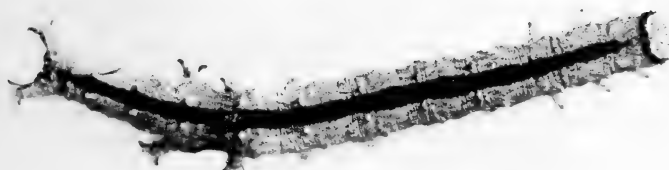


FIG. 1. Mature larva (dorsal) of *Catocala pretiosa*, ex ovis Cape May, New Jersey, reared on *Prunus maritima* May-June 1978 by D. F. Schweitzer (2.54 \times). Larva at YPM.

Based on material that I have seen and the literature (e.g., Sargent, 1976; Brower, 1974), this species seems to have formerly been widely distributed in the northeastern United States, though it may have been partial to coastal areas (e.g., Stonington, Connecticut and Kittery, Maine) and sandy areas [e.g., the Merrimack River Valley in New Hampshire and the Albany-Schenectady (Centre), New York "Pine Bush"]. Bailey's account (1877) suggests it was locally common at Centre, New York. Despite this, nothing has been published regarding its life history or foodplant; so, the following description is presented. About 13 late instar larvae reared from two females, both from Cape May, New Jersey taken in 1977 and 1978, were examined.

Description of Early Life Stages

Penultimate and ultimate instar larvae. As illustrated (Figs. 1, 2), dorsum pale gray and bold mid-dorsal stripe. Stripe, brown with thin darker, almost black, edges which do not include tubercles I or II. Facial stripe, black. Other dorsal markings, nearly untraceable. "Saddle" with faint light brown shading extending ventrad to tops of third and fourth prolegs. Venter whitish with very dark brown patches as shown. Dorsal horn present, brown. Dorsal ground color close to that in the black and white photograph in Fig. 1.

Earlier instars. Ground color darker, with usual pattern more visible, middorsal stripe not darkened but with fragments of darker edging.

Egg. Typical for the group, quite flat and rather circular.

First, last and two intermediate instar larvae; eggs and pupal shells are preserved at Peabody Museum. Reared moths are in that collection and the author's.



FIG. 2. Same larva as Fig. 1 clinging to edge of glass showing ventral markings.

Foodplant

The larvae were reared on *Prunus maritima*, but the natural foodplant has not been established. *Crataegus* sp. (?*crus-galli*) was also accepted by hatchlings. *Prunus maritima* is abundant at the Cape May locality and is present at sites of recent captures of *C. pretiosa* at Atsion and Batsto, Burlington Co., New Jersey by myself and John Nordin. It does not occur at the immediate locality near Eldora, Cape May Co., New Jersey where a number of recent captures were made by Joseph Muller. *P. maritima* could not have been the host of the former inland *C. pretiosa* populations in New Hampshire and New York. Extensive searching and beating (including nocturnally) of *P. maritima* thickets on 7 and 20 May 1979 and 1 June 1980 at Batsto and Atsion failed to produce *C. pretiosa* larvae, although last and earlier instar *Catocala ultronia* Hübner larvae were found on both 1979 dates. The few known *Crataegus uniflora* plants at Batsto were also checked in 1979. *Prunus serotina* is the only rosaceous tree or shrub known to be present at all New Jersey sites where *C. pretiosa* has been taken. *Crataegus* is scarce to absent at all such sites and in the New Jersey Pine Barrens region generally. *Amelanchier* and *Pyrus* (*Aronia*) spp. are frequent in this region.

Taxonomic Status

The notes on the larva of *C. crataegi* given by Forbes (1954) and the larval illustrations given by Barnes & McDunnough (1918) agree



FIG. 3. Lectotype *Catocala pretiosa* Lintner "Schenectady, N.Y. July 10, 1874. Lintner Coll." "pretiosa Lintner 3966 ♂" "J. A. Lintner Collection" (New York State Museum).

well with each other and with Saunders' (1876) original description. *C. pretiosa* differs in several aspects. *C. pretiosa* has a pale gray ground color; *C. crataegi* is decidedly brown. *Catocala crataegi* has a very different head capsule, featuring extensive brown mottling and a darkened face. *C. pretiosa* also lacks red or orange in the face which Saunders (1876) reports for *C. crataegi*. *C. pretiosa* also lacks orange on the tubercles and has a prominent brown line (not dots) on segment 11 (not 12 as Saunders states). The horn is not red in *C. pretiosa*, and there are no green or blue hues ventrally, and the spiracles are dark. *C. crataegi* apparently does not have a form with a dark dorsal stripe.

The alcohol preserved larva described as *C. crataegi* by Crumb (1956) appears to differ considerably from the above larvae and may be *C. mira* Grote. *C. pretiosa* differs from it on at least the following points: The dark granules are not more prominent on the thorax than on the abdomen; the middorsal stripe is dark brown, not pale, and its black border is quite prominent. The black U-mark on the face is not broken above seta A³. The adfrontal markings are very fine.

The larva of *C. mira* reportedly has a long twisted horn (Barnes &

McDunnough, 1918). I have collected such a larva in Connecticut (on *Pyrus Xpurpurea*); but several dozen known *C. mira* which I have seen from Florida had smaller untwisted horns as does Crumb's (1956) larva.

The larva of *C. pretiosa* differs from Crumb's (1956) *C. mira* larva from Iowa on at least the following points: The middorsal stripe is dark; tubercles are not orange; spiracles are dark brown, not white; the head has little pattern aside from the U-mark, and no brown or protuberances. It differs from six *C. mira* larvae from Liberty Co., Florida (leg. H. D. Baggett & D. F. Schweitzer in YPM) in several details as well, including: the lack of protuberances on the face, which is also much less brown and paler on *C. pretiosa*; the lack of weakly defined transverse bands of brown flecks dorsally on the thoracic and first two abdominal segments; the less prominent brown on the saddle mark behind the horn; and the lack of orange on the tubercles.

H. D. Baggett and colleagues have reared a number of *C. texarkana* Brower (most det. A. E. Brower) from larvae collected on *Crataegus* at Torreya State Park, Liberty Co., Florida from 1978 to 1980 (Fig. 9). I have examined photographs of larvae believed to be *C. texarkana* and they are similar to *C. pretiosa*. *C. texarkana* occasionally lacks the dark dorsal stripe and *C. mira* occasionally has such a stripe (H. D. Baggett, pers. comm. 1980, 1981). *C. texarkana* and *C. mira* feed together on *Crataegus* in April at Torreya State Park. *C. mira*, at least, also occurs there on wild plum (*Prunus angustifolia*) (reared by author, at YPM).

I have reared three broods of *Catocala blandula* larvae from Connecticut and one from Lebanon, New Jersey, and these were similarly dimorphic. These larvae differed from *C. pretiosa* in their lack of an abdominal horn and in having somewhat more dark mottling. *C. pretiosa* thus may prove to have an unstriped form.

Catocala pretiosa adults differ from *C. crataegi* on a number of characters. *C. pretiosa* has a paler median area of the forewing, with the reniform much more conspicuously ringed with bright white. There is little or no darkening of the forewing inner margin of *C. pretiosa*, and little or no brown beyond the postmedian line on the forewing of *C. crataegi*. *C. pretiosa* has a deeper orange hindwing than *C. crataegi*. The pale median area can be used to separate both of these species from *C. mira*. The hindwing color of *C. mira* is like that of *C. pretiosa*. For further descriptions and color figures of this group see Forbes (1954), Sargent (1976) and Barnes & McDunnough (1918).

Theodore Sargent has suggested to me that the present New Jersey



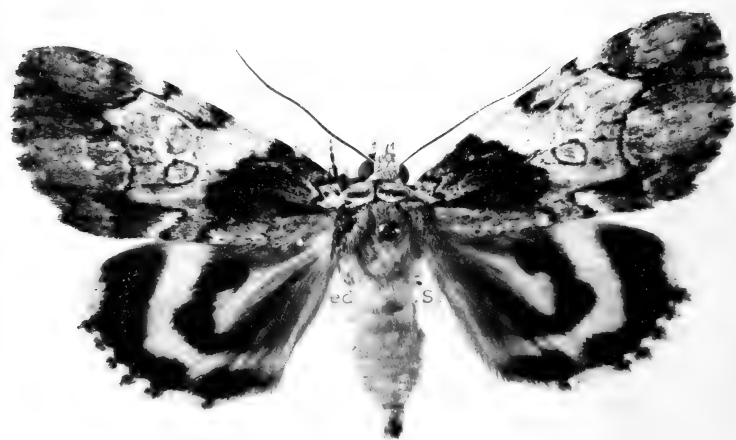
FIG. 4. *Catocala pretiosa* ♀, Schenectady, N.Y., 17 July 1877, J. A. Lintner coll. (NYSM).

population (Figs. 5, 6) might not be the same as the original *C. pretiosa* of Lintner. Indeed my Batsto, New Jersey specimen that Sargent illustrated (1976, p. 67, B) is not typical of *C. pretiosa*. It differs most obviously in having the dark basal area on the forewing extending to the inner margin. However, this specimen appears to be atypical of the New Jersey population now that adequate material has been examined. Most of the recent southern New Jersey specimens appear to me to match Lintner's description, the lectotype and old New England material quite closely.

The forewing black area appears to be paler and browner on five of the seven old specimens I have at hand than on recent New Jersey ones (14, 9 reared, at hand). However, other old *Catocala* I have examined are frequently similarly discolored because of fading.

Based on the above comparisons of larvae and the consistent differences in adult wing characters, I conclude that *Catocala pretiosa* is not conspecific with *C. mira* or *C. crataegi*. *Catocala pretiosa* is thus restored to its original status as a full species.

Separation of *Catocala texarkana* from *C. pretiosa* is extremely difficult. At present, some specimens cannot be determined with certainty. The original description of *C. texarkana* does not contain ex-



FIGS. 5, 6. *Catocala pretiosa* ♂, ♀; siblings to larva in Figs. 1 & 2, eclosed 21, 27 June 1978. (In author's collection.)



FIG. 7. *Catocala ?texarkana* ♂; Chapel Hill, North Carolina, 12 June 1974, leg. Chas. C. Horton (in T. D. Sargent collection).

plicit comparisons with related taxa, and I can find no constant differences between these two taxa. However, several characters will work for most specimens.

Many *C. texarkana* var. "bridwelli" have the inner margin conspicuously darkened in the median area as noted by Brower; almost all other specimens have some vague darkening of this region. *C. pretiosa* typically has only a few scattered dark scales, and no northern specimens have this conspicuous dark median shade. Sargent (1976, p. 67, B, C) illustrates specimens showing both extremes for northern *C. pretiosa*.

Typical *C. texarkana* has almost no black in the basal part of the forewing. A large *C. pretiosa* ♀ from Sherborn, Massachusetts is essentially a perfect match for three such topotypical specimens of *C. texarkana* (YPM, Bryant Mather colls.). Most other *C. pretiosa* have extensive basal black or at least a mixture of brown and black scales (but see Fig. 4). *C. texarkana* form "bridwelli" also has extensive basal black.

The basal black of *C. pretiosa* stops abruptly at the anal vein as noted by Forbes (1954) but may continue (when present) to the inner margin in *C. texarkana*. The lone exception among *C. pretiosa* seen is my Batsto, Jersey ♂ illustrated by Sargent (1976, p. 67, B).



FIG. 8. *Catocala ?texarkana* ♀; Fontana Dam, Graham Co. North Carolina, 1200–1800 feet, 8 July 1972, leg. D. F. Schweitzer (in author's collection).

Most *C. pretiosa* have less darkening beyond the reniform than is present on *C. texarkana*.

There apparently is some geographical variation in *C. texarkana*. Three Florida specimens and photographs of three others before me are all variety "bridwelli," and all have a prominently dark inner margin. Several other Florida specimens shown to me by H. D. Baggett were also "bridwelli." This is apparently a minority form at the type locality (Brower, 1976).

I have at hand a ♂ from Chapel Hill (cited as *C. pretiosa* by Sargent, 1976) and a pair from Fontana Dam, North Carolina. Two of these are illustrated (Figs. 7, 8). The Fontana ♂ could pass for a rubbed *C. pretiosa* but has some of the median dark scaling at the inner margin. The female collected with it (Fig. 8) has a strongly darkened inner margin and the brightest white median area I have seen on either taxon. These three have less subapical brown shading in the post median gray than on any *C. texarkana* (three photographs, seven specimens) before me now—a trait shared by most *C. pretiosa*. Two of these also have less darkening beyond the reniform than is typical of either species, but some *C. pretiosa* agree closely. I see no point in placing allegedly certain names on them now.

The specimens listed below from Virginia, Tennessee and Ohio all



FIG. 9. *Catocala texarkana*, dwarfed ♂; Torreya State Park, Liberty Co. Florida, ex larva on *Crataegus*, eclosed 27 April 1978, leg. H. D. Baggett (in author's collection).

have slightly more dark scales in the median white at the inner margin than more northeastern specimens. However, none has a solid dark inner marginal shade. These approach my Fontana ♂ (above). I can see no reason not to regard these specimens as *C. pretiosa*, despite this trivial difference. Texas, Florida, and North Carolina populations apparently are all composed largely of specimens that deviate more noticeably from northern *C. pretiosa*.

More material from the southern Appalachians and other poorly collected southern regions is needed. Until such specimens are available, the prudent course seems to be to treat the names in this group as proposed by their authors. Specimens from the Northeast can confidently be placed as *C. pretiosa*. Those from Ohio, Virginia, and eastern Tennessee appear almost identical. Populations in the Gulf Coast States appear to be *C. texarkana*. Specimens from North Carolina are, at present, unplaceable.

Distribution

There is little chance that *Catocala pretiosa* occurs in upstate New York or New England at present. There have been no captures in those areas for at least 40, and probably 80, years despite fairly intense collecting. It has not been taken recently at Albany despite substantial



FIG. 10. *Catocala texarkana* ♀; Torreya State Park, Liberty Co. Florida, 28 May 1978, leg. D. D. Baggett (YPM).

collecting by myself, T. L. McCabe, John Cryan and others. It also seems very likely that the species was formerly absent in southern New Jersey where it is now widespread and not rare. Lakehurst, New Jersey is one of the most intensively collected places in North America and has been studied from before 1900 into the early 1970's, and *C. pretiosa* has not been taken there. The area is very similar to Atsion and Batsto, and *Prunus maritima* is frequent. Smith (1899, 1910) gives no southern New Jersey records for *C. pretiosa*. I have seen none in collections taken prior to 1968. Smith (1899) records *C. crataegi* from New Jersey near New York City, and states "The variety *pretiosa* Lint., has also been taken in the state."

The first record in southern New Jersey appears to be Joseph Muller's capture of three specimens at Cape May on 28 June 1968; subsequent captures have been from 1972 to 1981 at Atsion, Batsto, Elmer and Eldora by John Nordin, myself, the Rutgers University staff and Muller. The date range is 23 June to 16 July. I visited the exact Cape May locality in 1977 and 1978 and collected the species on each of three nights. The moths have been taken mostly at sugar baits.

I have not attempted to catalog all records of *C. pretiosa*. However, during a visit to the U.S. National Museum (USNM) in July 1980, I recorded all specimens that seemed to be this species. These records,

plus the others given below, probably give a reasonable indication of the range of this species in the past. All recent records known to me are discussed above. All specimens recorded below were examined by me in 1979, 1980, or 1981 except as noted.

NEW HAMPSHIRE: Milford, 10 July 1877, *ex coll.* C. P. Whitney, det. Lintner as typical *pretiosa* (not seen by me, record courtesy of Richard E. Gray, Montshire Museum, Hanover, N.H.); Manchester (figured by Sargent, 1976, Pl. 8, Fig. 4; moth now at MCZ, Harvard U.). NEW YORK: Schenectady, July 10, 1874, Lintner coll., herein designated Lectotype (New York State Museum); Schenectady, July 15, 1974 and July 8, 1875 (USNM); July 17, 1877 (NYSM) (all four *ex* Lintner coll.); Albany, July 4, 1877 S. C. Waterman collector, *ex* Wm. W. Hill coll. (NYSM); Centre, July 1877, *ex* Oberthur coll. (USNM); Centre July 5, 1877 *ex* Oberthur & Barnes colls. (USNM); "Lint. N.Y." (certainly Albany-Schenectady region *leg.* Joseph Lintner) (USNM); "coll. J. Angus, West Farms, New York City" (which may be merely an address label) (2 at Rutgers University and one, USNM); Duchess Co., 14 and 16 August (2, E. L. Quinter coll.); no specific locality *ex* Barnes coll. (USNM). MASSACHUSETTS: Sherborn, July *ex* E. J. Smith coll. (Yale Peabody Museum = YPM). CONNECTICUT: Stonington, 29 June 1898 *ex* H. P. Wilhelm coll. (YPM, illustrated by Sargent, 1976, p. 67); no specific locality *ex* Barnes coll. (USNM); Ely coll. (no data, not definitely Connecticut, but very likely from East River, YPM); two with no data but believed to be from Connecticut, before 1940 *ex* John Reichert coll. (YPM). NEW JERSEY: no other data, "Col. B. Neumogen," *ex* Brooklyn Museum coll. (USNM); no specific locality July '83 *ex* J. B. Smith coll. (USNM); also Atsion, Batsto, Eldora, Elmer and Cape May, 1968-1980 (see above). PENNSYLVANIA: no specific locality, 10-6-96, *ex* Oberthur coll. (USNM). MARYLAND: no specific localities *ex* E. A. Smyth, Wm. Schaus & Edw. T. Owen colls. (USNM). OHIO: Columbus, W. N. Tallant coll., second label Edw. T. Owen coll. (3, USNM); no specific locality, *ex* Wm. Schaus coll. (USNM). VIRGINIA: Montgomery Co., 1947, E. A. Smyth coll. (USNM). TENNESSEE: Norris Park, 27 May 1938 (2, J. W. Cadbury coll.); no locality, "Teneese" *ex* Dodge coll. (YPM); no specific localities 5. 22, 27, 27, 28, all *ex* Barnes coll. (USNM).

Except for the southern New Jersey specimens, the records all appear to represent very old specimens; the 1947 Virginia record is doubtless the most recent. *Catocala pretiosa* quite clearly was more frequent, at least northward, in the past than it is today. The Virginia specimen is probably the most northern capture between about 1920 and 1968.

Specimens seen from Tennessee, Virginia and Ohio differ from most of the others in having slightly more dark shading along the forewing inner margin, and some are somewhat browner (faded?) and larger. These specimens might be *Catocala texarkana*, but as noted above, I tentatively regard them as *C. pretiosa*. All specimens from Texas to Florida (see Figs. 8, 10) are presumably *C. texarkana*.

Northern specimens should be easily identifiable, and at present *C. pretiosa* does not appear to be sympatric with either *C. mira* or *C. crataegi*. In New Jersey, *C. pretiosa* seems to be confined to the southern, coastal plain counties. I have one *C. mira* from this region (New Lisbon, 1972). Otherwise, *C. mira* and *C. crataegi* seem limited to the hilly northern counties. *C. mira* ranges from at least Massachu-

setts to Florida and west through much of the Midwest. *C. crataegi* is decidedly northern, reaching southward to Hamden, Connecticut; Lebanon, Hunterdon Co., New Jersey (J. Muller); Schuylkill Co., Pennsylvania (E. L. Quinter); Chicago, Illinois (Crumb, 1956) and Louisiana, Missouri (USNM). I have seen the specimens cited by Kimball (1965) from Florida (USNM, AMNH) and these are similar to Baggett's specimens of *C. texarkana* "bridwelli." I have not seen *C. crataegi* from the southern Appalachians.

If *C. texarkana* is in fact a good species and if the recent North Carolina specimens are *C. texarkana*, then southern New Jersey may be the last stronghold for *C. pretiosa*. However, this population seems to be of very recent origin, and perhaps other populations are still extant. This species should be looked for in the hard pine areas of eastern Maryland and southern Delaware. The prospects for long term survival of the species in southern New Jersey appear good if the foodplant is something common like *Prunus maritima*, which grows on coastal dunes and on disturbed sites and edges of woods in the Pine Barrens.

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AGGREGATION BEHAVIOR IN BALTIMORE CHECKERSPOT
CATERPILLARS, *EUPHYDRYAS PHAETON*
(NYMPHALIDAE)

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ABSTRACT. The aggregation behavior of early instars, overwintering fourth instars, and late instars of *Euphydryas phaeton* Drury was examined in natural populations. Activity outside the webs increased as larvae progressed through the first three instars. Mortality at diapause in late summer was 46 to 64% per web. The mean size of overwintering larval groups was one-fifth that of mean group size at diapause, as a consequence of mortality and group subdivision and separation. Mortality of overwintering larvae was 18 to 53%. Post-diapause instars were gregarious, until just prior to pupation.

The size of a group of animals can influence the fitness of an individual for a variety of reasons, such as improved thermoregulation, feeding facilitation, and effective defensive mechanisms (Allee et al., 1949; Alexander, 1974; Wilson, 1975; Morse, 1977; Bertram, 1978; Stamp, 1980a). In contrast to the larvae of most butterflies, the caterpillars of the Baltimore checkerspot aggregate in all instars. These larvae are conspicuous with their communal webs in mid-summer and their coloration and aggregated behavior in the spring. Information on larval aggregation behavior of *E. phaeton* has been largely descriptive. My objectives were to quantify the larval aggregation tendencies of early instars, overwintering fourth instars, and late instars of *E. phaeton* and to identify factors contributing to aggregation behavior.

METHODS

I observed *E. phaeton* from 1977 through 1979 at the Conservation and Research Center of the National Zoological Park at Front Royal, Warren Co., Virginia. Turtlehead (*Chelone glabra* L.: Scrophulariaceae), the larval host plant, grew there in dense patches in wet meadows. This host plant is a clonal, perennial; thus, each plant group consisted of numerous stalks.

Eggs and Early Instars

Egg clusters were located on turtlehead, and these host plant stalks were tagged. To determine the mean number of eggs per cluster, I collected and counted the eggs of 32 and 35 new clusters in 1977 and 1978, respectively.

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Twenty-one prediapause larval aggregations were observed at 1000, 1200, 1400 and 1600 h on three warm, sunny days in July to determine the numbers of larvae outside the webs. Webs were collected after larval diapause in August 1977, 1978, and 1979; 18, 37, and 10 webs, respectively.

Overwintering Fourth Instars

Fifteen plots 1 m apart were set up in late October 1978 to determine group size of overwintering fourth instars, which leave their webs in late fall to overwinter in plant litter on the ground (Bowers, 1978). To facilitate finding larvae, each plot consisted of a 1 × 1 m sheet of clear plastic on the ground. An eighth of a bale of hay was used for each plot. The hay was similar in amount and texture to the plant litter on the ground at this site. A web tied to a stake was placed in the center of each plot. To avoid damaging the webs, the number of larvae per web was not determined. However, the mean number of larvae per web was probably similar to that of the 1978 set of dissected webs ($n = 37$ webs, $\bar{x} = 110$ larvae ± 11 S.E.). By mid-November, after the caterpillars had moved from the webs into the hay, a few spines were marked of each caterpillar within a group, using a different color of Testor's enamel paint for each aggregation on a plot to monitor exchange of individuals among the groups over the winter. Preliminary tests indicated that the paint (primary and secondary colors) did not affect larval behavior. Larvae were checked in mid-November and mid-March to determine the number of groups, size of groups, and dispersal distance from the webs.

To determine the number of larvae surviving over the winter, I set up a second experiment with 30 boxes containing caterpillars in mid-October. Each clear plastic box (13 × 25 × 8 cm) had holes in the bottom, covered with window screen for drainage. Tanglefoot was sprayed on the upper sides of the box to prevent the caterpillars from leaving it. Dried grass in the boxes was similar in texture and depth to the plant litter on the ground in the study site. Fifteen boxes each contained 100 larvae and no cover, and another 15 boxes each had 100 larvae and a screen cover. Each box was held in place on the ground by four stakes. The surviving larvae were counted in mid-March.

Post-diapause Instars

To determine the aggregation behavior of late instars, three study sites were examined weekly from mid-April through mid-July in 1979. The number of larvae within one body length of each other (0.5 to 2

cm, depending on the instar) and the number of those greater than one body length from each other were recorded.

In June 1978 and 1979 the patches of turtlehead were mapped in two study sites. In both sites 3×3 m plots were divided into a hundred 30×30 cm squares. Plant groups were located within these squares. To determine the height of the turtlehead which was available in May, plant stalks were chosen by placing a rod through a plant group until 30 stalks were partitioned, and these stalks were measured. Because there were so few healthy plant groups during this period, only three plant groups were sampled.

To examine aggregation tendencies of late instars further, caterpillars were collected in mid-April and kept in cages ($25 \times 25 \times 76$ cm) in the laboratory at 23°C , 70% RH, and 16 h of light, approximating conditions in late spring. Ten larvae were placed in each cage with pots of snapdragon (*Antirrhinum* sp.: Scrophulariaceae). Snapdragon was chosen because turtlehead was rare in the study sites from April through May; snapdragon was easy to grow; *E. phaeton* larvae feed on other Scrophulariaceae in addition to turtlehead (Tietz, 1972); and they readily ate snapdragon. The first cage contained one plant about 25 cm in height, a second cage had two such plants, and a third had four plants. Five replicates were run. Observations of the larvae began 17 h after placing them in the cages and they were monitored at half-hour intervals for 3 h. Larvae within a body length (less than 1.5 cm) of each other were considered as aggregated. After the experiment, all of the larvae pupated; thus, it is unlikely that any behaved differently during the experiment due to unapparent parasitism. Furthermore, in the course of host-parasitoid studies (Stamp, 1980b, 1981b), I have not obtained tachinid flies, which are the major parasitoids emerging in the pupal stage of *E. phaeton*. If they occur in this *E. phaeton* population, they are rare.

RESULTS

Eggs and Early Instars

The mean number of eggs per cluster was 273.8 (± 23.1 S.D.; 95% confidence limits for a mean pooled for years). Of 42 aggregations of newly-hatched larvae, 95% moved to the top of the host plant stalk before feeding on the turtlehead.

Larvae fed from late June through early August on leaves enclosed within and adjacent to their communal webs. Larval activity outside the webs varied through the day (two-way ANOVA after square root transformation of count data, $P < .001$; with interaction between days and times of day, $P < .05$; Fig. 1). In July larval activity outside the

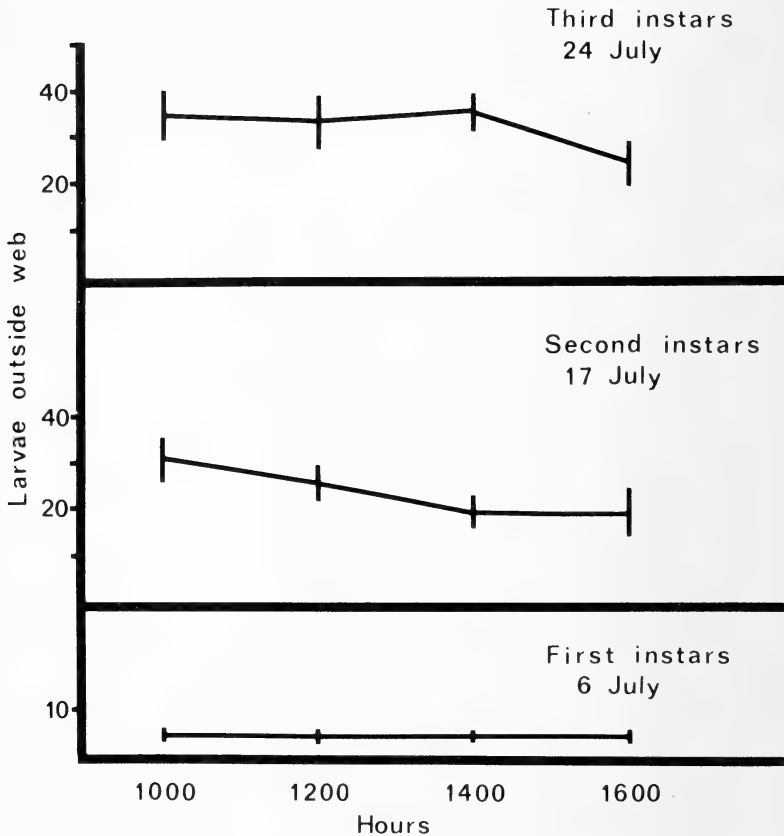


FIG. 1. Mean number of larvae outside webs ($n = 21$) with \pm one standard error.

webs increased as larvae progressed through the first three instars, with significantly fewer first instars outside the webs than during second and third instars (two-way ANOVA, $P < .001$; Newman-Keuls multiple range test [Zar, 1974]; Fig. 1). By the third instar, 86% more larvae were on the outside of the webs or feeding on adjacent leaves during the day relative to the first instars outside the webs. Larvae inside the webs, especially near the center, were quiescent or molting.

The larval aggregations collected after diapause were all in the center of their webs, usually on the upper half of plant stalks. The mean number of larvae per web at diapause was 110 to 216, with considerable variation among years (Fig. 2). Larval mortality due to predators within webs was probably small. Few potential predators were

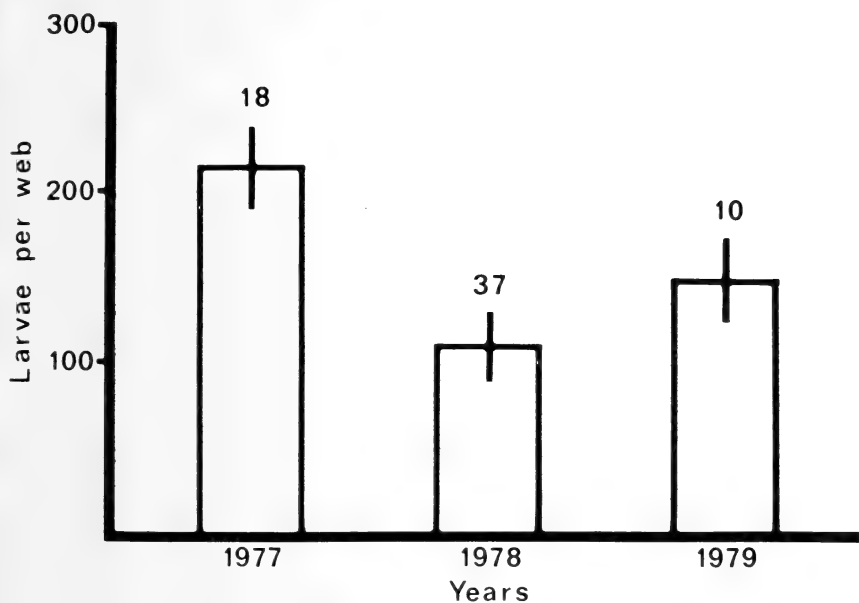


FIG. 2. Mean number of larvae per web at diapause, with \pm one standard error. The numbers of webs are indicated.

found in the 65 webs collected in 1977-79: two chrysid larvae, two ant colonies, and 27 spiders.

Mortality of the egg and larval stages up to diapause was at least 46%, based on a mean of 274 eggs per cluster and a mean of 148 larvae (± 18 S.E.) per web at diapause for 1977-79. This is a conservative estimate of mortality at this stage for two reasons. First, some webs were composed of larvae from more than one egg cluster on a plant stalk. For example, for plant stalks with egg clusters in 1979, the mean number of clusters per stalk was 1.5 (or 411 eggs; Stamp, 1980b). Furthermore, entire egg clusters rarely disappeared (Stamp, 1981a). Based on this mean of multiple egg clusters per stalk and mean number of diapausing caterpillars per web, mortality of the egg and larval stages up to diapause was 64%. Second, larval aggregations seldom split up, even when they defoliated their host plant stalk. The caterpillars expanded their web down the plant stalk and onto adjacent leaves, remaining together by using silk trails (e.g., Bush, 1969). None of the aggregations observed in this study subdivided. Thus, mortality up to diapause was in the range of 46 to 64%.

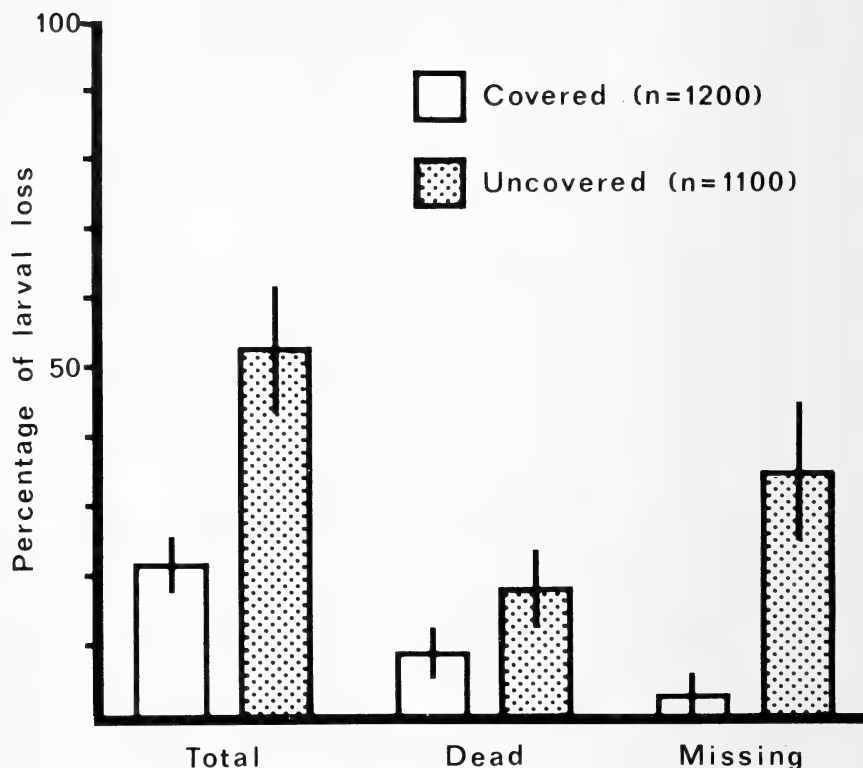


FIG. 3. Percentage of larval loss from screen-covered and uncovered boxes over the winter. Total numbers of larvae are indicated. The numbers of dead larvae per box between covered and uncovered boxes were not significantly different (Mann-Whitney U test, $P > .20$). The numbers of missing larvae between covered and uncovered boxes were significantly different (Mann-Whitney U test, $P < .002$).

Overwintering Fourth Instars

The mean size of overwintering larval aggregations was one-fifth that of mean group size at diapause, which was a consequence of group subdivision and mortality. The sizes of overwintering larval groups on plots were similar in November and March (mean of 21.4 larvae \pm 24.3 S.D. and 17.9 larvae \pm 26.9 S.D., respectively; two-sample t test, $P > .50$). Larvae were usually found in dry litter or on the plastic sheet 5 to 8 cm below the litter surface. In November most groups were tightly aggregated (larvae touching each other), but in March most were in loose aggregations (larvae within a body length of each other). All of the groups had moved between November and March. The larval aggregations in March were farther from their webs than in November (11.7 cm \pm 7.9 S.D. and 20.9 cm \pm 14.2 S.D.,

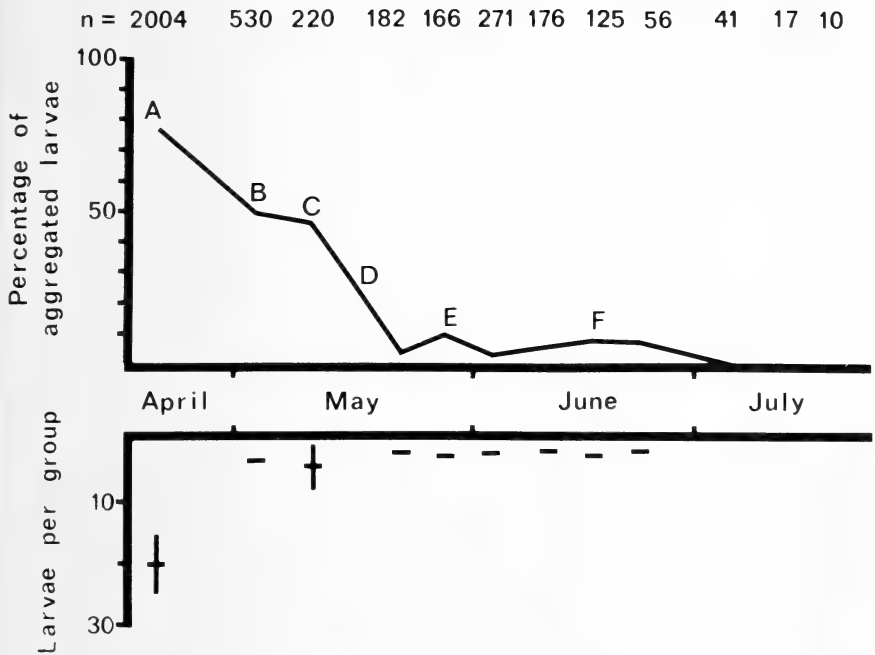


FIG. 4. Aggregation tendencies among post-diapause larvae. Top—line indicates the percentage of aggregated larvae, with total larvae shown by numbers. Factors related to aggregation patterns are: **A**, small patches of turtlehead in mid-April, **B**, no turtlehead above ground in two of three areas, **C**, no turtlehead in two areas and one-third of third area reduced to leafless, 15 cm stalks, **D**, pupation started and turtlehead beginning to reappear, **E**, turtlehead in all areas and first *E. phaeton* adults flying, and **F**, pupation ended. Bottom—mean number of larvae per group of those aggregated individuals, with \pm one standard error.

respectively; normal approximation to Mann-Whitney U test, $P < .01$). Some individuals changed groups over the winter. Over half of the larvae originally on the plots in November were missing in March. In mid-March there were 1.5 groups per plot (± 1.9 S.D.) in contrast to 2.3 groups per plot (± 1.0 S.D.) in mid-November, but this was not a significant difference (Mann-Whitney U test, $P > .05$). The missing groups had either moved off the plots (greater than 45 cm from their webs) or were dead. It appears that groups lost some individuals, but there is no evidence that entire groups died together.

Up to 18% of the caterpillars were dead and up to 35% were missing in the plastic boxes, for a total larval loss of 53%. The numbers of dead larvae per box in the covered and uncovered boxes were similar (Fig. 3); however, the numbers of missing larvae per box were greater in the uncovered boxes than in the covered boxes. Seven boxes were broken by deer and, thus, excluded from the experiment.

TABLE 1. Comparison of defoliated plant stalks and solitary caterpillars. Six completely defoliated plant groups were sampled in May, with a total of 397 stalks. The 226 larvae feeding on these stalks were classified as solitary (greater than a body length apart) or aggregated. Statistical analysis showed no correlation between number of stalks per plant group and the percentage of solitary larvae per plant group (Spearman rank correlation, $n = 6$, $P > .50$). Thus, at this time larvae occurring singly did not appear to be in response to the limited availability of the larval host plant.

	Plant group					
	1	2	3	4	5	6
Leafless plant stalks	31	33	60	82	91	100
Percentage of larvae which were solitary	26	26	12	36	47	0

Post-diapause Instars

Some 77% of the late instars were aggregated in mid-April (beginning of the post-diapause period), but only 20% prior to pupation in mid-May (Fig. 4). The mean group size of aggregated larvae was 20.5 (± 52.1 S.D.) in mid-April and 5.0 (± 7.1 S.D.) three weeks later. In both 1978 and 1979 a few small patches of turtlehead occurred in each of three study sites by mid-April. Less than 15% of the caterpillars were on turtlehead at this time. The patches of turtlehead were completely defoliated by late instars in two of three sites by mid-May in both years. Caterpillars in the two sites with defoliated turtlehead then mainly ate rosaceous shrubs about 10 m from the defoliated host plants. In the third area turtlehead was reduced by one third by mid-May. Many of the plants had few if any leaves, and the stalks were mere stubs, often with one or more caterpillars feeding on them. No correlation between the number of stalks per plant group and the percentage of single larvae on stalks per plant group was evident at this time (Table 1). Thus, the late instars were neither aggregated (that is, no negative correlation) nor dispersed (no positive correlation) in response to the limited amount of turtlehead available to them. Shortly after pupation began, the turtlehead began to recover and by mid-June the mapped areas of turtlehead very closely resembled the patches mapped the year before.

In the laboratory larval aggregation was highest when fewer plants were available (two-way ANOVA after square root transformation; for the number of plants per cage for all late instars aggregated in cages, $P < .05$; for number of plants per cage for larvae aggregated on plants, $P < .001$). The larvae fed actively, and individuals changed aggregations frequently. Half of the larvae were aggregated (mean of 4.7 aggregated larvae per cage). However, most were aggregated on the cages rather than on the plants (mean of only 1.6 aggregated larvae

on plants per cage). Of those caterpillars aggregated on the cages, 93% were at the top of the cages. Similarly, in the spring fifth and sixth instars were aggregated frequently at heights above the vegetation on dead plant stalks, even when turtlehead was readily available.

DISCUSSION

The small number of first instars on the outside of webs, relative to the numbers of second and third instars, was a consequence of how these three instars used the webs. Their abilities to defend themselves differed greatly. First instars were cryptically colored with single hairs extending from tubercles on their bodies. However, second and third instars had conspicuous reddish-brown bodies with dense, black spines projecting at 45 degree angles from tubercles in rows across their bodies. In contrast to first instars, third instars successfully knocked parasitoids away from them by head-jerking (Stamp, 1981b). Also, second and third instars of *E. phaeton* were probably toxic to some vertebrate predators, because larvae that were reared on turtlehead were unpalatable to blue jays (*Cyanocitta cristata* L.: Bowers, 1980). Thus, second and third instars of *E. phaeton* may be better protected against parasitoids and predators because of their size, spines and toxicity and consequently, less dependent on webs for protection against their enemies than first instars (Stamp, 1980b). Similar between-instar differences (in terms of body hair and response by predators) also occur in tent caterpillars (*Malacosoma americanum* [Fabricius]; Ayre & Hitchon, 1968).

The scarcity of first instar *E. phaeton* on the outside of the webs may also be a consequence of adequate food remaining within the webs for them. They enclosed the top two furled leaves of the stalk with silk and fed within the web. In contrast, second and third instars consumed leaves at a faster rate than first instars and often fed from the outside of the webs.

In addition, first instars may be more susceptible to low humidity than second and third instars. Morris & Fulton (1970) suggested that the webs of fall webworms increased microhabitat humidity, an important factor maintaining a high feeding rate and shortening the developmental period. Second and third instars may leave the web on warm days when they are most active to avoid overheating (Morris & Fulton, 1970).

The movement of groups of fourth instars between November and March may be an anti-predatory response, probably directed to invertebrate predators and insectivorous mammals. Larvae which remain aggregated in the course of such movement may enhance the

effect of aposematic coloration and unpalatability on most vertebrate predators. Maintaining a clumped distribution also reduces the chance of being discovered by predators, and being surrounded by others provides individuals with less risk of being attacked (Hamilton, 1971; Taylor, 1976, 1977).

Field observations and the aggregation tests in the laboratory suggest that late instars of *E. phaeton* were intrinsically gregarious, in contrast to a statement that they were largely solitary (Klots, 1951). They stayed together in April, sometimes even joining other aggregations and after defoliation of host plants. Solitary sixth instars collected during the pupal and adult flight periods were invariably those attacked by parasitoids earlier (98% of 95 larvae; Stamp, 1981b). Occasionally, even these parasitized caterpillars occurred in groups of two to four, either on top of leaves or between leaves bound by silk. A similar pattern was found for sawfly larvae (*Neodiprion swainei* Midd.), in that after defoliating their host plant, larvae migrated 180 m or more and continued to aggregate; whereas, diseased larvae were solitary (Smirnoff, 1960). The aggregated behavior of late instars of *E. phaeton* may be beneficial by enhancing the defensive mechanisms discussed above.

The decline in aggregation tendencies of late instars was correlated with food availability, pattern of larval mortality due to predators and parasitoids, and pupation. In areas where the host plants were totally defoliated and few other acceptable food plants were available, larvae became increasingly dispersed with time. If late instars fed primarily on other food plants, it might be advantageous for individuals to be solitary if the food they ate rendered them palatable. Bowers (1980) demonstrated that *E. phaeton* larvae were palatable to blue jays when as latter instars they fed on English plantain (*Plantago lanceolata* L.). Latter instars were reported to feed on this and a variety of other plants (Tietz, 1972). Thus, as a consequence of both the quality and quantity of available food, the advantages of aggregating in relation to predators may frequently change from one instar to the next.

These caterpillars were actively gregarious through all instars, this behavior contributing to an average group size at each larval stage. It is clear that the costs and benefits of aggregation changed as group size changed and as these animals progressed through the life cycle, a consequence of different factors operating on the larval stages.

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STUDIES ON THE *CATOCALA* (NOCTUIDAE) OF
SOUTHERN NEW ENGLAND. VI. THE
"PAIRING" OF *C. NEOGAMA* AND
C. RETECTA

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ABSTRACT. The closely related, Juglandaceae-feeding *Catocala* species, *C. neogama* and *C. resecta*, have occurred in nearly equal numbers at the same time of year over several years at a single location in southern New England. These two species have very similar cryptic forewings, but their hindwings differ markedly. Prior studies have suggested that *Catocala* hindwings function as startle devices in instances of avian attack, and that specific differences in hindwing patterns between otherwise similar species serve an anti-predator function by interfering with avian habituation to startle stimuli.

Rearing studies with *C. neogama* and *C. resecta* indicated that the two species have no effects on one another's development rate or survival, though larvae of the two species have a somewhat stronger tendency to disperse from one another than do larvae of either species alone. Detailed analyses of light-trap data from Washington, Connecticut showed that *C. neogama* and *C. resecta* have occurred in equal numbers both across and within seasons at that location. However, the variance in the ratios between these species over years was greatest both early and late in the season when moth abundances were lowest, and this finding is interpreted as evidence for frequency dependent selection by birds on this species pair.

At least 40 species of the noctuid genus *Catocala* may co-exist at a single location in the northeastern United States. A number of these species have very similar life histories, including common foodplants and nearly identical flight seasons. In some cases, pairs of these species have similar bark-like cryptic forewings and resting behaviors on tree trunks (Sargent, 1978).

One of the closest pairings of this sort involves *C. neogama* (Smith & Abbot) and *C. resecta* Grote (Fig. 1), two closely related Juglandaceae-feeding species (Barnes & McDunnough, 1918; Forbes, 1954). These moths were sampled at a light-trap for 12 years by Sidney A. Hessel in Washington, Connecticut, and there the two species occurred in nearly equal numbers, exhibited parallel fluctuations in annual abundance, and had essentially identical flight seasons (Fig. 2). The two species also have very similar cryptic forewings, though they differ markedly with respect to their hindwings—*C. neogama* having orange and black banded hindwings, and *C. resecta* having entirely black hindwings with a prominent white fringe (Fig. 1).

Catocala hindwings are hidden beneath the cryptic forewings when the moths are at rest, and these colorful or boldly patterned structures apparently function as startle devices in instances of avian attack. The crisp beak-imprints found on the wings of many wild-



FIG. 1. *Catocala neogama* (Smith & Abbot) (**above**) and *C. resecta* Grote (**below**). Life-size.

caught specimens provide evidence for this startle function, indicating that birds sometimes release these moths when the hindwings are exposed (Sargent, 1973). There is also evidence that birds will habituate, i.e., learn to respond, to particular hindwing patterns (Sargent, 1973), and I have proposed that the interspecific hindwing diversity among the *Catocala* serves to interfere with this habituation process (Sargent, 1969, 1976). This apparent advantage of hindwing diversity might then account for the close co-existence of species with very different hindwings (Sargent, 1978, 1981).

Habituation may be defined as the "waning of a response as a result of repeated stimulation which is not followed by any kind of reinforcement" (Thorpe, 1963). This learning process requires a series of encounters with the specific stimulus in question, and while some generalization to similar stimuli may occur, encounters with sufficiently different stimuli are known to interfere with, or abolish, the

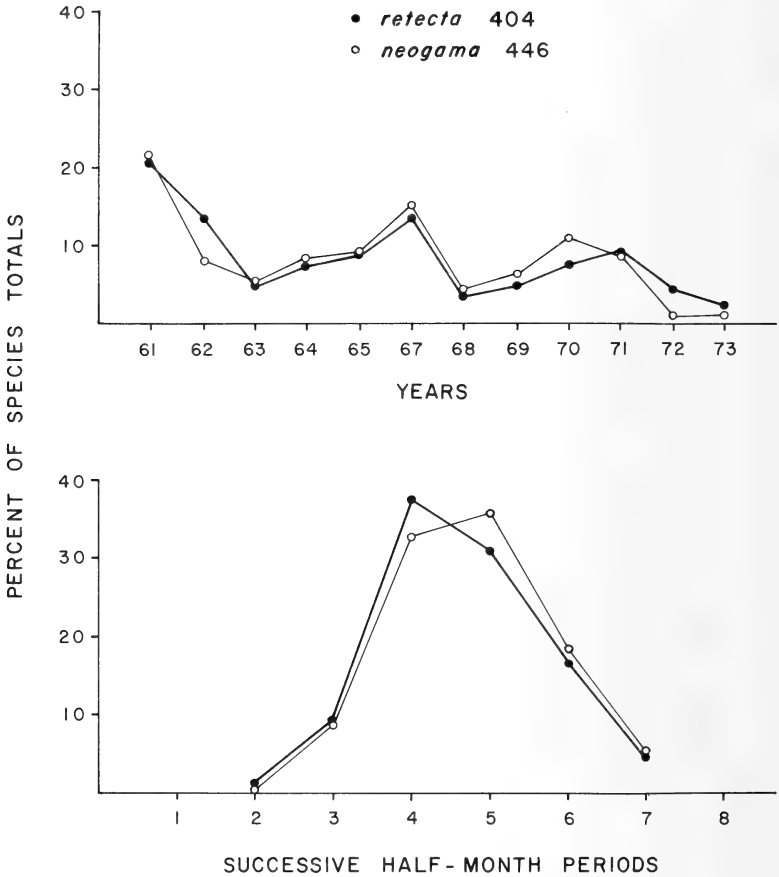


FIG. 2. The annual (**above**) and seasonal (**below**) fluctuations in abundance of *C. neogama* and *C. resecta* at Washington, Connecticut, based on specimens taken in a light-trap over 12 years. Abundances are expressed as percentages of the total number of individuals taken over the entire 12 seasons for each species (these totals given after the species names). The season half-months begin 1–15 July (1) and end 16–31 October (8).

development of an habituated response (Donahoe & Wessells, 1979). In the case of predators on *C. neogama* and *C. resecta*, it is assumed that habituation to the hindwings proceeds so long as only one of the two species is being encountered, and that under these circumstances the startle response eventually disappears, enabling a predator to capture individuals of that species. The number of successive encounters required for successful capture of one species, N_c , undoubtedly varies with many factors, including the species of predator and the time elapsing between successive encounters. However, evidence from

prior studies of avian startle (Blest, 1957; Coppinger, 1969, 1970) suggests that this value lies somewhere between two and perhaps five or six encounters. The presence of a second species with very different hindwings serves to reduce the probability of N_c occurring by interspersing experiences which cause the startle response to reappear. Thus, by interfering with the habituation process, both species benefit by occurring together.

The extent to which N_c would be realized in sampling from a randomly mixed population of *C. neogama* and *C. resecta* would be a function of the frequencies of these two species. If N_c was 4, and *C. neogama* and *C. resecta* occurred in equal numbers (50:50), then the probability of a predator encountering four successive individuals of one or the other species would be ca. 0.06. The results of similar calculations, for values of N_c between 1 and 5, and for frequencies of either species ranging from zero to one, are depicted in Fig. 3. Examination of this figure reveals that for values of N_c above 3, there is a considerable advantage for either species when it is less common than the other species. This advantage remains substantial when the species are about equally common, but rapidly declines for either species as it becomes much more common than the other species.

These calculations are based on the assumption that predators cannot distinguish *C. neogama* and *C. resecta* in the resting (cryptic) state. If such a distinction were possible, then predators might come to associate the two distinguishable cryptic prey with their two very different startle patterns and eventually habituate to both. However, the forewing similarities of *C. neogama* and *C. resecta* may preclude the formation of such forewing-hindwing associations and so create a very difficult habituation problem. This possibility would provide a selective basis for convergence between the two species in cryptic characteristics.

Thus far we have considered only a possible advantage of the co-existence of *C. neogama* and *C. resecta*. However, these species do utilize the same foodplants and one might envision a disadvantage of their co-existence with respect to competition for food. I have suggested previously, however, that *Catocala*, particularly species like these whose larvae feed on the mature green leaves of large deciduous trees, may not be foodplant limited (Sargent, 1978, 1980). If this were true, and if, as previously described, each species benefited with respect to predation as the other species increased in abundance (Fig. 3), then there would be little basis for competitive interference between them, and the two species might come to share what is essentially a single ecological niche.

The first section of this report is an attempt to shed some light on

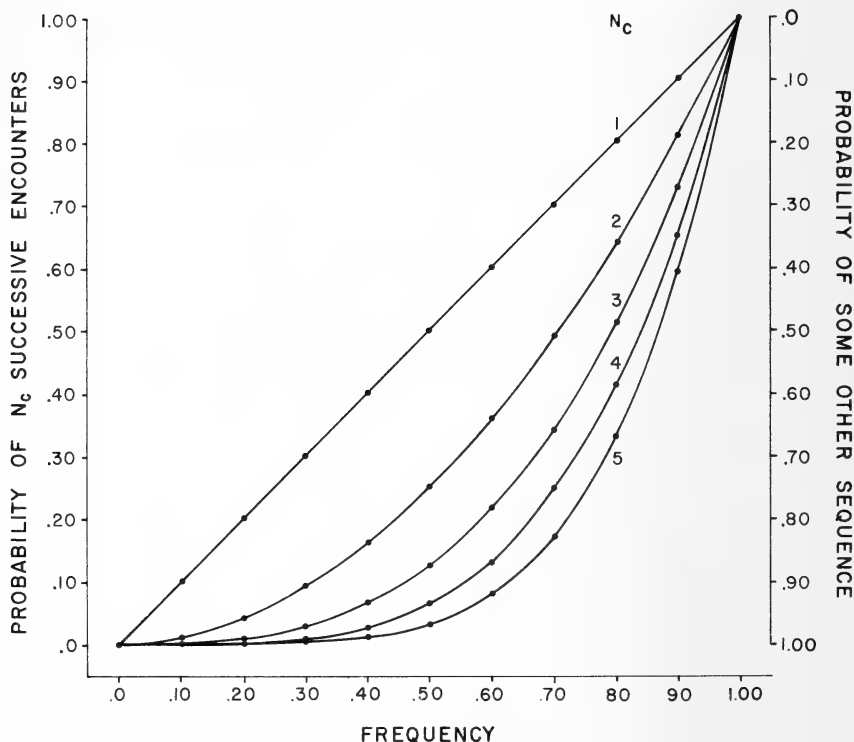


FIG. 3. The probability of a predator encountering the number of successive individuals of one species (e.g., *C. neogama*) necessary for startle habituation (N_c), when taking prey from a randomly mixed, two-species population (e.g., *C. neogama* and *C. resecta*) for various frequencies of the species in question (here *C. neogama*). Curves are plotted for values of N_c from 1 through 5. The probability of an encounter sequence other than successive individuals of the species (here *C. neogama*) is given on the right-hand ordinate.

possible competitive interactions between the larvae of *C. neogama* and *C. resecta*. These rearing studies were conducted in order to (1) corroborate, if possible, the identical phenologies reported from the field, (2) compare the survival and development rates of the two species when reared in pairs comprised of one or both species, and (3) describe any changes in larval behavior associated with the two-species as opposed to the one-species rearing condition.

The second section of this report is devoted to a detailed analysis of Hessel's field data, specifically to determine the extent to which *C. neogama* and *C. resecta* occurred in equal numbers over the season for the 12 years, 1961–1965 and 1967–1971, at Washington, Connecticut.

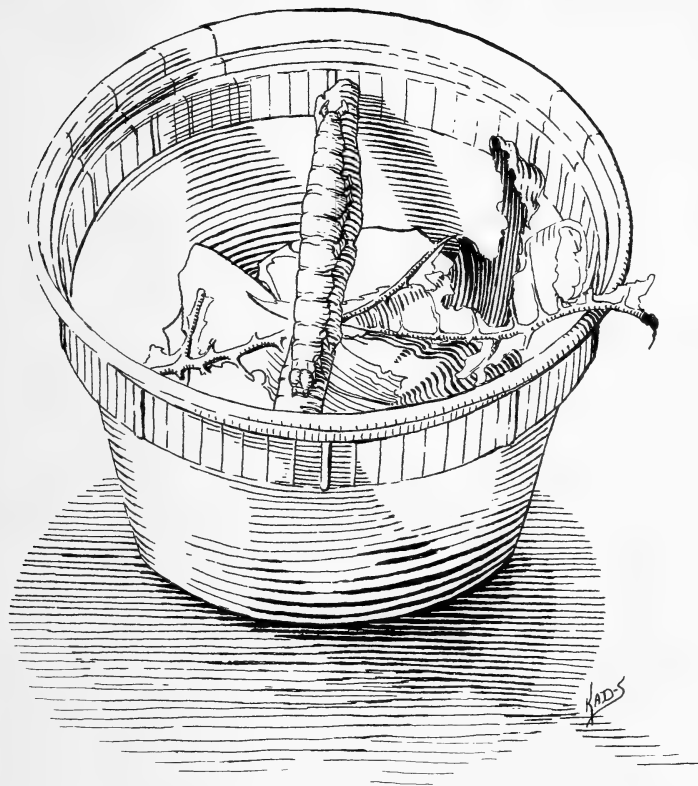


FIG. 4. The rearing situation for *C. neogama* and *C. resecta* larvae. Each container was supplied with leaves of the foodplant and a twig on which the larva(e) could rest (cover of the container not shown).

Finally, I will discuss the implications of the ecological correspondence of *C. neogama* and *C. resecta*, and speculate as to how their numerical equality might be maintained.

REARING STUDIES

Methods

One female each of *C. neogama* and *C. resecta*, wild-caught in Leverett, Franklin Co., Massachusetts during the summer of 1976, were induced to lay eggs in brown paper bags left hanging outdoors. The eggs were transferred to small glass jars with perforated lids and left in a sheltered, outdoor location to overwinter. Hatching of all the eggs occurred on 12 May 1977 for both species. The young larvae were immediately provided with leaves of shagbark hickory (*Carya*

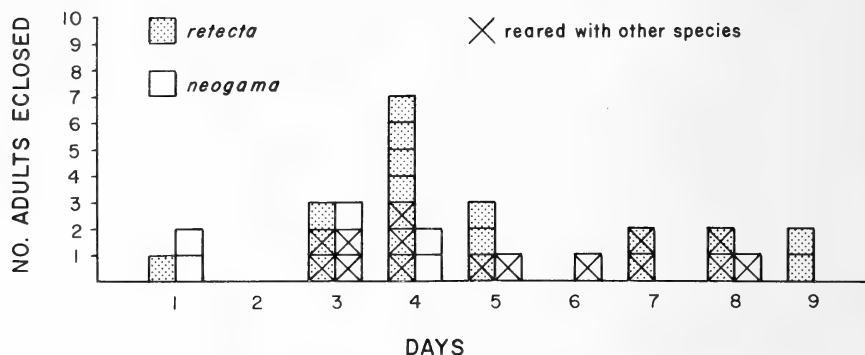


FIG. 5. The numbers of adult *C. neogama* and *C. resecta* eclosing over days (12–20 July) from larvae reared in single- and mixed-species pairs.

ovata) for feeding. On 24 May, the larvae were transferred from the glass jars and placed in pairs into pint-size plastic containers. Five containers with two *C. neogama* larvae, five containers with two *C. resecta* larvae, and 10 containers with one larva of each species were established. Each container was provided with a single hickory twig upon which the larvae could rest (Fig. 4). Fresh foodplant was supplied, and frass removed, on a daily basis.

The larvae of *C. neogama* and *C. resecta*, like those of most *Catocala*, appear very bark-like from the third instar onward and usually rest by day on twigs of the hostplant (Sargent, 1976). For 21 days (26 May–16 June) during this period, the resting positions of the larvae in all of the containers having two larvae (i.e., in which neither larva had died or pupated) were noted on one occasion, usually between 0700 and 0900 h. Data were recorded as to whether both, one, or neither larva(e) were on the twig in each container, with the species noted in those cases where both species were housed in the same container. Records were also kept of larval mortality and the dates of pupation and adult eclosion.

Results

The phenologies of *C. neogama* and *C. resecta* were essentially identical under these rearing conditions. The eggs of both species hatched on the same date (12 May) and their pupation periods commenced on the same date (9 June). The last pupa of *C. neogama* was formed on 16 June, and the last pupa of *C. resecta* was formed on 17 June. The adult eclosion dates overlapped completely, whether the moths were reared in single or mixed species pairs (Fig. 5). Thus, the

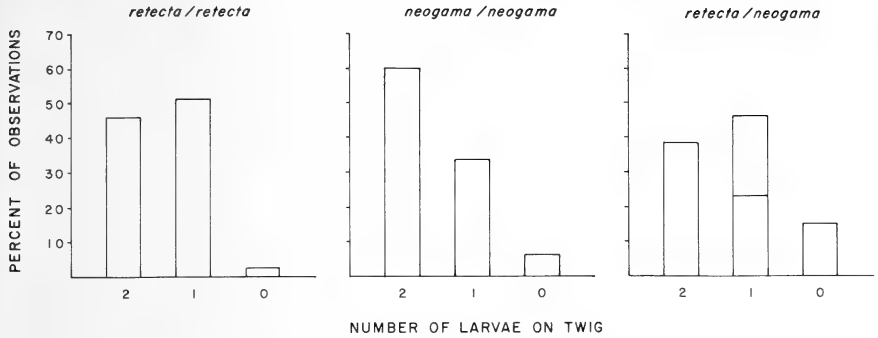


FIG. 6. The percentage of total daily observations when two, one, or no larvae were on the twig in rearing containers housing single-species (*retecta/retecta*; *neogama/neogama*) or mixed-species (*retecta/neogama*) pairs of larvae.

species were nearly perfectly synchronized and neither exerted an inhibitory effect on the development rate of the other.

All mortality occurred in the larval stage, but was restricted to *C. neogama*. This mortality was identical, however, in the single species and mixed species pairs (50% in both cases). Some aspect of the rearing conditions was less satisfactory for *C. neogama* than for *C. retecta*, but this difference was not related to the species with which a larva was reared.

The larvae of the two species exhibited rather similar resting behaviors in the single-species containers (Fig. 6). Both species preferred the twig (76.9% of the total observations in *C. neogama*; 71.7% in *C. retecta*), and the larvae often rested together on the twig (60.0% of the observed occasions when at least one larva was on the twig in *C. neogama*; 46.1% in *C. retecta*). Chi-square contingency tests indicate that the two species did not differ in their tendencies to utilize the twig ($\chi^2_{(1)} = 1.09$, $P > .30$), but that the *C. neogama* larvae had a greater tendency to occur together on the twig ($\chi^2_{(1)} = 5.44$, $P < .02$).

In the mixed-species pairs, both species exhibited a reduced tendency to utilize the twig (62.0% of the total observations in *C. neogama*; 61.4% in *C. retecta*), and a reduced tendency to occur together on the twig (45.5% of the observed occasions when at least one larva was on the twig) (Fig. 6). Chi-square contingency tests indicate, however, that these changes in behavior from the single species situation were only significant for *C. neogama* ($\chi^2_{(1)s} > 6.6$, $P < .01$).

The interspecific interactions seemed to involve mild aversion to one another's presence, particularly on the part of *C. neogama* to *C. retecta*. Neither species was clearly dominant on the twig, as the

occasions when only *C. neogama* or only *C. resecta* was on the twig were equally frequent (Fig. 6). There was no evidence of increased aggression between species as compared to within species, though detailed behavioral observations were not carried out. However, whatever the interspecific behavioral interactions in this situation, they had no discernible effects on survival or development rates (Fig. 5).

FIELD DATA

Methods

The late Sidney A. Hessel of Washington, Connecticut recorded the number of individuals of all *Catocala* species taken in a mercury vapor light-trap on virtually every night of every season from 1961–1965 and 1967–1973. Details of the method employed, and many of the data gathered, have been presented elsewhere (Sargent & Hessel, 1970; Sargent, 1976, 1977). Here I will focus on details relating to the seasonal occurrence of *C. neogama* and *C. resecta* at this location.

Results

As previously reported, *C. neogama* and *C. resecta* were taken in nearly equal numbers in each of the 12 years of Hessel's sampling, and the two species also showed nearly identical flight seasons (Fig. 2; Sargent, 1978). Further analysis reveals that the 50:50 proportion of *C. neogama* and *C. resecta* also obtained across the flight season when the data are summed over years (Fig. 7). There was no tendency for increasingly close approximation to the 50:50 proportion as the flight season progressed. However, the variance in the *C. neogama*/*C. resecta* proportions was greatest early and late in the season when the numbers of individuals taken were lowest, while this variance was least during mid-season when moth abundance was highest.

DISCUSSION

The co-existence of *C. neogama* and *C. resecta* in nearly equal numbers should confer a substantial advantage to both species with respect to deterring predators that tend to habituate to specific startle patterns (Fig. 3). And we have seen that these species may actually occur in nearly equal numbers over many years at a single location (Figs. 2 and 7). The question then is, what mechanism might maintain this seemingly advantageous numerical relationship of the two species?

The facts that *C. neogama* and *C. resecta* are closely related species that utilize the same foodplants at the same times suggest that they

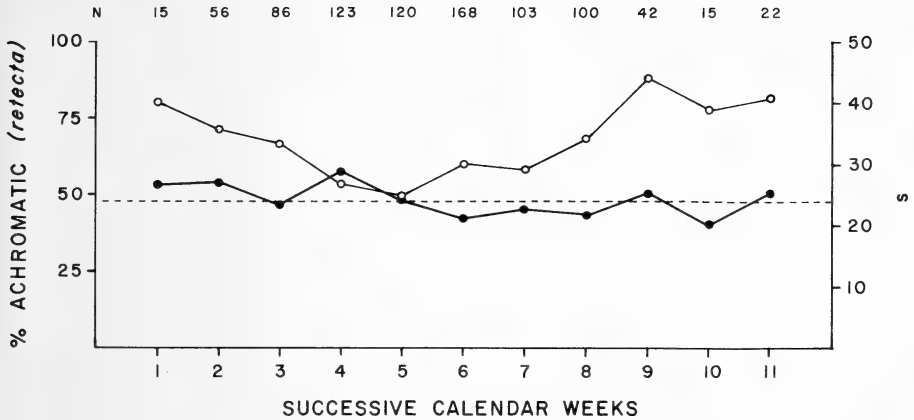


FIG. 7. The percentages of *C. neogama* and *C. retecta* totals (N) made up by *C. retecta* during successive weeks of the season (30 July–14 October) at Washington, Connecticut (solid dots), and the standard deviation for each point (open dots). Data are summed over 12 years, 1961–1965 and 1967–1973.

may be exposed to very similar selection pressures. These same facts also suggest that the two species are intense competitors for food. However, the results of the rearing studies reported here lend some support to prior suggestions that *Catocala* are not food-plant limited. When the two species were reared together, there were some changes in larval behavior (Fig. 6), but these seemed to reflect a mild inter-specific aversion that resulted in an increased tendency of the larvae to disperse. There was no evidence of detrimental aggressive interactions under these conditions, as neither species exerted an inhibitory effect on the survival or development rate of the other (Fig. 5).

Even if one were to grant, however, that food is not limiting for these species, it does not follow that they should occur in nearly equal numbers over long periods of time. Other factors (e.g., diseases, parasites, climatic variables) would almost certainly favor one or the other species at different times. Thus, the extremely close and continuous 50:50 proportion between *C. neogama* and *C. retecta* at Washington, Connecticut (Figs. 2 and 7) suggests the operation of a rather precise regulatory mechanism.

A number of mechanisms that are known to promote stable polymorphisms within species (e.g., heterosis and certain types of non-random mating) (see Sheppard, 1959) could not operate in this two-species situation. However, one extrinsic mechanism, frequency dependent selection, could operate here and warrants closer examination.

Frequency dependent selection, or "apostatic" selection (Clarke, 1962), occurs when each member of a pair of morphs or species is at an advantage with respect to predation when rarer than the other, but at a disadvantage when more common than the other (see Cain & Sheppard, 1954; Haldane, 1955; Clarke & O'Donald, 1964). Such a situation would seem to hold in the present case (see Fig. 3). Thus, if *C. neogama*, for example, comprised 25% of a *C. neogama/C. resecta* population at some point in time, then *C. resecta* should be more heavily predated until its numbers were roughly equal to those of *C. neogama*. If *C. neogama* became more common than *C. resecta* then *C. neogama* should receive more predation, and so on. In this way, predator selection would tend to promote and maintain a 50:50 proportion of the two species.

There is some evidence suggesting the operation of frequency dependent selection in the *C. neogama/C. resecta* situation at Washington, Connecticut. If one assumes that there is some threshold abundance of these moths below which they do not attract significant predation, and above which predation is significant (i.e., that this predator-prey relationship fits the so-called Type III function) (Holling, 1959, 1965, 1966), then the effects of predation should be maximal at mid-season when prey density is highest, and minimal or non-existent at the extremes of the season when prey densities are lowest. The *C. neogama/C. resecta* proportions at Washington, while averaging 50:50 across the entire season when the data are summed over years, do show less variance at mid-season (Fig. 7). This finding may be evidence that predators drive the system to equilibrium when the moths are abundant, but exert little influence when the moths are scarce. And this, in turn, could explain why *C. neogama* and *C. resecta* may not show the 50:50 relationship at locations where they are relatively rare (e.g., Leverett, Massachusetts; unpubl. data).

In summary, there is substantial evidence that *C. neogama* and *C. resecta* may occur in nearly equal numbers at a given location while occupying very similar ecological niches. This situation is seen as a consequence of several factors, including (1) a presumed close phylogenetic relationship between the two species, (2) an abundance of resources such that food is not limiting, and (3) predator selection that (a) promotes convergence in all characteristics associated with crypsis, (b) simultaneously promotes divergence in startle characteristics, and (c) acts in a frequency dependent manner with respect to these startle characteristics.

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OBSERVATIONS ON THE FLIGHT PERIODICITY OF BUTTERFLIES IN WEST MALAYSIA

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ABSTRACT. Data are presented on the flight activity of a large number of butterfly species observed over an eight-day period in West Malaysia. There is also discussion on variation in the flight periodicity shown by *Melanocyna faunula* (Westwood) (Amathusiidae) across altitude.

It has often been observed by naturalists who have collected in tropical regions that many species of butterflies display a distinctive periodicity in their flight activity. However, few empirical data have been published to support these observations, and what literature is available is sparse and confined to general comments concerning broad taxonomic groupings (Corbet & Pendlebury, 1978; Emmel, 1976) or contained in detailed studies of particular species (for example, Scott, 1974).

AREA AND METHODS

During a recent visit to West Malaysia, I collected, over a period of eight days, data on the flight activity of a large number of butterfly species. The method of data collection was to remain all day at a vantage point and note the number of sightings over half-hour intervals of various species of butterflies. I could record only those species with which I was familiar and which were unmistakable in flight; hence, I made no records of Lycaenidae or HesperIIDae.

Data were collected at two sites. The first, Tapah, where the most detailed studies were made, was along a steep mountain watercourse at an altitude of about 700 m. The vantage point was a rocky outcrop beside the stream, and it was from here that I made most of my observations. There was a wide break in the forest canopy along the stream, so the area received plenty of sunlight from about 0730 h until 1430 h. The forest was basically of a lowland type, with buttressed trees, vines, and large-leaved dipterocarps, although noticeably less luxuriant than forest at lower altitudes.

The second locality was at Tanah Rata, some 30 km from the first site, at an altitude of 1300 m. Here, too, the observation point was beside a stream, and the forest was open enough to allow sunlight to penetrate for the greater part of the day. The forest was of a stunted and open montane type, with smaller leaved trees and no vines.

In practical terms, an advantage of both sites was that neither afforded too great a field or range of vision, so that I was rarely confronted with too many butterflies to count or distracted by specimens at a distance too great for them to be identified quickly and accurately. In addition, overall population numbers at both sites were quite low, which permitted an accurate appreciation of butterfly activity at all times during the period of observation.

RESULTS

The observations are summarized in Tables 1, 2 and 3. For each species, numbers of sightings for each hourly interval from 0700 to 1800 h are expressed as a percentage of total number sighted. At Tapah data were collected on five days and are summarized in Table 1. Data were recorded for three days at Tanah Rata (1300 m). Table 2 summarizes these data for the first two days, which were both cloudy after 1100 h with only very occasional sunshine after 1200 h. Table 3 contains the data for the third day, which was sunny throughout. This division was made because it was noted that *M. faunula* were more active on days when the sky was overcast. The dates, and details of collecting times, are listed below each table.

Six species have been selected to illustrate various patterns of flight activity at Tapah, and histograms of percentage of sightings against time of sighting are given in Fig. 1. Fig. 2 illustrates the changing pattern of *M. faunula* activity with altitude and weather conditions.

DISCUSSION

Although the majority of butterflies were observed to fly between 0900 h and 1500 h, there are many which do not conform to this pattern.

Most Papilionidae, Pieridae, Danaidae and Nymphalidae are strictly diurnal, but there is a wide range of variation in duration of flight period and time of maximal activity.

Certain species remain active throughout the day but reserve particular periods for the different life functions. The Neotropical ithomiid, *Mechanitis isthmia*, visits flowers in the early morning and late afternoon, and devotes the warmer part of the day to courtship, mating, and oviposition, activities which take place in the shade (Emmel, 1976). My own observations in Malaysia indicate that many species of *Euthalia* (Nymphalidae) will fly around the sunlit forest margins in the early morning but move into the deep jungle later in the day.

The histograms for *Trogonoptera* and *Graphium* (Figs. 1a and 1b) show the type of pattern typical for most Papilionidae, Pieridae, Da-

TABLE 1. Observed flight activity of western Malaysian butterflies.

	700	800	900	1000	1100
PAPILIONIDAE					
<i>Trogonoptera brookiana</i> ♂		2.0	6.0	18.0	22.0
<i>T. brookiana</i> ♀		11.1	5.6	11.1	16.7
<i>T. amphrysus</i>		11.1	14.8	14.8	14.8
<i>Atrophenura varuna</i>		20.0	6.7		
<i>A. sycorax</i>		50.0			
<i>Papilio helenus</i>			2.9	20.0	22.9
<i>P. iswara</i>			14.3	42.9	28.6
<i>P. nephelus</i>				20.0	20.0
<i>Graphium evemon</i>		5.9	9.8	13.7	17.6
<i>G. antiphates</i>		3.1	6.3	9.4	31.3
<i>G. macareus</i>				12.5	37.5
PIERIDAE					
<i>Leptosa nina</i>			5.3	21.1	26.3
<i>Cepora nadina</i>			5.0	15.0	25.0
<i>Appias lycinda</i>		3.9	11.7	18.8	20.3
<i>A. indra</i>		6.7	26.7	20.0	33.3
<i>A. nero</i>			20.0	20.0	40.0
<i>Pareronia valeria</i>			21.4	21.4	28.6
* <i>Eurema</i> spp.		3.6	13.1	14.1	15.4
<i>Gandaca harina</i>		17.2	20.7	20.7	20.7
DANAIDAE					
<i>Danaus aspasia</i>			3.3	8.8	24.2
<i>Ideopsis gaura</i>				20.0	20.0
<i>Euploea mulciber</i>		1.3	9.0	21.8	25.6
<i>E. camaralzeman</i>				14.3	28.6
<i>E. diocletianus</i>			11.1	16.7	30.6
SATYRIDAE					
* <i>Ypthima fasciata</i>		0.9	6.3	9.0	23.4
* <i>Y. pandocus</i>		0.6	3.5	13.3	15.6
<i>Ragadia crisilda</i>				25.0	25.0
<i>Melanitis leda</i>					
AMATHUSIIDAE					
<i>Amathusia</i> spp.	14.3	14.3			
<i>Faunis gracilis</i>	24.4	20.0	4.4		
<i>Melanocyma faunula</i>	3.1	3.1	3.1	3.1	3.1
<i>Xanthotaenia busiris</i>	8.3	8.3	16.7		
<i>Thauria aliris</i>	16.6	16.6	16.6		
NYMPHALIDAE					
<i>Cupha erymanthis</i>		2.9	5.9	14.7	20.6
<i>Terinos terpander</i>		5.3	10.5	20.3	15.8
<i>Cyrestis nivea</i>			11.1	5.6	13.9
<i>Parthenos sylvia</i>					30.0
<i>Stibochiona nicea</i>					
<i>Polyura</i> spp.					10.5
<i>Charaxes bernardus</i>					

* Figures indicate captures rather than sightings. Dates and times of observations: 5-1-79 700-1800 h, 7-1-79 600-1900 h, 9-1-79 700-1900 h, 10-1-79 600-1800 h, 13-1-79 700-1800 h.

TABLE 1. Continued.

1200	1300	1400	1500	1600	1700	1800	Total
22.0	14.0	8.0	2.0	2.0	4.0		50
16.7	16.7	11.1	5.6	5.6			18
22.2	3.7	3.7	7.4	3.7	3.7		27
	6.7	33.3	33.3				15
					50.0		2
20.0	22.9	11.4	2.9				35
14.3							7
20.0	40.0						5
35.3	11.8	3.9	2.0				51
29.7	18.8	1.6					64
25.0	25.0						8
15.8	10.5	15.8	5.3				19
25.0	25.0	5.0					20
18.8	15.6	8.6	2.3				128
13.3							15
10.0	10.0						10
21.4	7.1						14
16.0	12.7	11.1	9.8	3.6	0.7		306
10.3	8.6	1.7					58
20.9	23.1	13.2	5.5		1.1		91
20.0	40.0						5
18.0	10.3	5.1	3.8	3.8	1.3		78
14.3	14.3		28.6				7
25.0	8.3	8.3					36
17.1	16.2	14.0	10.4	2.7			222
12.7	11.0	13.9	19.1	9.8	0.6		173
12.5	12.5	12.5	12.5				8
			16.7	33.3	50.0		6
				14.3	57.1		7
			8.9	26.7	15.6		45
	6.3	6.3	34.4	28.1	9.4		32
			16.7	33.3	16.7		12
					66.7		6
29.4	11.8	8.8	5.9				34
21.1	17.5	8.8	5.3	3.5			57
27.8	22.2	16.7	2.8				36
30.0	30.0	10.0					10
		75.0	25.0				4
47.4	26.3	15.8					19
46.7	26.7	20.0	6.6				15

TABLE 2. Observed flight activity of select species.

	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	Total
<i>Papilio helenus</i>			12.5	50.0		25.0		12.5				8
<i>Delias descombesi</i>			25.0	45.0	20.0		10.0					20
<i>Melanocyma faunula</i>		2.8	7.5	12.3	17.9	17.0	15.1	13.2	8.5	2.8	2.8	106

Dates and time of observations: 8-1-79 800-1800 h, 11-1-79 800-1800 h.

naidae, and many Nymphalidae and Satyridae. The flight period may be more concentrated as in *Graphium*, or spaced out as in *Trogonoptera*, but in both cases more activity occurs between 1000 h and 1400 h. Unlike the other papilionids, *Atropheneura* display a less regular flight pattern (possibly a function of the small sample size), but distinctly avoid the hotter parts of the day (Fig. 1c).

The Charaxinae (Fig. 1d) have a brief period of activity in the early afternoon, with over 90% of observations being made between 1200 and 1500 h. By contrast, *Gandaca harina* (Horsefield) (Fig. 1e) prefers the early part of the day but is on the wing for a longer period. Perhaps this can be explained by the very powerful flight of the Charaxinae, which when active, pause only briefly to refresh themselves, usually at dung or carrion. *Gandaca harina* flutters weakly, always around the same tree, and settles frequently.

Faunis gracilis (Butler) (Fig. 1f) exhibits a crepuscular flight pattern typical of the Amathusiidae. Records were not kept after 1800 h, owing to poor light, but a number were seen at this time. The related *Discophora timora* (Westwood) has been recorded at fruit bait as late as 2130 h (Corbet & Pendlebury, 1978). In *M. faunula*, the crepuscular habit is less pronounced, but the bulk of flight activity at 700 m is concentrated towards evening (Fig. 2a). At 1300 m it flies throughout the day, though it is more active in the afternoon on sunny days (Fig. 2c). On cloudy days at 1300 m, there was some reduction in activity (Fig. 2b) but not to the same extent as observed in *Delias*

TABLE 3. Observed flight activity of select species.

	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	Total
<i>Papilio helenus</i>			12.5	6.3	18.8	18.8	12.5	18.8	12.5			16
<i>Delias descombesi</i>		3.4	3.4	10.3	13.8	20.7	24.1	17.2	6.9			29
<i>Melanocyma faunula</i>		2.9	2.9	8.7	13.0	11.6	15.9	13.0	17.4	10.1	4.3	69

Date and time of observation: 15-1-79 800-1800 h.

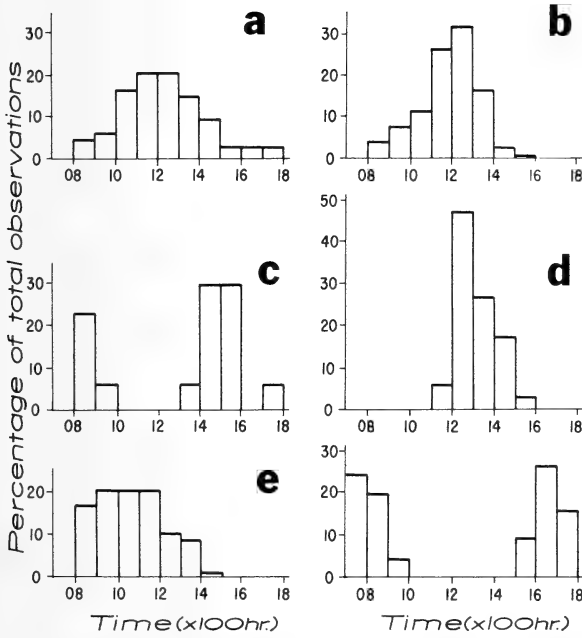


FIG. 1. Histograms illustrating flight activity of various butterfly species. (a) *Trogonoptera brookiana*; (b) *Graphium* spp.; (c) *Atrophencura* spp.; (d) *Polyura* and *Charaxes* spp.; (e) *Gandaca harina*; (f) *Faunis gracilis*. (Histograms represent pooled results for both sexes.)

descombesi (Boisduval), a montane species not found at Tapah, which only took to wing during short periods of sunshine.

Papilio helenus (Linnaeus) displays basically similar flight patterns at 700 and 1300 m. The different flight patterns of *Melanocyoma* at different altitudes suggest that temperature may be an important factor in determining activity.

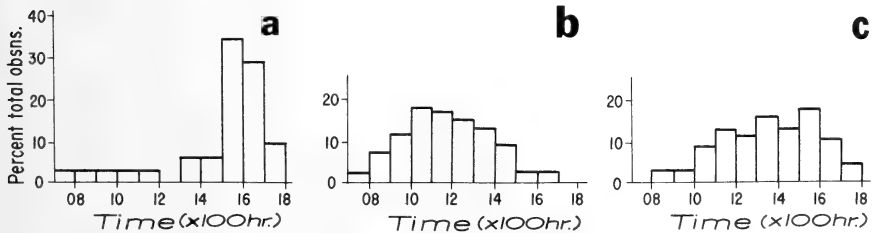


FIG. 2. Histograms illustrating flight activity of *Melanocyoma faunula* under differing conditions. (a) 700 m, sunny day; (b) 1300 m, cloudy day; (c) 1300 m, sunny day. (Histograms represent pooled results for both sexes.)

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GENERAL NOTE

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36(1), 1982, 60-61

**DOWNY WOODPECKERS AS PREDATORS OF
HYALOPHORA CECROPIA PUPAE**

The leaf-drop of a large silver maple (*Acer saccharinum* L.) in my yard during the fall of 1979 revealed 12 cocoons of *Hyalophora cecropia* (Hübner) scattered among its branches, many twenty to thirty feet above the ground. These pupae developed from eggs laid by the captivity-mated females I released the preceding spring. I felt content in thinking there would be a good source of wild males should I need them for backcrosses in my hybridization studies in this moth genus. Consequently, I decided not to collect them for storage as I usually do.

On 20 December 1979, as I returned from a late afternoon walk on an unusually clear cold day, I heard a pecking noise in the tree as I passed beneath it. To my chagrin, on a high branch a female downy woodpecker (*Dendrocopos pubescens* L.) was pecking one of the cocoons. It was perched on the cocoon, pecking with some difficulty as the flexible branch moved with the force of its bill. I repeatedly tried to drive it away but it always quickly returned and continued to peck. This experience recalled my discussion with Drs. Dale F. Schweitzer and Charles L. Remington at Yale University earlier in the season of jays feeding on the pupa in cocoons and the studies of Wald-bauer, Sternburg et al. (1967, Ann. Entomol. Soc. Amer., 60: 97-101; 1967, Ecology, 48: 312-315; 1970, Ann. Entomol. Soc. Amer., 63: 1366-1369) in Illinois of woodpecker predation on *Hyalophora cecropia* cocoons.

I then gathered all the cocoons I could reach with a twelve-foot extension pruner. Most had holes in them, as shown in Fig. 1. I opened several to find in most a shriveled pupal shell, its contents cleverly removed, likely by the tongue of the woodpecker. Of the seven cocoons I was able to reach, only one appeared to contain a living pupa.

I was further surprised to observe that the woodpecker seems to know which cocoons contained viable pupae, since those containing parasitized pupae appeared to be purposely avoided. Two cocoons contained dead larvae with tell-tale shriveled egg shells of tachinid parasites on their surfaces.

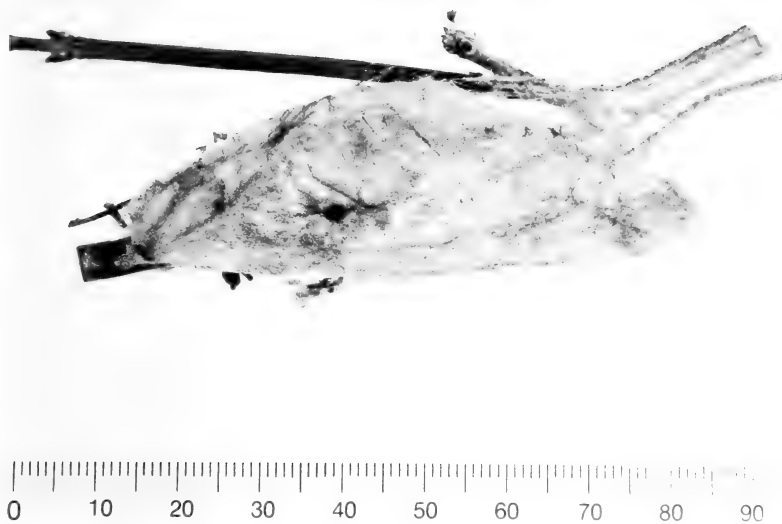


FIG. 1. Cocoon of *Hyalophora cecropia* with evidence of predation.

Perhaps, the woodpecker is able to hear or feel the rattle of a dry, shriveled pupae in the cocoon as it pecks, and hence avoids the wasted energy of drilling a hole through a tough pupal case only to find no food within.

It was extremely interesting to observe the behavior of this woodpecker as it methodically destroyed the remaining viable cocoons beyond my reach in the tree. There is no doubt woodpeckers find pupal Saturniidae a highly attractive food source during the winter.

THOMAS R. MANLEY, *Department of Biology, Bloomsburg State College, Bloomsburg, Pennsylvania 17815.*

OBITUARY

WILLIAM DONALD PATTERSON, JR., 1905-1980

William Donald Patterson, Jr., a sustaining member of the Lepidopterists' Society since 1953, died suddenly at his home in Atherton, California on 3 March 1980. Don's interest in Lepidoptera was avocational. He was interested in field work and in the support of studies of the butterfly and skipper fauna of Baja California, Mexico, and he further supported field work of students with other entomological projects in this area.

Don was born on 1 July 1905, in San Francisco, California. The first of three sons of William Donald Patterson and May Bird Patterson, he was raised in Centerville (now part of Fremont) and attended Piedmont High School. He graduated from Harvard University with an A.B. degree in Mining Engineering in 1927 and from Stanford University with an M.A. degree from the Graduate School of Business in 1930. In 1938 he was married to Dorothy Eden Wilcox.

Don, a third-generation Californian, a rancher and investor, operated the 3000 acre Patterson Ranch near Newark, Alameda Co., as well as a 10,000 acre cattle ranch near Livermore. His grandfather, George W. Patterson, came to California from Indiana in 1849 to join in the search for gold, and shortly thereafter bought a portion of the Spanish land grant—Rancho de los Potros de los Cerritos, which is now a part of the city of Fremont. The proximity of the ranch to San Francisco Bay permitted, in earlier days, the shipment of livestock and produce (especially wheat) by shallow draft schooners from a nearby slough to the port of San Francisco. The Livermore Ranch was acquired at a later time and has now become divided by the Lake Del Valle State Recreational Area, the establishment of which Don supported. Presently, this is a very popular aquatic recreational area; even though, as his son Bill recalls, this once was a beautiful valley with a sycamore lined creek. Thomas W. Davies remembers this area as the habitat of a large population of *Speyeria callippe* near *comstocki* (Gunder), which still occurs in smaller numbers on the slopes of the surrounding hills. The ranch is the type locality for the glyphierygid, *Choreutis apocynoglossa* Heppner (1976, Pan-Pacific Entomol., 52(3):256-262). In the early 1970's Don was interested in donating a portion of the ranch's oak woodland as a preserve, but unfortunately, there was no institutional support available for its establishment.

Don was an outdoors person, who began to collect butterflies and moths in his teens. He acquired some of the Lepidoptera books of his time—by Wright, Holland, McGlashan, and others, and he purchased specimens as well from a dealer in Hope, Arkansas. These collections became inactive and were stored in an attic. In the early 1950's his interest was renewed when his son Bill began collecting butterflies (the boy also discovered and salvaged specimens from the stored collections). In 1953 Don joined the Lepidopterists' Society as a sustaining member.

Don and Bill attended the 1954 Pacific Slope meetings of the society, in San Francisco, at the California Academy of Sciences. In 1955, Don was Secretary *Pro. Tem.* to the Second Pacific Slope meetings held at San Diego. At the Santa Barbara meetings in 1958 he presented an invited paper on the butterflies of the Sierra San Pedro Martir. It was during this period through contact with Dr. Jerry A. Powell, Charles F. Harbinson, and others, that his interest in Baja California butterflies was kindled (strengthened by his basic love of the peninsula). In late May and early June 1958, Dr. Powell, Bill Patterson, and Don made a 90 mile journey by foot, with mules carrying their gear, into the Sierra San Pedro Martir, Baja California Norte. Theirs was the first group of lepidopterists to explore the high tablelands with its coniferous forests. An interesting account of this exploration and record of species collected was published by Don & Powell (1960, J. Lepid. Soc., 13(4):229-235).

Don participated in over 20 trips into both the northern and southern states of Baja California, many of these for the purpose of collecting Lepidoptera. Most of the field work was undertaken before the present paved road was built, so that the country was rugged to explore. The trips were made by jeep, horseback, or by hiking and using



WILLIAM DONALD PATTERSON, JR., 1905–1980.
(Photography by F. Ramsdell Cummings.)

pack animals. Trip participants included his wife Dorothy, his son Bill, Dr. Ira L. Wiggins (on three trips), Joe Donohoe (on three trips), Dr. Powell, Dr. John T. Doyen, Sigurd L. Szerlip, Herman G. Real, and Colonel Forde. Joe Donohoe recalls Don's speciality of making soda biscuits in a reflector oven. Several thousand butterflies and skippers were collected as a result of the field work. Don was particularly pleased with the discovery and the patronym of *Erynnis tristis pattersoni* Burns (1964, Univ. Calif. Publ. Entomol., 37:143), and the co-discovery with Powell of *Apodemia mormo dileuca* Opler & Powell (1962, J. Lepid. Soc., 15(3):167–168). The *Erynnis* was collected in May 1959, in the Sierra de la Victoria, Baja California del Sur, and the *Apodemia* in May 1958, in the Sierra San Pedro Martir. More recently the scorpion, *Vaejovis pattersoni* Williams & Haradon, was described (1980, Occ. Pap. Calif. Acad. Sci., 135:65–66).

Don was interested in sponsoring research on the skippers and butterflies of Baja California, even though he did not anticipate publishing in this field himself. He hoped that such studies would contribute to a better understanding of the origin and relationships of the fauna of this peninsula. Arrangements were made in May 1969, to finance a post-doctoral position at the California Academy of Sciences with his commitment to provide a stipend for the first year of this study. A candidate for the position was selected, but at the last moment, that person decided otherwise. Starting in 1970,

Herman G. Real, then a student at San Jose State University, received partial support for several years, during which time he completed both his A.B. and M.A. degrees. His research focused on this region, and a large illustrated manuscript entitled "The Distribution of Skippers and Butterflies in Baja California, Mexico," was completed. This manuscript will be edited for publication in the near future.

Don also provided "seed money" to aid students in field work in Baja California. Small grants, usually of about \$500 each, were awarded through the California Academy of Sciences or the Explorers' Club. Between 1974 and 1979 the following persons received such awards (including the year and topic of research): Richard M. Haradon (1974, Scorpions); Warren E. Savary (1975, Solpugida); Dr. David B. Weissman (1977 and 1978, Orthoptera); Eric M. Fisher (1977, Diptera: Asilidae; in 1978, for field work at Barro Colorado Island, Panama); and Gay C. Hunter (1979, Diptera: Bombyliidae). In 1976 he provided the funds needed by the Academy to purchase the Robert G. Wind collection of North American butterflies (made available through the interest of Mrs. Clo Carroll).

Don was a very thoughtful man and an active person with many interests. He served as 80th president of the Society of California Pioneers in 1966-67. He served on the Board of Directors of the San Francisco Zoological Society and participated in a 1970 expedition to Nepal to collect an Indian Rhinoceros. This expedition utilized elephant transportation, and collections of butterflies were also made at this time. He also served on the Boards of Directors of the English Speaking Union of San Francisco and of the Leslie Salt Company. Don also held memberships in the Pacific Union Club of San Francisco and the Explorers' Club of New York and London. He was a West Coast Director of the San Francisco chapter of the Explorers' Club. In addition, Don was a Field Associate and Fellow (elected in 1971) of the California Academy of Sciences, a Vesterman of the Holy Trinity Episcopal Church in Menlo Park, and a member of the Atherton Town Planning Commission for 15 years. During the last 10 years, Don and his wife Dorothy spent each May in London, where they resided in the Sloane Square area. Don was a Fellow of the Royal Geographical Society and a member of both the English Speaking Union of London and the Zoological Society of London. During the Second World War, he oversaw work at the Joshua Hendy Iron Works of Sunnyvale, California.

Don is survived by his wife, Dorothy, Atherton, California, and 5 children: William D. Patterson, III, Sacramento; Wilcox Patterson, Woodside; George N. Patterson, Palo Alto; Mrs. Gerald Green, Ashland, Oregon; and Mrs. Eden Patterson, Jamestown, Tennessee; four grandchildren; and a brother, David G. Patterson, Alamo, California.

I am indebted to Mrs. Dorothy W. Patterson, Mr. William D. Patterson, III, Mr. Thomas W. Davies, Mr. Joseph A. Donohoe, IV, Mr. J. Roger Jobson, Dr. Jerry A. Powell, and Dr. Ira L. Wiggins for information contained in this article.

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Cover illustration: Mature larva of *Eumorpha fasciata* Sulzer (Sphingidae) feeding on *Ludwigia* sp. (Jussiaea) in southern Florida, where this hawk moth is generally found throughout the year. Original drawing by Mr. John V. Calhoun, 382 Tradewind Ct., Westerville, Ohio 43081, USA.

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FOODPLANT AND OVIPOSITION RECORDS FOR PANAMANIAN LYCAENIDAE AND RIODINIDAE

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ABSTRACT. We present larval foodplant and female oviposition records for 15 Panamanian butterfly species in the Lycaenidae and Riodinidae. Many of these species feed on reproductive parts of plants, e.g. flowers, rather than foliage. Some species are facultatively myrmecophilous, and one species may have an obligate relationship with ants. We discuss possible biological consequences of flower-feeding for lycaenid butterflies.

Larval foodplant records of Lycaenidae and Riodinidae are of particular interest for several reasons. First, many of these species feed as larvae on the flower-buds, flowers, and fruits of plants (Downey, 1962), and thus may exert stronger selective forces on their foodplants than foliage feeders (e.g. Breedlove & Ehrlich, 1968). Plant responses may include changes in flowering phenology (Breedlove & Ehrlich, 1968; Ehrlich et al., 1972) and synthesis of a variety of secondary compounds in flowers (Dolinger et al., 1973). The selective forces acting in turn on the butterflies, however, are unclear at present. Second, larvae of these related families utilize as a group a particularly broad spectrum of foods, including insect prey (Ehrlich & Raven, 1964). In addition, some species are unusually polyphagous (Downey, 1962). And third, the larvae of many lycaenid and riodinid species are tended by ants, a putatively mutualistic interaction (e.g. Hinton, 1951; Callaghan, 1977).

Larval foodplant records for Neotropical lycaenids and riodinids are more poorly known than those for other biogeographical regions (Downey, 1962). Many more records for this species-rich fauna need to be accumulated before general patterns of biological interest can be deduced or tested. We report here foodplant records that we made

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on Barro Colorado Island (BCI), Panama, a research station administered by the Smithsonian Tropical Research Institute, and in surrounding areas of Panama Province, Republic of Panama, during the past few years. We then discuss some possible consequences of flower-feeding by larvae and comment on the extent of myrmecophily in Panamanian riodinids.

Identification and deposition of insects and plants are as follows: Plants were identified by the junior author, by comparison with specimens in the Missouri Botanical Garden's herbarium in Ancon, Panama, and by various visiting botanists. Gordon B. Small of Balboa, Panama, and the senior author identified the butterflies by comparison with type specimens in the U.S. National Museum, with photographs of type specimens in the British Museum (Natural History), and with published plates and descriptions. Taxonomic notes are added where necessary to clarify identifications. Many of the species do not have valid generic names, and are placed for convenience in *Thecla* F., which correctly applies to species in a different tribe (Eliot, 1973). Larval head capsules, pupal skins, and adult specimens for species denoted by "Aiello lot #" are deposited in the collection of the junior author. Adult specimens and some preserved immature stages of other species are retained in the collection of the senior author.

We have had difficulty rearing many of these species from the egg with the notable exception of *Arawacus aetolus* Sulzer. As a result, some of our "foodplant" records are oviposition sightings. Other workers may be able to confirm whether or not these plants are suitable larval foodplants.

Lycaenidae

Arawacus aetolus lincoides (Draudt): We saw females ovipositing on the leaves and twigs of *Solanum lancaeifolium* in Gamboa on 10 September 1979, and 6 & 10 December 1979. Unlike many other lycaenids, females do not lay eggs on flowers or maturing fruits. Females oviposit readily on this plant in the lab, and we have reared more than a hundred individuals from eggs on the leaves of *S. lancaeifolium*. The ithomiine butterflies, *Mechanitis lysimia macrinus* and *M. polymnia isthmia* also oviposit on this plant species.

Although third and fourth instar larvae are often tended by the ants *Ectatomma tuberculatum*, *E. ruidum*, and *Pheidole* sp., they are reared easily in the lab without ants. A final (fourth) instar larva that we found in Gamboa on 2 January 1980 was tended by *Pheidole* and had a chalcidid wasp flying around it. This larva pupated between 4 & 6 January, and a chalcidid emerged on 25 January.

On 18 January 1980 we watched a female of *A. aetolus* oviposit on

Solanum ochraceo-ferrugineum along the road to Cerro Campana at 500 m. We found two other eggs and seven larvae on this plant. Two males and a female reared on leaves eclosed on 10 & 12 February. We switched another larva to *S. lancaefolium* after the third molt. It pupated on 4 February, and eclosed as a female on 14 February. In addition, the female that had oviposited on *S. ochraceo-ferrugineum* laid another 49 eggs on *S. lancaefolium* in the lab. Thirty-five of these eggs were reared to adult.

Boyce A. Drummond III reared three specimens of *A. aetolus separata* Lathy in Limoncocha (Rio Napo), Ecuador, on *Solanum coconilla*. A larva that he found on 4 June 1974 pupated on 8 June, and eclosed as a male on 19 June. Two larvae that he found on 19 June 1974 pupated on 26 June, and eclosed on 8 July (female) and 9 July (male).

Guppy (1904) reported the larval foodplant of the nominate subspecies from Trinidad as cocoa, but Kaye (1921) corrected the record to *Solanum* sp. It is likely that larvae of *A. aetolus* feed on a number of species of *Solanum* throughout its range.

Taxonomic note: Our identification of this species (and its subspecies) is based on an unfinished ms. of H. K. Clench. The senior author is completing this paper.

Tmolus echion (L.): We found a larva on leaves of *Stigmaphyllon lindenianum* (Malpighiaceae) on BCI on 31 May 1978. It pupated on 16 June, and eclosed on 29 June (Aiello lot 78-67).

A female of *T. echion* oviposited on a flower of *Aphelandra deppeana* (Acanthaceae) among numerous ants (*Ectatomma* sp.) on Taboga Island 12 miles off the southern coast of Panama on 24 December 1978. The ants were feeding on secretions from extra-floral nectaries on the flower bracts. We also found two egg shells on this flower, plus damage similar to that produced by lycanid larvae. No larvae were reared.

T. echion is of economic importance because it feeds on flowers of the weed *Lantana camara* (Verbenaceae). There are specimens reared from *L. camara* in the United States National Museum from Brasil (Sao Paulo, Rio de Janeiro, and Minas Gerais) and Costa Rica (Turrialba). Koebele introduced *T. echion* to Hawaii from Mexico about 1902 to control this weed (Swezey, 1913), and it was later introduced (1922-1923) (now extinct) to the Fiji Islands for the same reason (Robinson, 1975). Other larval foodplants of *T. echion* are the flowers of *Cordia sebestena* (Boraginaceae), *Datura arborea* (Solanaceae), *Solanum nodiflorum* (Solanaceae), and *S. sanitwongsei* in Hawaii (Zimmerman, 1958), and *Mangifera indica* (Anacardiaceae) in Brasil (Lima,

1936, 1947). Zimmerman (1958) and Lima (1947) list parasitoids of this species.

Taxonomic note: The ventral wing pattern of *T. echion* is remarkably similar to that of *Strymon basilides* (Geyer), and has been a continuing source of confusion. We follow Hewitson (1862–1878), Godman & Salvin (1887–1901), Draudt (1919–1920), and Clench (1961) in considering *T. echion* to be a senior synonym of *Thecla crolus* Cr., and not a senior synonym of *S. basilides* (but see Kaye [1908] and Lathy [1926] for a different opinion). *T. echion* lacks the red-orange spot of *S. basilides* located dorsally at the margin of cell Cu_1 - Cu_2 .

Larval foodplant records of *T. echion* and *S. basilides* have been somewhat confused as a result of the difficulty in identifying these species (e.g. Harris, 1927; Carter, 1933; Ehrlich & Raven, 1964). To date, however, *T. echion* has been recorded reliably only from dicots, and *S. basilides* only from monocots (see below).

"Thecla" mathewi Hew.: A larva feeding on a fallen corolla of *Cydistia* sp. (Bignoniaceae) pupated on 18 June 1979. A female eclosed before 4 July 1979.

Cyanophrys herodotus (F.): We found a green larva on the leaves of *Mikania* sp. (Compositae) on BCI on 7 May 1980. No flowers were present on the plant, and the larva was successfully reared on the leaves. Pupation took place on 13 May; a male eclosed 25 May (Aiello lot 80-47).

We observed a female bending her abdomen into the flowers of the introduced plant, *Clerodendron paniculatum* (Verbenaceae) on BCI on 1 August 1977 but could find no eggs. Females laid single eggs next to a bud of *Lantana camara* (Verbenaceae) on BCI on 7 June 1979 and on a flower stalk of *Cornutia grandifolia* (Verbenaceae) in Gamboa on 18 June 1979. Neither egg was successfully reared, but we infer that flowers of verbenaceous plants are an important larval food of this common species in Panama.

In Brasil, *C. herodotus* feeds on the flowers of *Mangifera indica* (Anacardiaceae) (three references in Silva et al., 1967–1968).

"Thecla" near enenia Hew.: We found a yellow and brown larva on the yellow flowers of *Mascagnia hippocratioides* (Malpighiaceae) on BCI, 31 May 1980. After it molted on 2 June we gave it flowers of a cultivated plant, *Hibiscus rosa-sinensis* (Malvaceae) (flowers of *Mascagnia* were no longer available). The larva ate the *Hibiscus* flowers and pupated 13 June. A small male eclosed at 1400 hours on 24 June. After eclosing the butterfly extruded and withdrew the brush organs (*sensu* Eliot, 1973) at the tip of its abdomen (Aiello lot 80-62).

Taxonomic note: This undescribed species is closely related to *enenia* Hew. Males possess a scent pad at the end of the forewing discal cell; whereas, males of *enenia*

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The printer inadvertently omitted the following paragraphs on page 69 from the above-titled article. This erratum is printed on gum-backed paper which may be moistened and affixed to the bottom of page 69.

"Thecla" hesperitis (B. & D.): We found two larvae inside fallen corollas of the liana *Cydista* sp. (Bignoniaceae) on BCI on 27 May 1979. Three nematomorph worms emerged from one larva on 30 May. The other larva molted to the final instar on 1 June, and pupated on 15 June. Eclosion occurred 27 June (Aiello lot 79-78).

Beutelspacher (1972) reared this widespread, common species from the leaves of *Tillandsia caput-medusae* (Bromeliaceae) in Mexico.

Strymon basilides (Geyer): A female laid an egg on an inflorescence bract of *Heliconia latispatha* (Musaceae) in Gamboa on 16 October 1979. We had found literally hundreds of eggs on the flowers and bracts of this common species and on the bracts of *H. wagneriana* during August 1979 when these plants first blossomed. Although *H. latispatha* continued to produce flowers until at least January, we found only occasional eggs on this plant after mid-September. Larvae brought into the lab on 6 & 8 September 1979 fed on flowers of *H. latispatha* by boring into them. One pupated on 15 September and another on 19 September. They eclosed as females on 23 & 27 September, respectively.

lack the scent pad. Otherwise, the two species are similar; future identification should pose no problems. We have seen specimens of *enenia* from Paraiba (Brasil), "Amazon," and Guiana. The new species is known from Panama and Honduras (Museum of Comparative Zoology).

"Thecla" ericusa Hew.: Kim Steiner reared a male and female of this common, widespread species on flowers of *Stigmaphyllon lindenianum* (Malpighiaceae). A larva that he found on 11 November 1977 at Gatun pupated on 19 November and eclosed as a female. A larva that he found on 8 April 1980 at Frijoles pupated on 13 April and eclosed as a male on 21 April. *T. ericusa* has been reared in Brasil from flowers of *Antigonum leptopus* (Polygonaceae) (Lima, 1947), where it is parasitized by a wasp of the genus *Tetrastichus*. In addition, there are four specimens in the U.S. National Museum from Trinidad and Tobago that were reared on the flowers of *Dioclea guinensis* and *Gliricidia* sp. (Leguminosae).

Taxonomic note: Identification of species in the *spurina-brescia* species groups (to which *T. ericusa* belongs) has been difficult (Clench, 1961, 1970). Draudt (1919-1920) noted that the proximal part of the duplex male scent pad of *T. ericusa* "has disappeared except some traces of it." This character is distinctive and is the primary basis of the present identification. Although the ventral wing pattern of the Brazilian type specimen (probably from the area around Rio de Janeiro) is considerably different from those in Panama, specimens with "intermediate" wing patterns occur in Bolivia, Colombia, and Venezuela. Male and female genitalia are indistinguishable among localities and differ only slightly from those of the apparently parapatric *brescia* Hew.

We watched a female lay a number of eggs on *Xiphidium caeruleum* (Haemodoraceae) in Gamboa on 21 September 1979 and found three larvae which had bored into the immature fruit of this plant. A larva pupated on 8 October and eclosed as a female on 17 October.

Larvae of *S. basilides* appeared to have Newcomer's glands on the 7th abdominal segment (Newcomer, 1912), but we found no ants associated with them. We reared no parasitoids, although others have (Harris, 1927; Carter, 1933; Lima, 1947).

This species has been raised on the bromeliads *Ananas cosmosus* (= *A. sativus*) and *Aechmea bracteata* (Harris, 1927; Carter, 1933; Beutelspacher, 1972; Silva et al., 1967–1968, list 38 Brazilian records) and will probably be recorded from the flowers and fruits of other monocots.

Taxonomic note: Confusion of foodplant records due to misidentifications of *S. basilides* and *T. echion* are noted under *T. echion*. A second source of confusion is that a few undescribed sibling species of *S. basilides* occur in various parts of its range, and some of the numerous records of pineapple (*A. cosmosus*) as a larval foodplant may refer to one or more of these sibling species.

The morphology of the male and female genitalia of *basilides* as well as adult behavior clearly indicate a close relationship with *melinus* Hbn., the type species of *Strymon*. *Basilides* will eventually be placed in *Strymon* or a closely related genus.

S. basilides has been misspelled as *S. basalides* by many workers (see Comstock & Huntington, 1959).

Strymon yojoa (Reakirt): We observed females bending their abdomens into flowers and buds of *Desmodium axillare* (Leguminosae) on BCI on 19 June and 15 July 1977 but could not find any eggs. On 19 July 1977, however, we found three larvae boring into the fruits of *D. axillare* where we had seen oviposition behavior. Although the larvae apparently had Newcomer's glands, no ants were tending them. The larvae fed in the lab on fruits and flowers of *D. axillare* and pupated on 23–27 June. Eclosion occurred on 4 July (two males) and 7 July (sex undetermined).

A female deposited a single green egg on an unopened bud of *Kohleria tubiflora* (Gesneriaceae) in Gamboa on 3 December 1979. We took the egg back to the lab but could not find the larva after it hatched. Although we found two eggshells on this plant, plus damage to buds and flowers typical of that done by lycaenids, we could not find any larvae.

This species has been reared previously from *Hibiscus tubiflorus* and *Hibiscus* sp. (Malvaceae) in Mexico (Kendall, 1975).

Michaelus vibidia (Hew.): We collected a yellow larva with brown stripes in a fallen corolla of *Pithecoctenium crucigerum* (Bignoniaceae) on BCI on 6 June 1978. The larva pupated on 10 June. The adult eclosed 24 June (Aiello lot 78-65).

Pseudolycaena damo (Druce): A female oviposited on a stipule of *Pterocarpus* sp. (Leguminosae) on BCI on 7 June 1979. The egg hatched on 11 June, but the larva died two days later. This species has been reared from *Croton niveus* (Euphorbiaceae) in Mexico (Kendall, 1975), but on BCI we found no immature stages of *P. damo* on *Croton bilbergianus* despite extensive searching.

"*Thecla*" *hemon* (Cramer): A female laid three eggs on twigs of *Inga pezizifera* (Leguminosae) on BCI on 8 June 1979. We found five other eggs on this plant. Although four eggs hatched, none was successfully reared. We also found three last instar larvae, presumably *T. hemon*, feeding on the leaves of this same plant on 15 June 1979, but they produced tachinid fly puparia from which no adult flies emerged. Previously recorded larval foodplants for *T. hemon* are *Inga* sp. in Brasil (Müller, 1878; Hoffman, 1930; Silva et al., 1967-1968) and the young shoots of *Theobroma cacao* (Sterculiaceae) in Trinidad (Guppy, 1904).

Riodinidae

Argyrogrammana crocea G. & S.: We found a flat orange-brown larva between two overlapping leaves of *Rheedia edulis* (Guttiferae) on BCI on 28 April 1979. The larva fed by scraping the leaf surface without disturbing the veins, which contain a white latex. The larva stopped eating and turned orange on 2 May. It made a silk girdle, consisting of numerous radiating strands, and pupated on 5 May. The pupa resembled the larva in color and pattern. Eclosion occurred on the evening of 17 May (Aiello lot 79-30).

Audre domina Bat.: A female laid four blue eggs on a twig of *Vismia baccifera* (Guttiferae) near several ants (*Ectatomma* sp.) that were tending membracids on Pipeline Road (five miles north of Gamboa) on 11 June 1977. An ant approached the female, and she flew away. We found 10 other eggs on this plant but found neither eggs nor ants on neighboring plants of the same species. The eggs hatched on 24 June, and the larvae died three days later.

A female flew about plants of *Turnera panamensis* (Turneraceae) on BCI on 18 May 1979 but did not land until she encountered a group of *Ectatomma tuberculatum*. As soon as she landed, several ants approached her. She flew away but returned several seconds later. This time as the ants approached her abdomen, she turned and presented them with her opened wings. While the ants repeatedly attacked her wings with their mandibles, she laid several blue eggs on the branch among some older darker ones. She then flew off to another group of ants. Four of the older eggs hatched on 19 May and

molted on 23 May. These second instar larvae, which resembled ant brood, did not feed and died a week later. The eggs laid on 18 May hatched on 31 May, but the larvae died shortly afterwards.

Last instar larvae of two species of *Audre* (= *Hamearis*, in part) pupate and diapause in ant nests (Bruch, 1926; Bourquin, 1953; see Hemming, 1934 for generic taxonomy), and we suspect that *A. domina*, which is apparently single-brooded in Panama, also has an obligate myrmecophilous relationship, including diapause in ant nests.

Thisbe irenea Stoll: Females oviposited on leaves and twigs of *Croton bilbergianus* (Euphorbiaceae) on BCI on 15 June 1977, on 6, 10, & 13 July 1977, and on 29 May 1979. We also found numerous larvae feeding on the leaves of this plant and reared three males and three females. Larvae fed only on younger leaves that had a pair of secreting extra-floral nectaries at their base on the underside of the leaf. Between feeding bouts, larvae rested along major leaf veins with their heads next to a nectary. We found at least five ant species tending both the nectaries and the larvae, although larvae are easily reared in the lab without ants. The larvae have pairs of "tubercles," which are occasionally everted, near their head and at their caudal end. These glands may be homologous with the "honey glands" and "eversible tubercles" reported by Ross (1966). Pupae have polyp-like glands that are tended by ants and have two black spots that give the appearance of holes through which parasitoids emerged. Pupae of the African lycaenid *Argiolaus maesa* also have spots that resemble parasitoid emergence holes (Hinton, 1955). Parasitoids of *T. irenea* include a chalcidid (*Spilochalcis* sp.) and a tachinid fly. In addition, one tachinid puparium had two small holes in it indicating that a hyperparasitoid had emerged from it.

DISCUSSION

Most of the lycaenids we reared oviposit and feed on reproductive parts of plants. A notable exception is *A. aetolus*, which appears to be an obligate foliage feeder; in both the field and lab, females do not oviposit and larvae do not feed on flowers and fruits of their solanaceous foodplants. *T. hemon* and *P. damo* may also feed primarily on foliage. We also found late instar larvae of *T. echion* and *C. herodotus* feeding on leaves, but females of these species have been seen ovipositing only on plant reproductive parts. On the other hand, we have never seen riodinids ovipositing on flower-buds, flowers, or fruits.

The biological consequences of flower-feeding for lycaenid butterflies, particularly in relation to polyphagy, have not been explored.

We tentatively propose three possible consequences that merit further investigation. First, flower-feeding may allow lycaenids, at least as early instar larvae, to feed on plants whose leaves are not available to butterfly larvae (perhaps due to chemical defenses). For example, Ehrlich & Raven (1964) list plant families including the Bignoniaceae, Gesneriaceae, and Begoniaceae that are not used, or are under-utilized by butterfly larvae. We recorded three flower-feeding lycaenid species (*M. vibidia*, *T. hesperitis*, and *T. mathewi*) on Bignoniaceae and one oviposition record (*S. yojoa*) on a flower in the Gesneriaceae. In addition, Zikan (1956) reared *Thecla azaria* Hew. from the flowers of a plant in the Begoniaceae. Many more records will be needed before we properly can assess the range of larval foodplants used by these insects. For evident reasons, we consider it imperative that foodplant records include the plant part fed upon.

A second consequence of flower-feeding is that it may allow individual lycaenid species to feed on a variety of unrelated plants. The range of seemingly unrelated foodplants used by some of the flower-feeding lycaenids discussed in this paper is striking and would be considered highly unusual for butterflies in other groups. In addition, one of the most polyphagous butterfly species known (*Strymon melinus* on 46 genera in 21 families [Howe, 1975]) is a flower-feeding lycaenid. Such polyphagy would be particularly advantageous to weedy, multivoltine species that frequently encounter changing habitats or seasons.

A third possible consequence of flower-feeding is that the abundance and diversity of adult lycaenid butterflies might "track" the abundance and diversity of flowering plants. The peak of flowering on BCI occurs at the end of the dry season (February to May) (Croat, 1978, p. 35), which corresponds to an increase of about two orders of magnitude in the abundance of lycaenid butterflies, at a time when many species in other butterfly families show a marked decrease in abundance (pers. obs.). A consequence of dry season abundance, in turn, is dispersal by strong, sustained dry season trade winds (Robbins & Small, 1981).

Myrmecophily has been recorded in many lycaenid species (e.g. Hinton, 1951) but for only seven species of Neotropical riodinids (Callaghan, 1977). We note that in addition to the records presented in this paper, we have encountered myrmecophilous larvae of at least five other riodinid species but were unable to rear them. We agree with Callaghan (1977) that a large proportion of the Neotropical riodinids will prove to be myrmecophilous.

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DIFFERENTIAL GROWTH AND UTILIZATION OF THREE FOODPLANTS BY FIRST INSTAR LARVAE OF *CITHERONIA REGALIS* (SATURNIIDAE)

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ABSTRACT. One hundred larvae of *Citheronia regalis* (Saturniidae) were reared singly in petri dishes through the first instar on three different foodplants. They grew most rapidly on persimmon (*Diospyros virginiana*), less so on sweetgum (*Liquidambar styraciflua*), and most slowly on wing-rib sumac (*Rhus copallina*). Survival was high on persimmon and sweetgum, but on sumac it was only 67 percent, with many larvae refusing to feed, and others dying after ingesting some food. Frass pellet counts done on 12 larvae indicated that persimmon was the most advantageous plant for larval growth, with sweetgum being of intermediate food value. Sumac may contain repellent or toxic chemicals which adversely affect larval growth. The differences in foodplant suitability apparently are genetic in this moth strain. These results further support the theory that neotropical ebonies (*Diospyros*) and *C. regalis* represent a co-evolved plant-herbivore relationship of long-standing, with the more temperate plant genera (*Liquidambar* and *Rhus*) having been exploited as alternate food sources only in comparatively recent times.

Among insects herbivory is widespread, with most species accepting a limited range of foodplants and exhibiting preferences for only one or two of these (Matthews & Matthews, 1978). Feeding responses are elicited by chemo-sensory cues (Dethier, 1966, 1970a & b; Barton-Browne, 1975), and a number of experiments involving lepidopterous larvae show clearly that such preferences can be induced and modified by prior experiences (Jermy et al., 1968; Feeny, 1970; Hanson, 1970, 1976; Hansen & Dethier, 1973). The degree to which plants and insects co-evolve has been intensively studied in several systems involving specific plant and lepidopteran groups (Ehrlich & Raven, 1964, 1967; Gilbert, 1971; Gilbert & Raven, 1975).

The polyphagous larvae of *Citheronia regalis* (Fabricius) (Saturniidae) (royal walnut moth) recently have been shown to exhibit differential growth and development on three genera of foodplants, representing three distinct plant families (Worth et al., 1979). These foodplants are persimmon (*Diospyros virginiana* L., Ebenaceae), sweetgum (*Liquidambar styraciflua* L., Hammamelidaceae), and wing-rib sumac (*Rhus copallina* L., Anacardiaceae). In that paper we postulated that persimmon and *C. regalis* were most compatible because of a long-standing, plant-herbivore relationship of neotropical origin; whereas, the latter two foodplants may have been exploited later by

this moth species as its geographic distribution extended into temperate regions.

The present paper will explore this hypothesis further by examining differential growth and leaf utilization among first instar *C. regalis* larvae on these same three foodplants. The demonstration of such feeding preferences in the young larvae at the onset of their leaf feeding will strengthen this hypothesis by indicating that such preferences have become genetically incorporated in the moth strain we have been studying. The previous experiments had not been designed to test the early larval feeding responses of the royal walnut moth.

MATERIALS AND METHODS

Ten freshly eclosed *C. regalis* females from the Eldora (Cape May Co.), New Jersey stock were tethered overnight (Worth, 1980) to attract either wild, or marked and released, males during late June and July 1979. Thirty fertile eggs from each female were placed singly in petri dishes lined with moist filter paper. Ten eggs each were placed on small leaf cuttings of persimmon, sweetgum, and sumac. Thus, a total of 100 eggs (including ten from each one of the females) was tested on each foodplant (300 in all), thereby maximizing the genetic variance within each subclass of the experiment.

Nine of the P_1 females had been reared on persimmon, whereas the tenth had fed on sumac. Among the nine persimmon females, four bred with released males, which also had fed on persimmon, and the remaining five bred with wild males, whose larval foodplants were unknown. The tenth female (reared on sumac) likewise bred with a released male, which had been reared on persimmon. Due to the heavy predominance of persimmon among the P_1 moths of both sexes, we have treated the broods as a fixed, rather than as a random, variable in the statistical analyses employed in this paper.

The petri dishes were examined daily to determine whether or not the larvae were feeding and if they required additional leaf material. All larvae were observed until they either molted to the second instar, or until they died. Four larvae on each foodplant (a total of 12 in all) were chosen at random from among the 100 larvae, and their frass pellets were counted daily in an attempt to relate leaf intake and relative assimilation to the duration of the first instar. Due to time limitations, larger numbers of larvae were not used to obtain these data. The small size and weights of these hatchling larvae likewise kept us from obtaining accurate larval and fecal pellet weights. However, since the fecal pellets are of uniform size the numbers produced by each larva represent a good substitute criterion.

TABLE 1. Effects of foodplant and brood on the duration of first instar (days) among 262 *Citheronia regalis* larvae, with a 2-way ANOVA test and mean pair comparisons. The samples represent ten 1979 broods of the Eldora, NJ stock. (The sample sizes are given in brackets.)

Duration of first instar ($\bar{x} \pm$ S.E.)	FOODPLANT			
	Persimmon (PR)	Sweetgum (SG)	Sumac (SM)	
	4.77 \pm 0.10 [95]	5.04 \pm 0.06 [100]	6.69 \pm 0.18 [67]	
ANOVA of duration of first instar (Foodplants and Broods are fixed)	df	Mean square	F-statistic	P
Between foodplants (F)	2	77.79	92.33	P < 0.005
Between broods (B)	9	3.58	4.25	P < 0.005
Interaction (F \times B)	18	2.80	3.32	P < 0.005
Within subclasses (individuals)	232	0.84	—	—

If the means (\bar{x}) are ordered from largest to smallest, Duncan's Multiple Range Tests show that the three means differ significantly from each other: PR < SG < SM (P < 0.05).

Our data have been analyzed using separate 2-way analysis of variance (ANOVA) tests on: 1) larval development time (duration of the first instar) and moth brood; and on 2) the number of frass pellets produced daily by the 12 larvae separated for this purpose. Due to an excessive number of zeros present in some of the daily frass count data, we performed a log transformation on the count data before analyzing them. Following both analyses, Duncan's Multiple Range Tests were used to test for statistical significance between individual mean pairs. Our statistical procedures follow those given by Freund et al. (1960).

RESULTS

Larval survival through the first instar was high (95–100%) on both persimmon and sweetgum but was much lower (only 67%) on sumac (Table 1). On the two aforementioned plants all larvae began to feed, as soon as their integuments had hardened. Those larvae placed on sumac, however, often wandered off the leaves, as if looking for another food source. Although a few began to feed immediately, the majority of larvae exhibited this wandering behavior. Many of the wanderers eventually returned to the sumac leaves and began to feed, although sparingly. Some never fed at all and starved to death while clinging to the presumably edible substrate. Each of the five larvae which died while feeding on persimmon was from a different brood. All fed well at first, and the cause of their deaths was not evident.

Table 1 shows the effects of foodplant and brood on the duration of first instar among the 262 surviving larvae. All three sample means

TABLE 2. Effects of foodplant and development time (days) on the number of frass pellets produced by 12 randomly chosen first instar *Citheronia regalis* larvae, with a 2-way ANOVA test and mean pair comparisons. The frass count data have been subjected to log transformation for analysis. (The total number of pellets is in brackets.)

	Actual \bar{x} \pm S.E. $\bar{x} \pm$ S.E. of transformed data	FOODPLANT		
		Persimmon (PR)	Sweetgum (SG)	Sumac (SM)
\bar{x} No. of frass pellets produced over a six day period by four larvae on each foodplant		18.17 \pm 3.63 [436]	27.88 \pm 5.00 [669]	30.25 \pm 3.36 [726]
		7.88 \pm 1.01	12.22 \pm 1.01	26.70 \pm 1.01
ANOVA of No. of frass pellets produced (Foodplants and days are fixed)	df	Mean square	F-statistic	P
Between foodplants (F)	2	1.73	39.69	P < 0.0005
Between days (D)	5	3.16	72.54	P < 0.0005
Interaction (F \times D)	10	0.85	19.61	P < 0.0005
Within subclasses (error)	54	0.04	—	—

Duncan's Multiple Range Tests show that the three $\log_{10}\bar{x}$'s (and consequently the other means, as well) differ significantly from each other: PR < SG < SM (P < 0.05).

are statistically significant from each other, with the larvae on persimmon exhibiting the most rapid growth and those on sumac the slowest growth rate. The between brood effects are also significant in this analysis, as is the foodplant \times brood interaction term. Thus, larvae from separate broods exhibit distinctive growth rates, and these relative rates vary differentially, depending on the type of foodplant utilized.

The frass pellet count results are given in Table 2. The numbers of droppings produced daily during the first instar by four larvae feeding on persimmon is significantly lower than the number produced by the four larvae feeding on either sweetgum, or sumac. Once again, all three means exhibit statistical significance and, likewise, both the effect between days and the foodplant \times days interaction term are statistically significant for the reasons given above.

The four larvae feeding on persimmon required only four days to complete the first instar, and they produced an average of 109 frass pellets. Those on sweetgum required five days in this stage and produced an average of 167 droppings. On sumac the first instar interval lasted six days, and the four larvae had a mean production of 182 fecal pellets.

DISCUSSION AND CONCLUSIONS

These results confirm and extend the conclusions of our earlier experiments. Persimmon represents the optimal foodplant for the El-

dora, New Jersey stock of *C. regalis* when compared to either sweetgum or wing-rib sumac. That sweetgum occupies an intermediate position is more clearly shown than in our former experiments, while sumac stands out as an inferior food resource. The moth larvae exhibit differential responses to these three foodplants immediately as they begin to feed. Our results further support the hypothesis that the persimmon-*Citheronia* relationship is one of long standing and one which has become highly adaptive.

The frass counts suggest that the three foodplants provide different nutritional values, since larvae on persimmon did not have to eat as much to attain full size. Larvae on sweetgum had to eat half again as much as the former ones did to achieve the same growth. Although these tiny larvae were not weighed or measured, by inspection those on persimmon and sweetgum attained the same average size, while those surviving on sumac, despite feeding longer and more voluminously, were smaller when entering their first ecdysis. Such differential utilization and assimilation of the three foodplant genera by freshly hatched first instar larvae strongly suggests that the New Jersey strain of *C. regalis* is genetically more compatible with persimmon than it is with either of the two other foodplant genera.

These findings suggest that the food substances and nutrients required by this larval strain of *C. regalis* can be obtained more easily from persimmon than from either sweetgum or wing-rib sumac. The food compounds and nutrients ingested from leaves belonging to the later two plants are more difficult for the larvae to extract and utilize metabolically. Consequently, the *regalis* larvae are forced to expend more energy ingesting greater amounts of leaf material to accomplish the same amount of assimilation and growth when feeding on sweetgum or wing-rib sumac, thus, reducing their ecological efficiencies as plant predators.

Also, repellents such as toxic chemicals are present in sumac, despite the ability of some larvae to subsist on this plant. Perhaps it is significant that some of the other species of *Rhus* (*R. radicans* L., *R. toxicodendron* L., and *R. vernix* L.) possess recognized poisonous qualities (such as tannins and lacquer-like substances contained in the leaves). In spite of this, at least one neotropical species (*Citheronia splendens* (Druce) is known to feed on certain Anacardine genera such as *Shinus* and *Rhus* (Vasquez, 1944), but this insect also uses walnut (*Juglans*) and wild cotton (*Gossypium*) in Arizona (Ferguson, 1971).

The sumacs (*Rhus* spp.) represent a temperate zone genus of an extensive tropical Family, consisting of about 50 genera and nearly 400 species (Rodgers, 1920). There are 16-17 species of *Rhus* in North

America, nine of which are tree sized, including *R. copallina*. Both sweetgum and persimmon represent relict genera of trees, numerous species of which are found in the Eocene deposits of western North America, dating back about 55,000,000 years B.P. (Peattie, 1966). Today, the genera *Liquidambar* and *Rhus* represent mainly temperate plant groupings; whereas, *Diospyros* is more closely affiliated with tropical ebonies. This, we believe, is why persimmon represents the better foodplant for *C. regalis*, a temperate moth species having numerous neotropical relatives. We suspect that *C. regalis* has exploited the temperate plant genera more recently and that *Diospyros* represents the major foodplant of long-standing.

Larvae obtained from the moth that had been reared on sumac (and had mated with a male reared on persimmon) did not display a higher survival rate on sumac than offspring of moths in which both parents had been reared on persimmon. Whether better adaptation to sumac would take place over successive generations when both parents are reared on sumac is a question to which the senior author will next direct his curiosity.

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DYSSSTROMA HERSILIATA FORM "MIRANDATA"—A RECESSIVE COLOR FORM (GEOMETRIDAE)

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ABSTRACT. Two successive generations of *Dysstroma hersiliata hersiliata* (Gn.) and *Dysstroma hersiliata* form "mirandata" (Tayl.) have been successfully reared in the laboratory. The results of selective matings have shown that *D. hersiliata* form "mirandata" is homozygous for a recessive color form of *D. hersiliata hersiliata*. Rearing and overwintering techniques are described.

Dysstroma hersiliata hersiliata was originally described by Guenée in 1857 and *D. h.* form "mirandata" by Taylor in 1910. Distinct differences between the two can be seen in the color of the median and antemedian bands. Specimens of *D. hersiliata* have a dark grey median band and a deep orange-yellow antemedian band with paler inner and outer margins; those of *D. h.* form "mirandata" have a yellow-brown median band with dark grey costal edge and an antemedian band which is a slightly darker orange-yellow than that of *hersiliata*. *Dysstroma h.* form "mirandata" is similar to *D. h. cervinifascia* (Wlk.) except for the antemedian band which in *cervinifascia* appears as a dark greyish yellow-brown band with a yellow-brown median margin.

Dysstroma hersiliata cervinifascia and *D. h.* form "mirandata" seem to have the same geographic distribution as *D. hersiliata*, in fact a collection made at Mistassini, Quebec by J. R. McGillis on 8 August 1956, have turned up *hersiliata*, *h. cervinifascia* and *h.* form "mirandata" specimens. The male and female genitalia of the above 3 all appear to be similar, which indicates a strong possibility that *h. cervinifascia* may be just another color form of *hersiliata* as well. Future rearings may prove or disprove this.

MATERIALS AND METHODS

Two adult females, one *D. hersiliata hersiliata* and one *D. hersiliata* form "mirandata" were captured 5 July 1978 at Dunrobin Ontario by Dr. Eugene Munroe. These were placed in individual 32 oz waxed cardboard containers in which gooseberry foliage and a vial of sugar water with a cotton wick were placed. After the females had died, all the eggs were placed on a piece of #40 nylon mesh over damp vermiculite in 8 oz clear plastic containers. The eggs were stored outdoors in a screened, shaded building until 10 October 1978, when the containers were placed in plastic bags and buried approximately 22.5 cm (9 inches) underground among gooseberry plants and left to

overwinter. On 19 April 1979, as the buds of the gooseberry were beginning to open, the eggs were removed from the ground, brought in to room temperature and placed in 8 oz plastic containers lined with damp tissue paper. After hatching, the larvae were placed into groups of 10 in 8 oz plastic containers with gooseberry foliage. Each resulting pupa was placed in individual 2 oz plastic vials with a small piece of damp wick. Soon after the moths emerged and their wings had dried they were placed in pairs in 32 oz waxed cardboard containers and set up in the same manner as the original parental rearing.

Twelve pairs were placed together for mating. The resulting eggs, larvae and pupae were prepared and cared for in the same manner as previously described.

One of the most difficult aspects of rearing this *Dysstroma* species was overwintering the eggs successfully. Several previous attempts to overwinter eggs for varying lengths of time in a refrigerated environment had failed. However, the eggs were successfully overwintered when buried in the ground. In the Ottawa area the ground in the winter of 1978-79 had a good snow cover for most of the winter; whereas, the ground in the winter of 1979-80 was bare for most of the season, resulting in deep frost penetration. This may have influenced the percentage of eggs which hatched successfully in the two winters; approximately 44% in 1978-79 and approximately 20% in 1979-80. Water did seep into the containers while they were buried in the ground both years, despite precautions taken against this; nevertheless, the eggs still hatched successfully. The humidity in the refrigerated environment was probably much too low, causing the previous failures.

RESULTS

By 10 July 1978 the original wild female *D. hersiliata* (79-1) had laid 40 eggs and the female *D. h.* form "mirandata" (79-2) 75 eggs. The eggs were laid singly, loosely attached to the foliage and bottom of the container. By 25 April 1979, 290 days later, 31 larvae of 79-1 and 58 larvae of 79-2 had hatched. By 4 June 1979, 36 days later, all adults of the F1 generation had emerged. The 79-1 stock produced 13 male and 10 female *hersiliata* offspring, (100% *hersiliata*), while 79-2 produced 11 male and 13 female *hersiliata*, as well as 10 male and 18 female "mirandata" offspring, (46% *hersiliata* and 54% "mirandata"). Of the 12 F1 generation matings, 7 were successful in producing F2 offspring. These are listed in Table 1.

There were only 2 distinct color forms from these crosses with no intermediates.

TABLE 1. Results of selective matings between *Dysstroma hersiliata* and *D. hersiliata* form "mirandata."

Number	Parent F1		Number of eggs	Offspring F2		% <i>hersiliata</i>
	Male	Female		<i>hersiliata</i>	"mirandata"	
1	<i>hersiliata</i> 79-1	<i>hersiliata</i> 79-2	30	5 female 5 male		100%
2	<i>hersiliata</i> 79-2	<i>hersiliata</i> 79-1	19	4 female 2 male		100%
3	<i>hersiliata</i> 79-1	"mirandata" 79-2	176	15 female 19 male	9 female 25 male	50%
4	<i>hersiliata</i> 79-2	<i>hersiliata</i> 79-2	25	1 female	1 male	50%
5	"mirandata" 79-2	"mirandata" 79-2	45		13 female 11 male	0%
6	<i>hersiliata</i> 79-2	<i>hersiliata</i> 79-2	23	2 female 2 male		100%
7	<i>hersiliata</i> 79-2	<i>hersiliata</i> 79-2	41	2 male		100%

CONCLUSION

The wild female *D. h.* form "mirandata," 79-2, produced both *hersiliata* and *h.* form "mirandata" offspring demonstrating that the two are color forms of the same species. If one assumes that "mirandata" is the recessive color form, and judging by the 46% *hersiliata* and 54% "mirandata" F1 generation 79-2 produced, then one of the partners of 79-2 would have been homozygous for the recessive color characters, aa, while the other partner would have been heterozygous, Aa (aa × Aa). The wild female *hersiliata*, 79-1, produced only *hersiliata* offspring. If one assumes that *hersiliata* is the dominant color form then the partners of 79-1 could have been only two possible combinations, judging by the 100% *hersiliata* F1 generation that was produced. Either both partners were homozygous for dominant color characters, AA and AA, or one partner was homozygous, AA, and the other heterozygous, Aa (AA × AA or Aa × AA). In pair number 3 of the F1 matings a male *hersiliata* offspring from 79-1 was mated with a female "mirandata" offspring from 79-2. Since 50% of the F2 generation was *hersiliata* and 50% "mirandata," the F1 generation of 79-1 probably resulted from an Aa × aa mating, producing 50% of the F1 generation of 79-1 heterozygous and 50% homozygous for the recessive color form (Aa or aa). If the male of 79-1 had been homozygous for the dominant color character then all the F2 generation of the number 3 F1 mating would have been as the *hersiliata* color form.

In pair number 5 of the F1 matings a male and female "mirandata" of 79-2 were mated. All of the F2 generations were the "mirandata" color form as would be expected if "mirandata" is the recessive form. I therefore conclude that typical *D. hersiliata* is a dominant color form and that *D. h.* form "mirandata" a recessive color form.

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DATES OF SELECTED LEPIDOPTERA LITERATURE FOR THE WESTERN HEMISPHERE FAUNA

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ABSTRACT. Lepidoptera literature of 58 authors, involving Western Hemisphere species which have had various dates applied to specific titles, are listed and correct dates noted. In some cases works are given dates by sections of pages and plates.

This selection of literature references on Western Hemisphere Lepidoptera, primarily original descriptions of taxa, does not include all works on Lepidoptera of this fauna. Included are only those works that have repeatedly been dated incorrectly by subsequent authors or had various kinds of confusion surrounding their correct dates. In many cases dates of specific pages or plates are noted.

This list was originally prepared in conjunction with the work of the collaborators now engaged in cataloging and reviewing the Neotropical Lepidoptera for the series, *Atlas of Neotropical Lepidoptera*. Inasmuch as various dates have often been applied to various works on Neotropical Lepidoptera, this list was prepared to determine the correct dates of certain works as best known at this time, thus ensuring consistency regarding dates used in the *Atlas*. It is hoped that this listing will also be of help to other authors when consulting these works.

The literature is listed alphabetically and chronologically by author. For each of the 58 authors in the main listing, their full known name and dates of birth and death are provided when known. Likewise, the full titles to each work are given. A second section to this listing covers works on dates of the main citations and other works on Lepidoptera.

A number of persons helped to ensure the accuracy of dates in this listing, the following having been especially involved: D. S. Fletcher, and K. Sattler [British Museum (Natural History), London]; J. G. Franclemont (Cornell University, Ithaca, New York); A. Diakonoff (Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands); G. Lamas (Museo de Historia Natural, Lima, Peru); and J. F. G. Clarke and E. L. Todd (Smithsonian Institution, Washington, D.C.).

Selected Lepidoptera Literature

Agassiz, Jean Louis Rodolphe (1807-1873)

1842-1847. Nomenclator zoologicus, continens nomina systematica generum ani-

malium tam viventium quam fossilium. Soloduri: Jent and Grassman. 12 fascicles. [Lepidoptera: fascicle 9–10, 1846. Index universalis, 1847. (see Bowley & Smith, 1968; Fletcher, 1979)].

Berthold, Arnold Adolph (1803–1861)

1827. *Natürliche Familien des Thierreichs. Aus dem französischen, mit Anmerkungen und Zusätzen.* Weimar. 604 pages. [predates Latreille, 1829, of which it is a German translation with additions by Berthold.]

Boisduval, Jean Baptiste Alphonse Déchauffour de (1801–1879)

1832. *Faune entomologique de l'océan Pacifique: Lépidoptères.* In, *Voyage de . . . l'Astrolabe . . . pendant . . . 1826–29, sous le commandement de M. J. Dumont d'Urville, & c.* Paris: Tastu. 267 pages, plates 1–5. [April 1832].

1836. *Histoire naturelle des insectes: Spécies général des lépidoptères.* Paris: Roret. 690 pages, 24 plates. [type-species designations do not conform to Article 69(a) (iii) of the ICZN] [11 April 1836; see Cowan, 1969].

[1875]. *Sphingides, Sesiidae, Castnides.* In J. B. A. D. de Boisduval and A. Guenée, *Histoire naturelle des insectes: Spécies général des lépidoptères hétérocères*, 1:568 pages, 11 plates. Paris: Roret. [not 1874].

Busck, August (1870–1944)

[1934]. *Microlepidoptera of Cuba.* *Entomologica Americana* 13:151–202, plates 30–36. [not 1933].

Butler, Arthur Gardiner (1844–1925)

1869–1874. *Lepidoptera exotica, or descriptions and Illustrations of Exotic Lepidoptera.* London: E. W. Jansen. 190 pages, 64 plates. [Pp. 129–136 missing through typographical error].

	Pp.	1–8	Pls.	1–3
Jun 1869		9–58		4–22
Sep 1869–71		59–66		23–25
Apr 1871		67–74		26–28
Jul 1871		75–84		29–32
Oct 1871		85–94		33–35
Jan 1872		95–104		36–38
Apr 1872		105–114		39–41
Jul 1872		115–120		42–44
Oct 1872		121–128		45–48
Jan 1873		137–144		49–51
Apr 1873		145–152		52–54
Jul 1873		153–162		55–57
Oct 1873		163–174		58–60
Jan 1874		175–190		61–64
Apr 1874				

Clerck, Carl Alexander (1710–1765)

1759–[1764]. *Icones insectorum rariorum cum nominibus eorum trivialibus, locisque e C. Linnaei . . . Systema Naturae allegatis.* Holmiae [=Stockholm]. 21 pages, 55 plates. [1759: plates 1–12. [1764]: plates 13–55. (see Higgins, 1970)].

Costa, Orenzio-Gabriele (1787–1867)

[1836]–1850. *Lepidotteri.* In *Fauna del Regno di Napoli ossia enumerazione di tutti gli animali che abitano le diverse regioni di questo regno e le acque che le bagnano contenente la descrizione de nuovi o poco esattamente conosciuti.* Naples: Torchi. 446 pages, 38 plates. [dates by Direction 59 (see Tremewan, 1977)].

[1836]	Pp. 1-314
1848	315-370
1849	371-402
1850	403-418
1849	419-422

Cramer, Pieter (1721-1776)

1775-1782. *De Uitlandsche Kapellen voorkomende in de drie waereld-deelen Asia, Africa en America*. Amsterdam: Baalde. 4 volumes, 400 plates. [Opinion 516, plus Cramer as author of vol. 4 by posthumous publication (see Roepke, 1956)].

1775	Vol. 1: pp. 1-132	Pls. 1-84
1776	133-156	85-96
1777	Vol. 2: pp. 1-152	97-192
1779	Vol. 3: pp. 1-104	193-252
1780	105-176	253-288
1780	Vol. 4: pp. 1-90	289-336
1781	91-164	337-372
1782	165-252	373-396
1782	Supplement (by C. Stoll)	
	Pp. 1-20	397-400

Curtis, John (1791-1862)

1823-1839. *British entomology; being illustrations and descriptions of the genera of insects found in Great Britain and Ireland: containing coloured figures from nature of the most rare and beautiful species, and in many instances of the plants upon which they are found*. London. 16 vols., 770 pls. [See Sherborn & Durrant (1911): title page dated 1823 but plates are dated from 1824-1839. Second edition is dated 1829-1840 from the plates. Third edition is a reprint dated 1862.]

[Denis, Johann Nepomuk Cosmas Michael (1729-1800), and Ignaz Schiffermüller (1727-1809)]

1775. *Ankündigung eines systematisches Werkes von den Schmetterlingen der Wienergegend*. Vienna: Bernardi. 322 pp., 2 pls. [Authorship and date by Opinion 516 (ICZN); 1776 edition with altered title page; see Sattler, 1970]

Diakonoff, Alexey Nikolaevich

[1968]. *Microlepidoptera of the Philippine Islands*. Bull. U.S. Natl. Mus. 257:1-484. [31 Jan. 1968, not 1967; see Clarke, 1980].

Donovan, Edward (1768-1837)

1792-1813. *The natural history of British insects; explaining them in their several states . . . with the history of such minute insects as require investigation by the microscope*. London. 16 vols., 576 pls.

1792	Vol. 1	100 pp.	Pls. 1-36
1793	2	102 pp.	37-72
1794	3	100 pp.	73-108
1795	4	102 pp.	109-144
1796	5	116 pp.	145-180
1797	6	92 pp.	181-216
1798	7	102 pp.	217-252
1799	8	92 pp.	253-288
1800	9	82 pp.	289-324
1801	10	102 pp.	325-360
1804	11	107 pp.	361-396

1807	12	107 pp.	397-432
1808	13	78 pp.	433-468
1810	14	95 pp.	469-504
1811	15	88 pp.	505-540
1813	16	101 pp.	541-576

1822-1827. Naturalist's repository, or miscellany of exotic natural history exhibiting . . . specimens of foreign birds, insects, shells, & c. London. 5 vols., 180 pls. [See Reynell (1917): each number published as 3 plates and accompanying text each month.]

[Apr 1822-Mar 1823]	Vol. 1: viii & 198 pp.	Pls. 1-36
[Apr 1823-Mar 1824]	Vol. 2: iv & 236 pp.	37-72
[Apr 1824-Mar 1825]	Vol. 3: iv & 104 pp.	73-108
[Apr 1825-Mar 1826]	Vol. 4: iv & 113 pp.	109-144
[Apr 1826-Mar 1827]	Vol. 5: iv & 98 pp.	145-180

Doubleday, Edward (1811-1849)

1846-1852. The genera of diurnal Lepidoptera: comprising their generic characters, a notice of the habits and transformations, and a catalogue of the species of each genus. London: Longman. 534 pp., 67 pls. [See Hemming (1941): J. O. Westwood authored volumes from 1850-1852.]

1846	[Vol. 1]	Pp. 1-18	Pls. A-4
1847		19-132	5-25 & 28
[1848]		133-142; 145-200	26-27; 29; 31-44
[1849]		201-242	30; 45-52; 56-58; 60-62; 64
[1850]	[Vol. 2]	243-326	53-55; 63; 65-66
[1851]		327-466	59; 67
[1852]		467-534	—

Druce, Herbert (1846-1913)

1881-1900. Lepidoptera-Heterocera, in F. D. Godman and O. Salvin, *Biologia Centrali-Americana*; or, contributions to the knowledge of the fauna and flora of Mexico and Central America. Zoology: Insecta. London: Taylor & Francis. 3 vols.

1881	Vol. 1: pp.	1-24	
1883		25-32	
1884		33-112	
1885		113-160	
1886		161-200	
1887		201-256	
1889		257-344	
1890		345-440	
1891		441-490	Pls. 1-40 [undated]
1891	Vol. 2: pp.	1-24	
1892		25-128	
1893		129-184	
1895		185-272	
1896		273-336	
1897		337-440	
1898		441-536	
1899		537-592	
1900		593-622	Pls. 41-101 [undated]

Drury, Dru (1725-1803)

1770-1782. Illustrations of natural history; wherein are exhibited . . . figures of exotic insects, according to their different genera, & c. London: White. 3 vols. [See Opinion 474 (ICZN)].

1770	Vol. 1: 130 pp., 50 pls. [no scientific names]
1773	(index to vol. 1) [plus scientific names]
1773	Vol. 2: 90 pp., 50 pls.
1782	Vol. 3: 76 pp., 50 pls.

Duponchel, Philogene Auguste Joseph (1774–1846)

1844–1846. Catalogue méthodique des lépidoptères d'Europe pour servir de complément et de rectification à l'histoire naturelle des lépidoptères de France. Paris: Méquignon-Marvis 523 pp.

1844	Pp. 1–64
1845	65–296
1846	297–523

Dyar, Harrison Gray (1866–1929)

[1903]. A list of North American Lepidoptera and key to the literature of this order of insects. Bull. U.S. Natl. Mus. 52:1–723. [not 1902; see Clarke, 1950].

Esper, Eugen Johann Christoph (1742–1810)

1776–[1830]. Die Schmetterlinge in Abbildungen nach der Natur mit Beschreibungen. Erlangen: W. Walthers. 5 vols. [See Heppner, 1981].

Teil I: Die Tagsschmetterlinge.

1776	Pp. 1–72	Pls. 1–12
1777	73–176	13–36
1778	177–216	37–48
1779	217–388	49–50

Fortsetzung.

1780	1–36	51–56
1781	37–124	57–74
1782	125–140	75–80
1783	141–172	81–88
1784	173–184	89–92
1786	185–190	93

Supplement. Teil I: Abschnitt 1.

1789	1–60	94–101
1794	61–68	102–106
[1798]	69–88	107–109
1800	89–104	110–112
[1803–04]	105–120	113–116

Supplement. Teil 2.

1805	1–24	117–122
[1805–30]	25–48	123–126

Teil II: Die Abendsschmetterlinge.

1778	Pp. —	Pls. 1–6
1779	1–80	7–18
1780	81–196	19–[25]

Fortsetzung.

1782	197–212	26–31
1783	213–228	32–35
1786	229–234	36

Supplement. Abschnitt 2.

1789	1–4	37
[1789]	5–12	[38–40]
1794	13–16	41
1798	17–20	—
1800	21–40	42–46
[1803–04]	41–52	47

Theil III: Die Nachtschmetterlinge.

1782	Pp.	1-56	Pls.	1-12
1783		57-104		13-23 & 6A
1784		105-136		24-31
1785		137-272		32-55
1786		273-396		56-79

Supplement. Abschnitt 3.

1789		1-36		80
[1789]		—		81-85
1794		37-64		86-90
[1798]		65-72		91
1800		73-94		92-93
[1800-07]		95-100		94
[1807]		101-104		—

Theil IV: Die Eulenphalenen.

Band I.

1786	Pp.	1-32	Pls.	80-91	(Noct. 1-12)
1787		33-112		92-121	(Noct. 13-42)
1788		113-160		122-139	(Noct. 43-60)
1789		161-176		140-145	(Noct. 61-66)
1790		177-208		146-155	(Noct. 67-76)
				(rev. pls. 99B & 105B)	
1791		209-352		156-177	(Noct. 77-98)
				(rev. pls. 117a & 125b-c)	
1794		353-372		178-183	(Noct. 99-104)

Band II. Abschnitt 1.

1796		373-420		184-186	(Noct. 105-107)
1798		421-464		187-191	(Noct. 108-112)
[1799-1803]		465-496	[192-193]		(Noct. 113-114)
1804		497-632		194-196	(Noct. 115-117)
1805		633-698		197-198	(Noct. 118-119)

Band II. Abschnitt 2.

1798		1-44		—
[1799-1803]		45-54		—
1804		55-62		—
1805		63-85		—

Theil V: Die Spannerphalenen. [pp. 129-148 lacking by error in numbering]

1795	Pp.	1-40	Pls.	1-4
[1795-1801]		41-196		5-35
1801		197-220		36-40
1803		221-244		41-46
[1806]		245-276		47-52

1784-1801. Die ausländischen oder die ausserhalb Europa zur Zeit in den übrigen Welttheilen vorgefundenen Schmetterlinge in Abbildungen nach der Natur mit Beschreibungen. Erlangen: W. Walthers. 254 pp., 63 pls. [See Hayward, 1953; Poche, 1938].

1784	Pp.	1-20	Pls.	1-4
1785		21-36		5-8
1786		37-52		9-12
1788		53-64		13-16
1790		65-80		17-20
1791		81-96		21-24
1792		97-144		25-36
1793		145-160		37-40
1796		161-192		41-46

1797	193-204	47-50
1799	205-220	51-54
1801	221-254	55-59 & 60A-D

Eversmann, Eduard Friedrich von (1794-1860)

1841. Fauna entomologica, quam per viginti fere annes in provinciis Volgam fluvium inter et montes Uralenses observavit et descriptionibus illustravit. Vol. 1: Lepidoptera. Casani. 166 pp.

1844. Fauna lepidopterologica Volga-Uralensis exhibens lepidopterorum species. Casani. 633 pp. [A revised edition of 1841, with added pages.]

Fabricius, Johann Christian (1745-1808)

1777. Genera insectorum eorumque characteres naturales . . . adjecta mantissa specierum nuper detectarum. Chilonii [=Cologne]: Bartsh. 324 pp.

1781-[1782]. Species insectorum exhibentes eorum differentias specificas, synonyma auctorum, loca natalia, metamorphosin adiectis observationibus, descriptionibus. Hamburg & Cologne: Bohn. 2 vols.

1781 Band 1: pp. 1-552

Band 2: pp. 1-494

[1782] Appendix: pp. 495-514; index pp. 515-517.

1807. In J. C. Illiger, Die neueste Gattungs-Eintheilung der Schmetterlinge aus den Linneischen Gattungen *Papilio* und *Sphinx*. Mag. Insektenkunde 6:277-295. [See Opinion 232 (ICZN) for priority over Fabricius, 1807b.]

1807b. Index alphabeticus in systema antliatorum genera et species continens . . .

1806. Brunsvici [=Braunschweig]: Reichard. 32 pp.

Feisthamel, Joachim Francois Philiberto de (1791-1851)

1839. Supplement a la zoologie du voyage de la Favorite comprenant la description de lépidoptères nouveaux. Mag. Zool. 9:17-26; 10 pls. [Reprinted in 1840: 13 pp., 10 pls. Paris: Bertrand.]

Felder, Cajetan (1814-1894), Rudolf Felder (1842-1871), and Alois Friedrich Rogenhofer (1831-1897)

1865-1875. Reise der österreichischen Fregatte Novara um die Erde in den Jahren 1857, 1858, 1859 unter den Behilfen des Commodore B. von Wüllerstorff-Urbair. Zoologischer Theil. Zweiter Band: Zweiter Abtheilung. Vienna. 5 parts, 140 pls. [See Dalla Torre, 1913; Fletcher, 1979; Higgins, 1963].

[1865]	Heft 1 (Felder & Felder)	Pp. 1-136	Pls. 1-21
1865	Heft 2 (Felder & Felder)	137-378	22-47
1867	Heft 3 (Felder & Felder)	379-535	48-74
1874	Heft 4 (R. Felder)	1-10	75-107
1875	Heft 5 (R. Felder & Rogenhofer)	1-20	108-140

Fischer von Röslerstamm, Josef Emanuel (1787-1866)

1834-1843. Abbildungen zur Berichtigung und Ergänzung der Schmetterlingskunde, besonders der Microlepidopterologie als Supplement zu Treitschke's und Hübner's europaischen Schmetterlinge, mit erläuterndem Text. Leipzig. 308 pp., 100 pls. [20 parts]. [See Fletcher & Griffin, 1943.]

1834	Pp. 1-16	Pls. 1-10
1835	17-36	11-20
1836	37-60	21-30
1837	61-102	31-40
1838	103-132	41-50

1839	133-188	51-65
1840	189-216	66-75
1841	217-268	76-90
1842	269-288	91-95
1843	289-308	96-100

Freyer, C. F. (?)

1831-1858. *Neuere Beiträge zur Schmetterlingskunde mit Abbildungen nach der Natur*. Augsburg. 7 vols., 700 pls.

1831	Vol. 1: pp.	1-80	
1832		81-162	
1833		163-182	Pls. 1-96 [undated]
1833	Vol. 2: pp.	1-40	
1834		41-82	
1835		83-114	
1836		115-162	Pls. 97-192 [undated]
1836	Vol. 3: pp.	1-20	
1837		21-52	
1838		53-124	
1839		125-166	Pls. 193-288 [undated]
1839	Vol. 4: pp.	1-20	
1840		21-82	
1841		83-94	
1842		95-166	Pls. 289-384 [undated]
1842	Vol. 5: pp.	1-40	
1844		41-92	
1845		93-164	Pls. 385-480 [undated]
1846	Vol. 6: pp.	1-20	
1848		21-82	
1849		83-104	
1850		105-146	
1851		147-198	
1852		(title page)	Pls. 481-600 [undated]
1858	Vol. 7: pp.	1-180	Pls. 601-700 [undated]

[no wrapper dates available for parts of volume 7]

Godart, Jean Baptiste (1775-1825)

1819-[1824]. *Papillons*. In *Histoire naturelle; entomologie, ou histoire naturelle des crustacés, des arachnides, et des insectes*, in *Encyclopédie méthodique*. Vol. 9. Paris. [See Cowan (1967, 1968) for parts credited to Latreille].

1819	Pp.	1-328
[1824]		329-828

Godman, Frederick Ducane (1834-1919), and Osbert Salvin (1835-1898)

1879-1901. *Lepidoptera-Rhopalocera*. In *Biologia Centrali-Americana . . . Zoology: Insecta*. London: Taylor & Francis. 3 vols.

1879	Vol. 1: pp.	1-56
1880		57-88
1881		89-168
1882		169-224
1883		225-288
1884		289-360
1885		361-400
1886		401-487
1887	Vol. 2: pp.	1-112
1889		113-184

1890	185-240
1893	241-328
1894	329-384
1895	385-416
1896	417-440
1897	441-448
1899	449-460
1900	461-588
1901	589-782
[no date]	Vol. 3: 112 pls.

Gray, George Robert (1808-1872)

1853. Catalogue of lepidopterous insects in the . . . British Museum. Pt. 1: Papilionidae. London. 84 pp., 15 pls. (8 Jan 1853) [See Sherborn, 1934].

Grose-Smith, Henley (1833-1911), and William Forsell Kirby (1844-1912)

1887-1902. *Rhopalocera exotica*, being illustrations of new, rare, and unfigured species of butterflies. London: Gurney & Jackson. 3 vols. [Exact dates for different sections need to be ascertained from the appropriate species name, since the volumes are completely mixed as to dates for the various species and pages are not consecutive but involve only each species description in most cases.]

Guenée, Achille (1809-1880)

1845. Essai sur une nouvelle classification des microlépidoptères et catalogue des espèces Européennes connues jusqu'à ce jour. *Ann. Soc. Ent. France* (2) 3:105-192, 297-344.

[1846]. *Europaeorum microlépidopterorum index methodicus*. Paris: Roret. 106 pp. [Reprint of 1845 paper].

Guérin-Méneville, Felix Edouard (1799-1874)

1830-[1838]. Crustacés, arachnides et insectes. *In Voyage autour du monde . . . sur . . . la Coquille pendant . . . 1822-25 . . . par M. L. I. Duperry, & c.* Vol. 2 (2) (1). Paris. 319 pp., 22 pls. (Lepidoptera: pp. 271-286 [10 Dec 1838]) [See Cowan, 1971a].

1830 (26 May)	Pls. 13-14
1831 (29 May)	14**
1830 (1 Sep)	15-16
(25 Nov)	17
1831 (15 Jun)	18
(7 Mar)	19

1829-1844. *Rhopalocera*. *In Iconographie du règne animal de G. Cuvier, ou représentation d'après nature de l'une des espèces les plus remarquables et souvent non figurées de chaque genre d'animaux. Avec un texte descriptif mis au courant de la science. Ouvrage pouvant servir d'atlas a tous les traités de zoologie*. Paris. (Insects: 576 pp., 110 pls.) [See Cowan, 1971d].

1829	Pls. 3-12
1830	13-14, 21-24
1831	25-30, 42-46, 52-55, 60, 62, 76, 24-25 bis, 28 bis
1832	77-92, 99, 84 bis
1833	31, 36-39, 47-49, 59, 101, 39 bis
1834	32-35, 50, 61, 64-66, 49 bis
1835	15-20, 40, 51, 56-58, 67-75, 93-98
1836	100, 102-104
1837	1-2, 41, 63
1844	Text pages 1-576

Haworth, Adrian Hardy (1767-1833)

1803-1828. *Lepidoptera Britannica, sistens digestimen novam lepidopterorum quae in Magna Britannica reperiunter . . . adjunguntur dissertationes variae ad historiam naturalam spectantes*. London: J. Murray. 609 pp. [4 parts].

1803	[Part 1]	Pp. 1-136
[1809]	[Part 2]	137-376
[1811]	[Part 3]	377-512
1828	[Part 4]	513-609

Heinemann, Hermann von (1812-1871)

1863-[1876]. *Die Schmetterlinge Deutschlands und der Schweiz. Zweite Abtheilung. Kleinschmetterlinge*. Braunschweig: Schwetschke. 2 vols. [With F. Wocke for Vol. 2, part 2].

1863	Vol. 1 (Part 1)	Pp. 1-248; plus 1-39
1865	Vol. 1 (Part 2)	1-214; plus 1-27
1870	Vol. 2 (Part 1)	1-388
[1876]	Vol. 2 (Part 2)	389-825; plus 1-102

Herrich-Schäffer, Gottlieb August Wilhelm (1799-1874)

1843-1856. *Systematische Bearbeitung der Schmetterlinge von Europa, zugleich als Text, Revision und Supplement zu Jakob Hübner's Sammlung europäischer Schmetterlinge*. Regensburg: G. J. Manz. 6 vols. [See Hemming, 1937].

Volume 1: Die Tagfalter

1843	Papilionides	Pp. 1-40	Pls. 1-5, 29-34
1844		41-122	6-28, 35-52
1845		123-162	53-57
1846		163-164	58-70
1847		—	71-77
1848		—	78-79
1849		—	90-91
1850		—	92-102
1851		—	103-118
1852		—	119-127, 130-132, 134
1853		—	128-129, 133
1854	[Index]	1-20	
1855	[Index]	21-24	
1845	Hesperides	—	Pls. 1-3
1846		—	4-5
1848		—	6
1854		—	7

Volume 2: Die Schwärmer, Spinner und Eulen

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1863	Pp. 1-36	Pls. 1-16
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1816	Pp.	1-16
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1823	Part 3:	1–6	13–18
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1884	Volume 3:	1–88	144–157
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1907	Pp. 1-40	Pp. 1-48
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	English Edition	German Edition
1913	Pp. 1-32	Pp. 1-32
1915	33-192	33-192
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1918	233-280	249-280
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English Edition		German Edition	
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1925	157-228		181-228
1926	229-308		229-308
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1889			181-224		35-42
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1873	Pt. 2-7:	9-60	2-7
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1899	Suppl. 2:	1-11	—
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THE CHROMOSOMES OF A WILD SILKMOTH,
ARCHAEOATTACUS EDWARDSII, WITH A RECORD
HIGH CHROMOSOME NUMBER
FOR SATURNIIDAE

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ABSTRACT. The diploid chromosome number of *Archaeoattacus edwardsii* (White), new to chromosome cytology, is 128, the highest so far reported in the family. The karyotype is characterised by the presence of two exceptionally larger (probably sex) chromosomes. The sex mechanism is XX ♂ : XY ♀. The females show a prominent sex chromatin body in germ as well as somatic cells. The evolutionary status of the species has been discussed.

Besides the usually high number and smaller size of the chromosomes, the cytogenetical studies in moths also involve difficulties regarding the procurement of stages from caterpillar to adult, as the mitotic and the male meiotic divisions are passed before the adult stage. So far, the chromosome numbers of only 30 saturniid species (including the present report), belonging to 16 genera (Table 1) out of about 1000 species recorded, are known. Interestingly, the chromosome number in *Archaeoattacus edwardsii* (White) is the highest. The karyotype and the sex chromatin in this species are described here for the first time.

MATERIAL AND METHODS

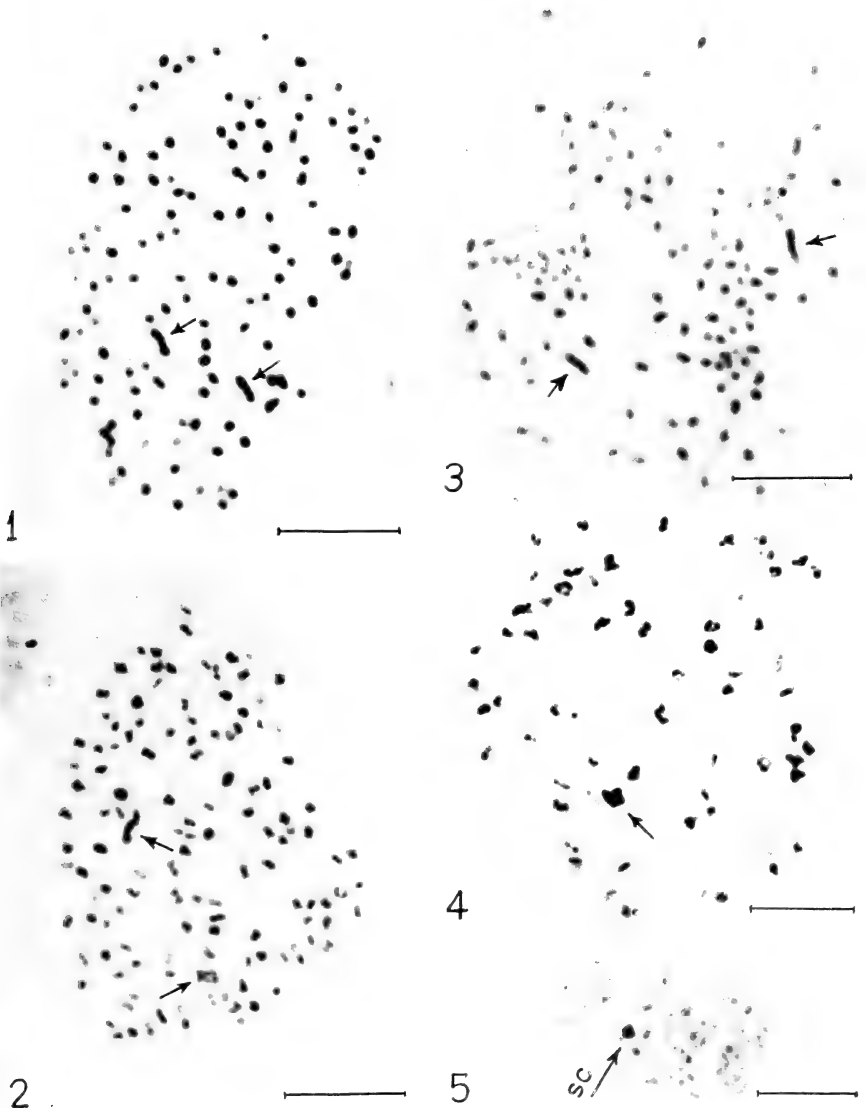
For the present study the cocoons were collected from Khasi Hills (Meghalaya) during Sept.-Oct. 1979. The slides were prepared from the gonads and brain tissues of both sexes. Some cocoons were also raised to the adult stage for the systematic determination of the species. Giemsa-stained cytological preparations were made by heat-dry smear technique (Narang & Gupta, 1979a), using, however, a 5% concentration of the stain. Some of the preparations were made after injection of 0.1 ml of 0.05% colchicine for 2.30 to 3 h.

OBSERVATIONS

The diploid number of chromosomes has invariably been found to be 128 at mitotic metaphase in germinal (Figs. 1 & 2) as well as neuroblast cells (Fig. 3) in as many as 15 cells of 6 males and 20 cells of 3 females. The same chromosome number has been confirmed by the count of 64 bivalents in 5 male diakineti cells (Fig. 4). The karyo-

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FIGS. 1-5. Chromosomes of *Archaeoattacus edwardsii*: 1, spermatogonial metaphase; 2, oogonal metaphase from colchicized individual showing localized centromeres; 3, mitotic metaphase from neuroblast cell (♀); 4, diakinesis (♂); 5, oogonal interphase showing sex chromatin (SC). Arrows indicate larger (sex ?) chromosomes. Bar represents 10 μm.

type is further characterized by the presence of two exceptionally larger chromosomes. The average length of these chromosomes is nearly the same (i.e., $2.5 \mu\text{m}$ in male and 2.5 & $2.7 \mu\text{m}$ in female). The smaller chromosomes range in length from $0.5 \mu\text{m}$ to $1.25 \mu\text{m}$.

The mitotic metaphase chromosomes of *edwardsii* have been found to be of monocentric type as studied in the colchicized preparations. Fig. 2 reveals an interstitial centromere in some of the chromosomes; whereas, the position of the centromere in others is not discernible, due to their smaller sizes.

A prominent, large-sized and positively heteropycnotic sex chromatin body has been clearly observed in interphase and prophase cells of brain and germ tissues of the females. The average size of sex chromatin at the interphase stage (Fig. 5) is $1.15 \mu\text{m}$.

DISCUSSION

The presence of the same and even number of the chromosomes in both the sexes and the formation of a sex chromatin body in the females indicates the sex chromosome mechanism in *Archaeoattacus edwardsii* to be $\text{XX} \delta : \text{XY} \text{♀}$, as concluded for eight other saturniid species (Gupta & Narang, 1980a; Gupta & Narang, 1981); the sex chromatin, formed both in germ and somatic cells, represents the Y-chromosome.

Bauer (1943) and White (1957) suggested that the big chromosome frequently found in Lepidoptera is a sex chromosome, at least in those species which have a very high chromosome number. In the family Saturniidae to which the present species belongs, the modal chromosome number is $n = 31$, which has been reported in 18 species out of the 30 investigated so far (Table 1). The two exceptionally larger chromosomes of this species, with $n = 64$, seem to, likewise, represent the sex chromosomes. The difference in the size of these chromosomes compared to the autosomes is probably because the sex chromosome mechanism in this group is nicely balanced and fission or other such rearrangements in sex chromosomes may disturb the mechanism. This is also clear from the fact that there are very few cases in Lepidoptera in which multiple sex chromosomes are known.

In the tribe Attacini of the subfamily Saturniinae, seven species, four from genus *Hyalophora* and one each from *Philosamia*, *Callosamia* and *Archaeoattacus*, have so far been cytogenetically worked out. The haploid chromosome number in all the species of *Hyalophora* is 31, while it is 13–14 in *Philosamia cynthia* (Drury) (in its different races), 19 in *Callosamia promethea* (Drury) and 64 in *A. edwardsii*. Further work in other genera and species of Attacini is urgently needed for exploring the evolutionary trends in this tribe.

TABLE 1. Known haploid chromosome numbers for species of Saturniidae.

S. No.	Name of the species	Haploid chromosome number	References (First report)
SUBFAMILY: SATURNIINAE			
TRIBE: SATURNIINI			
1.	<i>Actias selene</i>	31	Deodikar et al. (1969)
2.	<i>A. luna</i>	31	Unpublished
3.	<i>Antheraea assamensis</i>	15	Deodikar et al. (1962)
4.	<i>A. compta</i>	15	Gupta & Narang (1981)
5.	<i>A. frithi</i>	31	Jolly et al. (1977)
6.	<i>A. mylitta</i>	31	Sinha & Jolly (1967)
7.	<i>A. pernyi</i>	49	Kawaguchi (1933, 34)
8.	<i>A. (=Telea) polyphemus</i>	30	Cook (1910)
9.	<i>A. roylei</i>	31	Jolly et al. (1970)
10.	<i>A. sivalica</i>	31	Jolly et al. (1978)
11.	<i>A. yamamai</i>	31	Kawaguchi (1933)
12.	<i>Cricula trifenestrata</i>	31	Narang & Gupta (1979a)
13.	<i>Dictyoploca cachara</i>	30	Narang & Gupta (1979b)
14.	<i>D. japonica</i>	31	Oba (1942) (cited by Makino, 1951)
15.	<i>D. simla</i>	31	Unpublished
16.	<i>Graellsia isabelae</i>	31	Templado et al. (1975)
17.	<i>Loepa katinka</i>	28	Narang & Gupta (1979c)
18.	<i>Saturnia pyri</i>	30	Pariser (1927)
19.	<i>Sonthonnaxia maenas</i>	31	Narang & Gupta (1979d)
20.	<i>Eriogyna pyretorum</i>	30	Gupta & Narang (1980b)
21.	<i>Eudia (=Saturnia) pavonia</i>	29	Kernewitz (1915)
TRIBE: ATTACINI			
22.	<i>Archaeoattacus edwardsii</i>	64	(Present work)
23.	<i>Philosamia cynthia</i>	13-14	Dederer (1907, 15); Deodikar & Thakar (1958)
24.	<i>Hyalophora (=Platysamia) cecropia</i>	31	Bytinski-Salz (1938)
25.	<i>H. euryalis</i>	31	Bytinski-Salz (1938)
26.	<i>H. gloveri</i>	31	Bytinski-Salz (1938)
27.	<i>H. columbia</i>	31	Bytinski-Salz (1938)
28.	<i>Callosamia promethea</i>	19	Cook (1910)
SUBFAMILY: HEMILEUCINAE			
TRIBE: HEMILEUCINI			
29.	<i>Automeris io</i>	31	Cook (1910)
SUBFAMILY: CITHERONIINAE			
30.	<i>Anisota (=Dryocampa) rubicunda</i>	31	Ennis (1976)

In the sister tribe Saturniini the probable modal number as indicated by the available data (Table 1) is $n = 31$, which is also the modal number for Lepidoptera as a whole (Suomalainen, 1969; White, 1973). From this it can be assumed that the same number, $n = 31$ (at present known only from genus *Hyalophora*), might be the ancestral number

of the tribe Attacini, and the lower chromosome number of *Philosamia cynthia* ($n = 13-14$) and *Callosamia promethea* ($n = 19$), and the higher number for *A. edwardsii* ($n = 64$) might have evolved from this number by the mechanism of chromosomal fusions and fissions respectively (see discussion below). The presence of a single pair of exceptionally larger (probably sex) chromosomes and simple XX ♂ : XY ♀ sex mechanism in *A. edwardsii* speaks against an incidence of polyploidy.

Bigger (1975, 76) clearly showed localized centromeres in the mitotic chromosomes of five butterflies and pointed out that there are two types of centromeric organizations. According to him at early mitotic metaphase the chromosomes exhibit a monocentric organization, either exclusively or, more probably, with one portion of the diffuse centromere exerting a dominant influence over the remainder. He further stated that with the advancement of metaphase the influence of this centromere is either lost or superseded by the combined influence of the rest of the centromere. Several other authors (e.g., Danilova, 1973; Gassner & Klemetson, 1974; Rishi & Rishi, 1979; Gupta & Narang, 1981) have also reported clear primary constrictions (localized centromere) at mitotic and/or meiotic II metaphases in several Lepidoptera. But there has appeared absolutely no report, either by light microscopy or by electron microscopy, about the localized nature of the centromere at metaphase I in this group. This dual centromeric organization and the presence of morphologically distinguishable sex chromosomes in Lepidoptera probably explains why the chromosome numbers in this group are less variable than the diffuse kinetochore (e.g., in *Luzula*) would at least theoretically allow.

It is a point of common observation in saturniids, like several other lepidopterans (see Gupta, 1964; Suomalainen, 1979), that the chromosomes of high-numbered species are always smaller than the chromosomes of low-numbered species. This evidence and the presence of the non-localized nature of centromere, at least at metaphase I, probably indicates the occurrence of fission. The possibility of the other structural rearrangements like inversions, translocations, etc. cannot, however, be disregarded.

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ADDENDUM AND CORRIGENDA TO "CLASSIFICATION OF THE SUPERFAMILY SESIOIDEA"

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ABSTRACT. The subgenera *Dipchasphecia*, *Ductispina*, *Paradipsosphecia*, *Pseudosphecia*, and *Synansphecia* are synonymized with *Bembecia* in Sesiidae. The names *Bembecia reisseri* Capuse, *Chamaesphecia rangnovi* Capuse, *Homogyna porphyractis* Meyrick, *Microsynanthesdon tanala* Minet, and *Sesia okinawana* (Matsumura) are added. A number of other changes and corrections are noted.

In a recently completed paper on Sesiioidea (Heppner & Duckworth, 1981), a major reference to Sesiidae (Capuse, 1973) was inadvertently left out of the world review for the family Sesiidae. Thus, we wish to make note of the following taxa as an addition to our review of the superfamily.

The following generic names, proposed as subgenera, are hereby placed as synonyms of *Bembecia*:

Pseudosphecia Capuse, 1973b:147, **new synonymy**

Type-species: *Dipsosphecia tenebrosa* Püngeler, 1915, by original designation [described as a subgenus of *Bembecia*].

Ductispina Capuse, 1973b:149, **new synonymy**

Type-species: *Dipsosphecia turcmena* Bartel, 1912, by original designation [described as a subgenus of *Bembecia*].

Paradipsosphecia Capuse, 1973b:150, **new synonymy**

Type-species: *Dipsosphecia barbara* Bartel, 1912, by original designation [described as a subgenus of *Bembecia*].

Dipchasphecia Capuse, 1973b:161, **new synonymy**

Type-species: *Dipsosphecia roseiventris* Bartel, 1912, by original designation [described as a subgenus of *Chamaesphecia*; type-species now placed in *Bembecia*].

Synansphecia Capuse, 1973b:166, **new synonymy**

Type-species: *Sesia triannuliformis* Freyer, 1845, by original designation [described as a subgenus of *Chamaesphecia*; type-species now placed in *Bembecia*].

The following additions and corrections are also noted:

- p. 9. Change setae D2 to D1 and D1 to D2 at the end of the larval diagnosis.
- p. 15. Change *Phycodes eucallynta* Meyrick, 1937, to Meyrick, 1937a.
- p. 16. Under current taxa, change 1063 to 1066 species and change 83 to 84 species.
- p. 20. Under current taxa, change 782 to 786 species. Under *Bembecia*, change 58 to 59.
- p. 21. Under *Homogyna*, change 9 to 10; under *Microsynanthesdon*, change 1 to 2.
- p. 27. Under *Sesia*, add *Spherodoptera* [sic] Matsumura, 1931a:1017, [misspelling].

- p. 28. Add *Sesia okinawana* (Matsumura, 1931a:1017), *Spherodoptera* [sic], [**new combination**], as a valid species from the Oriental region. Change *Sesia montelli* (Löfquist, 1922:82), *Aegeria* from a valid species to a junior synonym of *Sesia bembeciformis* (Hübner).
- p. 30. Change *Synanthedon danieli* Capuse, 1973, to Capuse, 1973a.
- p. 35. Under *Chamaesphesia balcanica* Zukowsky, 1929, add *C. rangnovi* Capuse, 1973b:167 [**nomen nudum**], as a synonym. Change *C. corsica* (Staudinger, 1856) to a synonym of *C. meriaeformis* (Boisduval, 1840), since the latter is not a **nomen nudum**, due to a short description in a footnote. *Chamaesphesia meriaeformis* becomes the valid name for the species.
- p. 36. Change *Chamaesphesia monspeliensis* (Staudinger, 1856) to synonymy with *C. tengyraeformis* (Boisduval, 1840), since the latter is not a **nomen nudum**, due to a short description in a footnote. *Chamaesphesia tengyraeformis* becomes the valid name for this species.
- p. 37. Change *Scalarignathia* Capuse, 1973, and *Scalarignathia kaszabi* Capuse, 1973, to Capuse, 1973a.
- p. 39. Add *Bembecia reisseri* (Capuse, 1973b:156), *Pyropteron* [**new combination**], as a valid species from the Palearctic region.
Under *B. chrysidiformis* (Esper, 1782), *B. polistiformis* (Boisduval, 1840) is not a **nomen nudum** due to a short description as a footnote in the original article.
Change *Bembecia bestianaeli* Capuse, 1973, *Bembecia dancaudani* Capuse, 1973, *Bembecia hannemanni* Capuse, 1973, and *Bembecia ili* Capuse, 1973, in each case to "(Capuse, 1973a), *Dipsosphesia* [**new combination**]."
- p. 40. Since *Chamaesphesia tengyraeformis* (Boisduval) 1840 (*Sesia*) is now a valid name and not a **nomen nudum**, *Bembecia tengyraeformis* (Herrich-Schäffer, 1851) (*Sesia*) becomes a junior homonym, to be replaced by *Bembecia sanguinolenta* (Lederer, 1853). The latter name becomes the valid name for this species.
- p. 42. Add *Microsynanthedon tanala* Minet, 1976:40, for the Ethiopian region.
- p. 43. Add *Homogyna porphyractis* Meyrick, 1937b:119, as a valid species from the Ethiopian region.
- p. 49. Change *Brenthia dendronympha* Meyrick, 1937, to Meyrick, 1937a.
- p. 50. Change *Brenthia spintheristis* [sic] Meyrick to *B. spintheritis*.
- p. 51. Under *Millieria dolosana* (Herrich-Schäffer) add *M. dolosalis* (Heydenreich, 1851:63), *Choreutis* [**nomen nudum**], as another synonym.
- p. 52. Change *Tebenna chrysotacta* [sic] (Meyrick) to *T. chrysotacta*.
- p. 62. Add the Capuse reference noted in this paper under the other Capuse, 1973a, reference and indicate it as 1973b.
- p. 75. Add the following reference under Meyrick and change the listed 1937 reference to 1937a: 1937b. Aegeriadae. *Exotic Microlepidoptera* 5:119.
Add the Minet reference as listed below under literature cited.

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EXPERIMENTAL HYBRIDIZATION BETWEEN *PHYCIODES* *THAROS* AND *P. PHAON* (NYMPHALIDAE)

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ABSTRACT. *Phyciodes tharos* and *P. phaon* are common species that occur sympatrically over much of the southern United States. The species differ in larval, pupal, and adult phenotypic appearance, habitat preference, and larval foodplant. F₁ hybrids and backcrosses between the species showed an unusual pattern of incompatibility, with relatively slight hybrid breakdown in one direction of the cross and total inviability in the reciprocal cross. The results differ strongly from those obtained in crosses between *P. tharos* and other *Phyciodes* species.

In the southern part of the southwestern United States *Phyciodes tharos* Drury and *P. phaon* Edwards are the dominant *Phyciodes* species. They are closely related taxonomically, but while *P. tharos* ranges northward into southern Canada, *P. phaon* is confined to the South and Southwest and ranges into Central America. Except for *P. phaon*, all of the half-dozen or so members of the *P. tharos* species group feed on asters in the larval stage. The larval foodplant of *P. phaon* is *Lippia* (Verbenaceae), an herbaceous perennial found commonly along sandy roadsides in the Deep South.

In northern Florida (e.g., Alachua, Bradford, and Levy Cos.) *P. tharos* and *P. phaon* are often sympatric along roadsides and in other open, sandy areas, but while *P. phaon* seems fairly closely restricted to this habitat, *P. tharos* is common also in moist grassy fields, lawns, and pine-palmetto savannah. Laboratory experiments indicate that *P. tharos* larvae feed readily on a wide array of *Aster* species, and that each habitat contains suitable foodplants.

Both species are multivoltine, with the spring emergence beginning in mid-March in northern Florida. First generation adults of both species are of the extreme "spring" phenotype ("marcia" in *P. tharos*, "hiemalis" in *P. phaon*) with much more extensive dark markings on the ventral hindwing than in the "summer" phenotype ("morpheus" and "phaon," respectively). Although fairly similar in appearance, adults of the two species are easily distinguished by differences in color pattern (Fig. 1, Table 1). The larvae also differ in appearance (Table 1), although in general that of *P. phaon* is more similar in appearance to *P. tharos* than are those of *P. campestris* Behr (Oliver, 1978) or *P. batesii* Reakirt (Oliver, 1979a). In addition first instar larvae of both *P. campestris* and *P. batesii* form rudimentary communal webs, whereas *P. tharos* and *P. phaon* do not. The haploid chromosome numbers of both latter species is 31 (Maeki and Remington, 1960). There are apparently no records of natural hybrids. The rela-

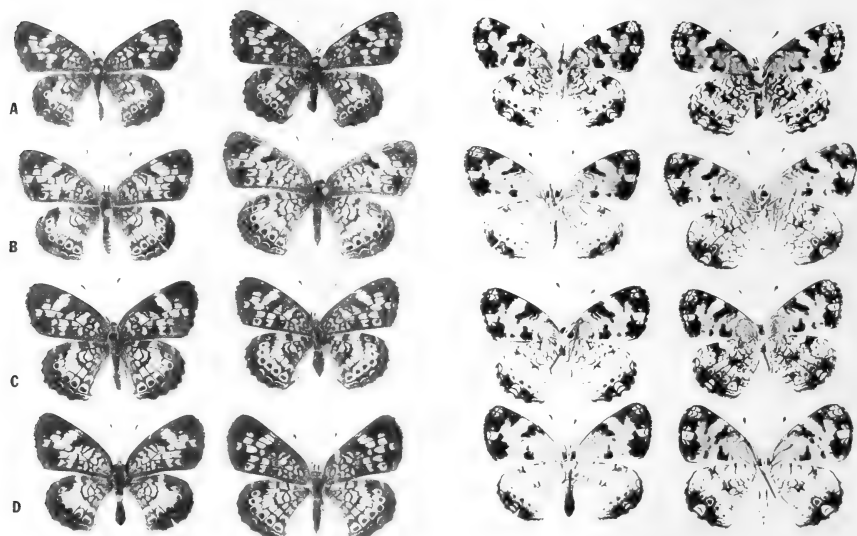


FIG. 1. Parental-type, F_1 hybrid, and backcross adults: **Row A**, *P. phaon*; **B**, *P. tharos*; **C**, F_1 hybrids *P. phaon* ♀ × *P. tharos* ♂; **D**, backcrosses (*P. phaon* ♀ × *P. tharos* ♂) ♀ × *P. tharos* ♂. Specimens show, left to right: male dorsal, female dorsal, male ventral, female ventral.

tively close taxonomic relationship of *P. tharos* and *P. phaon*, together with the unusual foodplant of *P. phaon*, made it seem especially desirable to me to investigate the relationship between these two species as part of my ongoing study of the evolutionary genetics of the *P. tharos* group.

METHODS AND MATERIALS

Laboratory stock was derived from one female of *P. tharos* taken 17 March 1979 in Gainesville, Alachua Co., Florida; two females of *P. tharos* and one male and two females of *P. phaon* taken 16 and 21 March 1979 four mi. west of Otter Creek, Levy Co., Florida; and from one male and four females of *P. tharos* and three females of *P. phaon* taken 17, 18, and 24 March 1979 three mi. north of Waldo, Bradford Co., Florida. Cultures at the University of Florida were maintained at 25°C and under approximately natural photoperiod conditions (for April at latitude 29°30'N). On 19–21 April 1979 the cultures were transferred to my laboratory in Pennsylvania, where they were maintained at 27°C days, 24°C nights, and given 16 h light/24 h using rows of fluorescent tubes.

TABLE 1. Differences in phenotypic appearance of mature larva, pupa, and adult of *P. tharos*, *P. phaon*, and their F_1 hybrid (*P. phaon* ♀ × *P. tharos* ♂).

Character	<i>P. tharos</i>	<i>P. phaon</i>	F_1 hybrid
I. Mature larva			
a. Proleg color	Brown	White	Very light brown
b. Color tubercle bases	Brown	White	Brown
c. Color dorsal dark stripes	Chocolate brown w. small white flecks	Mottled, 50% white, 50% brown	Mottled, more than 50% brown
d. Width, dorsal light stripes	Narrower than width of tubercles	About as wide as tubercles	Lower: solid white, same width as <i>P. tharos</i> ; upper: mottled to extent of <i>P. phaon</i>
e. Width, lateral light stripes	Narrower than width of tubercle	About 4 times as wide as tubercle	Same as (d.)
f. Color, head capsule	Brown w. dorsal white patch, very small lateral-ventral patch	Dorsally like <i>tharos</i> but with large ventral white patch	Dorsally like <i>P. tharos</i> , ventral patch reduced to ½ size of <i>P. phaon</i>
II. Pupa			
a. Color	Light tan to dark wood brown	Usually light tan	Light tan to dark brown
b. Overall shape	More angular, projections more pronounced	More rounded, projections less pronounced	Intermediate
III. Adult.			
a. Dorsal body vestiture	W. large proportion of tawny hairs	Very few tawny hairs	Like <i>P. tharos</i>
b. Color, ventral antennal club	Almost always very dark	Light tawny gray	Variable, light to dark
c. Intensity, black pattern elements	Relatively light	Relatively heavy	Intermediate
d. Color, dorsal and ventral forewing	Tawny areas nearly even; median black band often broken into sep. patches	Median tawny band, marginal lunule, submedian spot contrastingly pale; black band heavy and continuous	Intermediate
e. Color, ventral hindwing	Ground even straw yellow; discal and basal dark markings tan, outer marginal patch chocolate brown; dark markings less crisp	Ground cream w. a large contrasting central tawny spot; dark markings all chocolate brown, usually very crisp	Ground intermediate; often w. central tawny spot; both <i>P. tharos</i> and <i>P. phaon</i> discal and basal dark markings present, not quite superimposed; markings crisp

Matings were made by the hand-pairing method (Clarke, 1952) or in small cages. Mated females were housed in 10 × 20 cm glass cylinders and given potted plants or cut sprigs of various asters or *Lippia nodiflora* (L.) Michx. for oviposition. Eggs were removed daily and counted, and the substrate leaf kept fresh until the eggs hatched. Larvae of *P. tharos* were reared on cut sprigs of *Aster* in 10 × 20 cm glass cylinders with screening over the tops; whereas, *P. phaon* were reared on cut sprigs of *Lippia* in 7 × 10 cm closed plastic boxes, since the *Lippia* plants tended to desiccate if exposed to the open air. After transferral of the cultures to Pennsylvania all hybrid larvae were reared on *Aster* because of the unavailability of *Lippia*. For this same reason no control broods of *P. phaon* were reared in Pennsylvania after early May.

F₁ progeny of wild-collected wild-mated females or (in two cases) unmated, wild-collected females were used for the hybrid pairings and as parental-type stock for backcrosses. No stock used was inbred. Observations were made on parental population, F₁ hybrid, and backcross phenotypic appearance and larval foodplant acceptance, interspecific courtship behavior, development times and adult eclosion patterns, fertility, adult sex ratios, and embryonic, pupal, and eclosing adult viability. Single species controls were reared simultaneously for comparison with hybrid and backcross broods.

Data on egg fertility, viability, and sex ratios were treated statistically using the Wilcoxon Two-Sample Test. Adult fertility was measured by a count of the number of visibly developing eggs divided by the total number of eggs laid after a single mating. Development times from hatching of the egg to eclosion of the adult were estimated by calculating the 99% confidence intervals for the medians of the distributions (Owen, 1962). Distributions of development times within broods or series of broods have been represented by adult eclosion graphs showing the number of adults emerging from pupae each day.

RESULTS

Interspecific Courtship Behavior

Males of both species show vigorous courtship behavior when caged with females of their own or of the other species. Females apparently rarely accept males of other species, however, and only one interspecific pairing, *P. phaon* ♀ × *P. tharos* ♂, was made without forced pairing.

Phenotypic Appearance

Differences in phenotypic appearance of the fifth instar larvae, pupae, and adults of the parental species and their F₁ hybrid (*P. phaon*

♀ × *P. tharos* ♂) are summarized in Table 1. Adults are shown in Fig. 1. The backcross (*P. phaon* ♀ × *P. tharos* ♂) ♀ × *P. tharos* ♂ generally resembled *P. tharos* except for the following characters: 1) larva—width of lateral light stripes slightly wider than on *P. tharos*; 2) adult—color of ventral antennal club dark, sometimes with a light tip; 3) color of dorsal and ventral forewing intermediate between *P. tharos* and *P. phaon*; 4) color of ventral hindwing with ground lighter than *P. tharos*, often with a slight, diffused central tawny spot; discal and ventral markings more like *P. tharos* but with some *P. phaon* influence present; dark markings more sharply defined than on *P. tharos*. The larva and pupa of *P. phaon* and the larva of *P. tharos* have been figured by Emmel and Emmel (1973) and the pupa of *P. tharos* by Holland (1931).

In nature both *P. tharos* and *P. phaon* show seasonal polyphenism regulated by photoperiod (Oliver, 1976, unpubl. data). In both species the short-day forms, which fly in fall and spring, have the underside of the hindwings suffused with dark brown or violet-brown, which obscures the other dark markings. The character of this suffusion is closely similar in both species. Under the laboratory conditions described above only light-colored long-day forms were present in the parental cultures. The males in the F₁ hybrid broods were only of the long-day form; varying proportions of the females were of the short-day form (Brood No. 79-6: 23.3%; 79-17: 0%; 79-18: 13.1%; 79-34: 0%; 79-35: 17.6%; 79-36: 71.1% [see Table 4 for numbers of females involved]). A few backcross females showed moderate expression of the short-day phenotype.

Foodplant Acceptance

In laboratory oviposition tests *P. phaon* accepted only *Lippia*, *P. tharos* only *Aster*. F₁ hybrid females (*P. phaon* ♀ × *P. tharos* ♂) accepted either plant readily.

Newly hatched larvae without feeding experience given the foodplant of the other species fed to a very limited extent and died without increase in size. F₁ hybrid larvae of the cross *P. phaon* ♀ × *P. tharos* ♂ fed readily on either foodplant. One early brood of this cross was split into *Lippia*- and *Aster*-feeding groups. Growth was markedly slower on *Lippia*, and the *Lippia*-feeding group was changed to *Aster* when the cultures were moved to Pennsylvania. Part of one brood of the backcross (*P. phaon* ♀ × *P. tharos* ♂) ♀ × *P. tharos* ♂ was started on *Lippia* and grew until the second instar, when all of the larvae (N = 40) died.

Viability, Fertility, and Sex Ratio

Embryonic viability in the parental control broods was extremely high. In the F₁ hybrid (*P. phaon* ♀ × *P. tharos* ♂) there was significant

reduction in viability (Table 2). In the reciprocal hybrid there was either complete very early embryonic inviability or a complete lack of egg fertilization following insemination. Females mated in this cross oviposited normally (in large egg patches), rather than in the pattern demonstrated by uninseminated females (very few eggs laid, widely scattered over the foodplant). Since in other *Phyciodes* crosses this has proved to be an infallible indicator of mating success, these matings were assumed to be successful even though the presence of spermatophores was not verified. The backcross (*P. phaon* ♀ × *P. tharos* ♂) ♀ × *P. tharos* ♂ showed a significant reduction in visible egg fertility and reduced embryonic viability. The reciprocal backcross *P. tharos* ♀ × (*P. phaon* ♀ × *P. tharos* ♂) ♂ showed massive reductions in egg fertility and complete embryonic inviability. The reduction in visible egg fertility in these crosses may have been due to very early embryonic inviability or to reduced parental fertility. No stock of *P. phaon* could be maintained in Pennsylvania for backcrosses because of a lack of *Lippia* for foodplant.

Post-larval (i.e. prepupal, pupal, and ecdysing adult) viability was significantly lower for the *P. phaon* parental broods than for *P. tharos* ($P = .005$) (Table 3). This may have been due to the different larval rearing containers for *P. phaon*, since humidity in these containers was very high. F_1 hybrid and backcross broods were reared in the same manner as *P. tharos*; post-larval viabilities of these two series of broods were significantly lower than for *P. tharos* ($P = .005$ for both values) but not lower than both *P. tharos* and *P. phaon* considered together. It is possible that neither parental foodplant was ideal for the hybrid larvae, and that some reduction in viability was due to this.

Adult sex ratios in the F_1 hybrid broods and in the backcross broods showed no change from those of the parental control broods (Table 3).

Development Times and Eclosion Graphs

Development times from hatching of the egg to eclosion of the adult were about the same for the two parental species, although some broods of *P. phaon* averaged a day or so faster than *P. tharos* (Table 4). Development times of the *P. phaon* broods varied more than did those of *P. tharos*.

In F_1 hybrid broods of the cross (*P. phaon* ♀ × *P. tharos* ♂) reared on *Aster*, males showed development times similar to those of the control broods, but those of the F_1 females averaged at least several days longer than those of the controls. Development times of both males and females of this F_1 hybrid tended to vary more than those of the controls. In addition, the eclosion graphs of both sexes showed

TABLE 2. Mean egg fertility and embryonic viability (with standard deviation) of *Phyciodes tharos* and *P. phaon* control, F₁ hybrid, and backcross broods. P values refer to differences of hybrid or backcross broods with controls.

Species/cross	No. of broods	No. of eggs	Fertile/laid	Hatched/laid	Hatched/fertile
Parental Controls					
<i>P. tharos</i>	9	2399	0.995 ± 0.005	0.995 ± 0.005	1.000 ± 0.000
<i>P. phaon</i>	4	697	1.000 ± 0.000	1.000 ± 0.000	1.000 ± 0.000
F₁ Hybrids					
th ♀ × ph ♂	9	3955	0.000 ± 0.000 (P < 0.001)	0.000 ± 0.000 (P < 0.001)	—
ph ♀ × th ♂	7	2285	0.991 ± 0.019 (N.S.)	0.945 ± 0.039 (P < 0.005)	0.944 ± 0.032 (P < 0.005)
Backcrosses					
(ph ♀ × th ♂) ♀ × th ♂	11	2910	0.905 ± 0.117 (P < 0.001)	0.747 ± 0.239 (P < 0.001)	0.806 ± 0.192 (P < 0.001)
th ♀ × (ph ♀ × th ♂) ♂	7	2576	0.012 ± 0.014 (P < 0.001)	0.000 ± 0.000 (P < 0.005)	0.000 ± 0.000 (P < 0.005)

TABLE 3. Mean incidence (percentages) of prepupal through eclosing adult inviability and adult viability of *Phyciodes tharos* (th), *P. phaon* (ph), F₁ hybrids, and backcrosses. Tests of significance refer to comparison with combined parental controls (sex ratio) or *P. tharos* alone (viability).

Species/cross	No. of broods	Dead prepupae	Dead pupae	Total no. eclosing	Sex ratio (mean % ♂)	Eclosion incomplete	Viable adults
th controls	8	0.0	3.6	541	54.2	2.0	94.6
ph controls	4	5.8 (N.S.)	28.2 (P = 0.01)	194	49.1	1.8 (N.S.)	66.8 (P = 0.005)
ph ♀ × th ♂	6	0.3 (N.S.)	9.2 (P < 0.05)	575	46.0 (N.S.)	2.2 (P = 0.025)	87.6 (P = 0.005)
(ph ♀ × th ♂) ♀ × th ♂	6	1.3 (P = 0.025)	13.2 (P = 0.10)	435	49.9 (N.S.)	4.4 (P = 0.025)	81.2 (P = 0.025)

TABLE 4. Development times in days from hatching of egg until eclosion of adult for *P. tharos* and *P. phaon* control broods, F₁ hybrid (*P. phaon* ♀ × *P. tharos* ♂) and backcrosses ([*P. phaon* ♀ × *P. tharos* ♂] ♀ × *P. tharos* ♂). "Medians" show 99% confidence limits. See text for rearing conditions. Mr = March, A = April, My = May, J = June.

Brood no.	Date hatched	Males			Females		
		N	Min-Max	Median	N	Min-Max	Median
<i>P. tharos</i>							
79-3	29 Mr	37	25-27	26	43	24-30	26-27
79-5	29 Mr-3 A	16	25-29	26-28	18	24-31	26-28
79-9	27-29 Mr	111	24-30	26	125	25-32	27
79-10	30 Mr-1 A	37	25-26	25-26	27	25-28	25-26
79-24	4 My	47	18-20	19	30	19-24	19
79-25	1-4 My	54	18-21	19-21	32	19-21	19-20
79-26	4 My	33	18-19	18	20	18-19	18-19
<i>P. phaon</i>							
79-7	29 Mr-1 A	30	23-30	24-26	34	25-29	26-27
79-12	31 Mr	23	23-24	23	34	23-25	23-24
79-13	1-2 A	35	23-26	24	30	24-31	24-26
F₁ Hybrids							
79-6	29 Mr-1 A	44	25-35	29-30	29	37-52	40-43
79-17	1-6 My	35	19-26	20	65	21-31	23-24
79-18	30 A-5 My	64	17-24	19-21	63	21-29	23-25
79-34	8-11 My	10	19-24	19-24	17	22-29	22-26
79-35	7-11 My	56	18-27	19-20	93	20-30	23-26
79-36	6-10 My	58	18-44	19-22	45	22-33	25-28
Backcrosses							
79-47	5 J	9	17-20	17-20	16	19-24	19-24
79-49	4-5 J	50	16-20	17-18	49	17-26	18-19
79-50	5 J	54	15-20	17-18	83	17-22	19-20
79-51	4-5 J	28	16-23	17	23	18-23	19-21
79-55	7-8 J	67	17-25	19-20	61	18-24	20-21
79-58	10 J	22	15-20	17-19	20	18-21	19-20

a tailing-off effect. This was more marked in the females (Fig. 2). Because of slightly different rearing conditions, broods hatched during March and early April cannot be compared with those hatching during May and June. Development times of the backcrosses to *P. tharos* were significantly shorter than those of *P. tharos* or of the F₁ hybrids.

DISCUSSION

At first glance the results seem to give a somewhat contradictory picture of incompatibility between *Phyciodes tharos* and *P. phaon*. In the F₁ hybrid (*P. phaon* ♀ × *P. tharos* ♂) and its backcross to *P. tharos* ♂, hybrid sex ratios are normal and development times only slightly affected; whereas, the reciprocal hybrid is totally inviable,

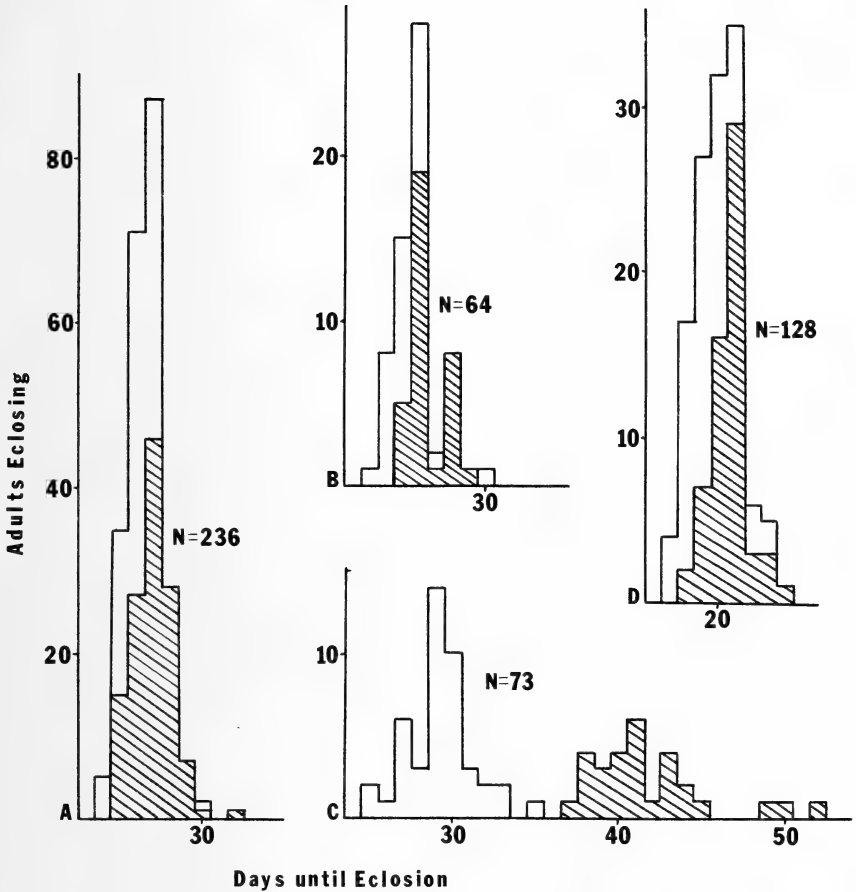


FIG. 2. Distributions of times required for development of typical *P. tharos*, *P. phaon*, F₁ hybrid, and backcross broods from hatching of eggs until eclosion of adults. **A**, *P. tharos*, Brood 79-9; **B**, *P. phaon*, Brood 79-7; **C**, F₁ hybrid *P. phaon* ♀ × *P. tharos* ♂, Brood 79-6; **D**, backcross (*P. phaon* ♀ × *P. tharos* ♂) ♀ × *P. tharos* ♂, Brood 79-55. (See Table 4 and text for rearing conditions and dates.)

and the backcross *P. tharos* ♀ × (*P. phaon* ♀ × *P. tharos* ♂) ♂ almost so. It would appear from these results that, while the nuclear materials of *P. tharos* and *P. phaon* are quite compatible (i.e. can cooperate to direct harmonious growth and development) and while *P. tharos* nuclear material is relatively compatible with *P. phaon* or hybrid cytoplasm, *P. phaon* nuclear material is highly incompatible with *P. tharos* cytoplasm. This incompatibility may involve crucial differences in one or more of the many factors that determine the composition of the cytoplasmic environment in which foreign nuclear material must

function to produce a viable hybrid individual organism. An incompatibility of this sort may be ultimately attributable to a relatively slight degree of differentiation in gene regulation (see Oliver, 1979b, for a fuller discussion) and does not contradict the other results presented here. The conclusion is, then, that *P. phaon* and *P. tharos* show relatively slight overall genetic differentiation. Hybridization in nature is probably prevented by barriers involving courtship behavior.

The pattern of hybrid incompatibility in the present series of crosses is quite different from that shown in hybridization experiments using *P. tharos* and *P. campestris* (Oliver, 1978), *P. batesii* (Oliver, 1979a), or the entity I have referred to as *P. "tharos Type B"* (Oliver, 1979a, 1980). These combinations show a homogeneous pattern of effects, which involves mainly slight to moderate (but not total) reduction in viability in the F_1 hybrids and backcrosses, skewed F_1 adult sex ratios, and abnormal F_1 hybrid development times. In the F_1 hybrid females eclosion occurs before that of the males when *P. tharos* is the male parent. In the reciprocal crosses female eclosion is delayed, and male and female curves usually do not overlap. In the (*P. phaon* ♀ × *P. tharos* ♂) F_1 hybrid broods, however, females show slightly delayed rather than speeded up eclosion times. These abnormalities in development time probably are in some way related to parental species differences in larval diapause induction thresholds (Oliver, unpubl. data).

Expression of the "marcia"- "hiemalis" phenotypes in the female F_1 hybrids may indicate that this form results unless the "morpheus"- "phaon" form is induced. One possible explanation for failure of this induction in female hybrids is that the "switch" gene and/or modifiers are linked with both a diapause induction-development rate gene complex and with sex. Since it is the females that are heterogametic in Lepidoptera, in this cross the female "morpheus"- "phaon" form must be induced in *P. phaon* cytoplasm using regulation by *P. tharos* genetic material, this induction fails in a high percentage of individuals. This case seems to be analogous to that in the cricket genus *Pteronemobius* (Masaki, 1978), where the F_1 hybrid males (the heterogametic sex in Orthoptera) show abnormal growth rates and photoperiodic responses.

The pattern of hybrid incompatibility between *P. tharos* and *P. phaon* differs also from that in butterfly hybrids outside the genus (reviewed in Lorković, 1978, and Oliver, 1979b). In general these latter show incompatibility similar to that in the other *Phyciodes* crosses discussed above. I know of no case in which the reciprocal F_1 hybrids differ so drastically in viability as do those between *P. tharos* and *P. phaon*, although recent crosses between *Pieris callidice*

Hübner and *P. occidentalis* Reakirt (Pieridae) (Shapiro, 1980) show a basic similarity that may be due to the same genetic effects.

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NOTES ON THE BIOLOGY OF
ZEGRIS EUPHEME (PIERIDAE)

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By comparison with the much researched Pierini, the ecology and behavior of Euchloini are rather poorly known. Only for the Palaearctic *Anthocharis cardamines* L. have detailed studies been made (Williams, 1915; Wiklund & Ahrberg, 1978). In this note I record some observations made in Morocco during 1978 on another euchloinid, *Zegris eupheme* Lederer, which are of interest for their similarities and contrasts with *A. cardamines* and with Pierini.

Z. eupheme is a large handsome insect, of disjunct distribution in the Palaearctic, being found in southern Spain and Morocco (subspecies *meridionalis*), and southern U.S.S.R., Asia Minor and the Near East (subspecies *eupheme*). It is unusual among the Pierinae in being particularly associated with a single crucifer species, *Isatis tinctoria* L., although it may use other Cruciferae as larval host plants (Powell, 1932). In the Middle Atlas Mountains of Morocco, the butterfly flies during late April and May and may often be seen in areas where the foodplants are growing. At this time of year the growth of vegetation is rich and verdant in valley bottoms; spring is the time of greatest floral and faunal abundance (thereafter the high summer temperatures give a very desiccated-looking landscape). *I. tinctoria*, a large, yellow-flowered crucifer about 1 m in height, grows in peripheral open areas around valleys, including roadsides and stony banks, where vegetation is otherwise short. At Ifrane, in the Middle Atlas, *Z. eupheme* has been associated with *I. tinctoria* since at least 1965, when the late Baron de Worms (1965) recorded flourishing populations of butterfly and crucifer in a hollow next to the Ballima Hotel. On subsequent visits he confirmed the continuing success of both populations, which were both still abundant in 1978. Most of the observations recorded here were made in this small area (about 100 m square); however, *I. tinctoria* occurred in sporadic small groups elsewhere, and *Z. eupheme* was very wide-ranging and could be found in almost any habitat in the area (ranging from rocky slopes to cedar forest).

As to be expected from its size, *Z. eupheme* is a very fast flier, making it impossible to net by pursuit. Like the satyrid *Eumenis semele* (L.), it often evades capture by dropping below the sweep of the net. The only successful method of capture is to station oneself in areas where *Z. eupheme* is flying and try 'head on' shots. The males

appear to 'patrol' (*sensu* Scott, 1974) areas in search of females, and during such flight they investigate any flying insects of the approximate size and color of *Z. eupheme*. Thus, males were seen to chase, vigorously and persistently, individuals of the white pierids, *Pieris brassicae* L. and *Artogeia rapae* (L.), and the yellowish pierids, *Gonepteryx rhamni* L. (both the primrose colored male, and the paler female) and *Colias crocea* Gffy. All such interactions were initiated by *Z. eupheme*, although other pierids are equally investigative in other situations. Several interactions were seen between males of *Z. eupheme*, but only one encounter was observed between sexes, which happened to produce a successful courtship and copulation. On being contacted the female flew about 10 m, with the male spiralling vigorously around her. She then landed, with the male continuing in the air and after a few seconds took off again. Once more the male appeared to force her to the ground but did not settle himself, fluttering around her head. This process was repeated several times, and on each occasion the pair moved a few meters. Eventually, the male settled down in a head to head position and rapidly moved around and initiated copulation with the now quiescent female. At this point the animals were collected; dissection of the female revealed no spermatophores, confirming that she was unmated. Seven other females each contained a single spermatophore, perhaps indicating that *Z. eupheme* leans toward monogamy as does *A. cardamines* (Courtney, 1980). At no time did females adopt the 'mate-refusal' posture (raising the abdomen vertically, while spreading the wings), a typical reaction of other Pierinae females.

The eggs of *Z. eupheme*, like those of most Eucloini, are placed upon the inflorescences of the crucifer host. When laid the egg is white, but it soon develops a red color, as in other Holarctic Eucloini (e.g. Williams, 1915). By careful examination of the flowerheads of *I. tinctoria*, it is readily possible to find the eggs. During the inclement weather of 28 and 29 April 1978 (snow occurred on May 1), the position of every *Z. eupheme* egg on *I. tinctoria* at the Ballima Hotel site was mapped. It was soon apparent that only certain *I. tinctoria* were chosen as oviposition sites. Eggs were concentrated upon unopened buds, and open flowers were never chosen (Table 1). Similar behavior in *A. cardamines* has been hypothesized to be adaptive, leading to larval feeding only on young buds and fruit, which represent optimal food (Wiklund & Åhrberg, 1978). Additionally, eggs were nonrandomly distributed among foodplants, with plants on the edge of the clump receiving many more eggs than those in the center. However, since edge plants are automatically those at low density, it is impossible to decide whether female *Z. eupheme* prefer to lay eggs

TABLE 1. *Z. eupheme* eggs upon *I. tinctoria* plants of different floral ages.

Plants with —	N	Number of eggs
10% flower buds open	377	85
10-90% flower buds open	233	19
Flowers fully open	121	0
	731	104

$\chi^2 = 41.6$, $P < 0.001$ at 2 d.f.

on plants at low density or prefer edge plants or both. Fig. 1 presents the observed deposition of eggs as a density plot. Similar patterns of egg deposition are known for *A. cardamines* (Wiklund & Ahrberg,

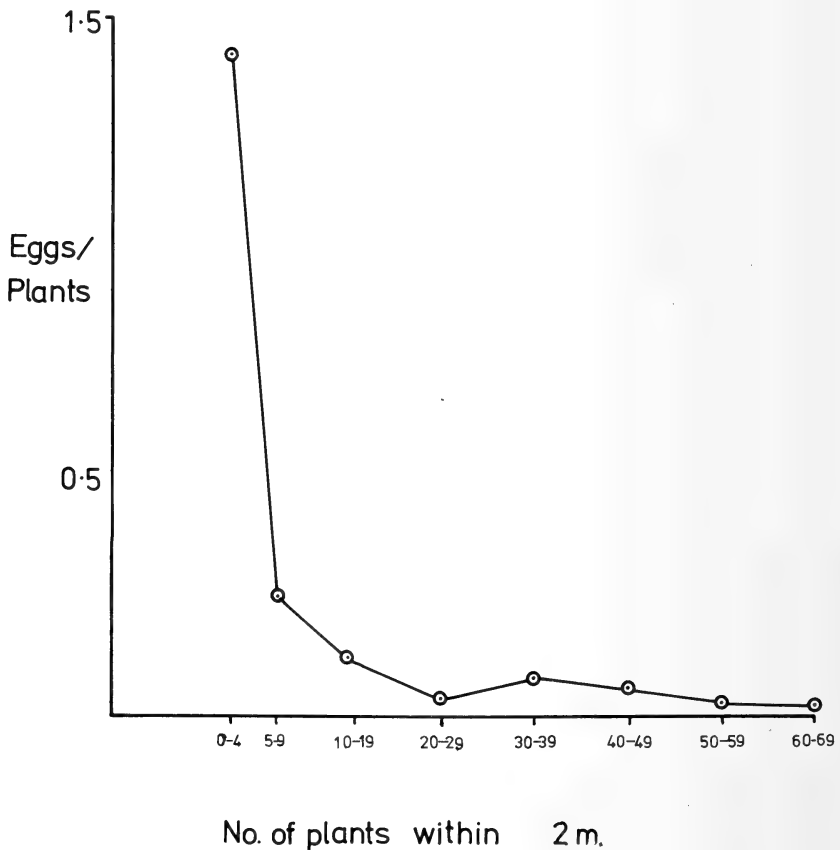


FIG. 1. The effect of *I. tinctoria* density (expressed as the number of other individuals within 2 m) upon the *Z. eupheme* eggload (eggs/plants). A total of 104 eggs on 731 plants were found.

1978) and for the pierids *Artogeia rapae* (e.g. Kobayashi, 1965), *A. napi* (in prep.), *Pontia protodice* and *P. occidentalis* (Shapiro, 1975). Various hypotheses have been suggested for the cause of such 'edge' effects, including choice by females of areas where parasite attacks are rare (Shapiro, 1975) and the incidental effects of female movement patterns and searching behavior (Jones, 1977). In such a large, mobile butterfly as *Z. eupheme*, Jones's hypothesis predicts an extremely pronounced edge-effect, as appears to be the case at Ifrane (a fuller discussion of edge-effects in Pierinae, particularly *A. cardamines*, is in preparation). The age of *I. tinctoria* inflorescences was not related to plant density.

Larvae of *Z. eupheme* were not studied. Beautifully camouflaged crab-spiders, common on the flowerheads of *I. tinctoria*, were potential predators. Powell (1932) records a very high rate of parasitism by braconids (*Apanteles* spp.).

Z. eupheme adults were only seen to feed from *I. tinctoria* blooms, despite a profusion of other nectar sources available. The adults were also frequently found roosting upon the host plant, at which times the yellow-green mottling of the hind-wing underside provided admirable camouflage, blending with the yellow inflorescences. It may be that restriction of larval feeding to a single plant species (or predominantly so) has allowed similar specializations (to predictable resources) in adult behavior.

ACKNOWLEDGMENTS

Although the Ballima Hotel site is openly accessible, I soon became aware that it is, in fact, a restricted area, belonging to the Moroccan Army. To the senior officers, who accepted my explanations as to cryptic maps (of flowers and butterfly eggs) and released both me and my data, I am extremely grateful. This work was carried out during the tenure of an S.R.C. Research Studentship.

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HOSTPLANT RECORDS AND DESCRIPTIONS OF JUVENILE STAGES FOR TWO RARE SPECIES OF *EUEIDES* (NYMPHALIDAE)

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ABSTRACT. New hostplant records are presented for two species of *Eueides*. *E. lineata* feeds on an as yet undescribed species of *Passiflora* in southern Mexico, and *E. vibilia* feeds on old leaves of *Passiflora pittieri* on the Osa Peninsula of Costa Rica. Behavioral observations are given and juvenile stages described for the two *Eueides* species. Larval mimicry is suggested for *E. vibilia* and two sympatric species of *Heliconius*, and an evolutionary mechanism for the mimicry is discussed.

Heliconiine butterflies are the best known group of Neotropical Lepidoptera. Their taxonomy has been unusually well worked out (Emsley, 1963, 1964, 1965; Brown & Mielke 1972; Brown 1976, 1979). This work has provided a firm basis for biological study on the species (reviewed by Brown, 1981). One of the most important features of the work on heliconiines has been their hostplant specialization (Gilbert, 1975; Benson et al., 1976; Benson, 1978; Smiley, 1978). All known species of Heliconiini use hostplants in the closely related families Passifloraceae (Benson et al., 1976) or Turneraceae (D. H. Janzen, pers. comm.), and are usually specialized within particular subgenera of the Passifloraceae (Benson et al., 1976). Relationships between *Heliconius* and *Passiflora* have proved to be useful tools in the taxonomy of both groups. We here describe the hostplants and larval stages of two little known species of *Eueides* (Nymphalidae: Nymphalinae: Heliconiini): *E. lineata* and *E. vibilia*, respectively. The young stages of *Eueides lineata* Salvin & Godman and its hostplants were previously unknown. Although the young stages of *Eueides vibilia* Godart are known (Brown, 1981) they have not been described in detail, and there are no hostplant records north or west of Guyana (Benson et al., 1976). We have used a method for description of young stages which allows direct comparison with the descriptions of Beebe et al. (1960).

Localities

In Mexico we found *E. lineata* at Playa Escondida near Catemaco, Veracruz (18°30'N, 95°0'W) and at Laguna Encantada above San Andres Tuxtla, Veracruz (18°30'N, 95°10'W). Playa Escondida is on the Gulf coast, and we made our observations at altitudes of between 50 and 100 m above sea level where there is some forest and recently cut pasture. At Laguna Encantada there are the scrubby remains of forest around the Laguna, which now acts as a rather eroded watering hole for cattle; the altitude was approx. 600 m.

The larvae and adults of *Eueides vibilia* were found at San Pedrillo, Parque Nacional Corcovado, Costa Rica (8°38'N, 83°44'W). They were not found at Sirena, which is also within the park (8°28'N, 83°35'W). Both of the Corcovado sites are on the Pacific coast

at sea level. All four of the sites have tropical lowland rainforest, but of a type with a moderately pronounced dry season.

Eueides lineata

A. Distribution and Mimicry

E. lineata is an exclusively Central American and Mexican butterfly. It is usually found at altitudes below 1000 m (Brown, 1979) and participates in the common "orange" mimicry ring in this area, which includes *Dryas julia* (Fab.), *Eueides aliphera* (Godart), *Eueides lybia* (Fab.), *Eueides vibilia*, and *Dione juno* (Cramer). *E. lineata* is illustrated in color, together with its co-mimics, in Lewis (1974, pls. 43–44) and Smart (1976, pl. 87). The adult *Eueides* that have been tested are distasteful to birds, although they are not rejected as much as *Heliconius* (Brower et al., 1963); so, the mimicry involved here is probably Müllerian.

B. The Hostplant

The hostplant of *E. lineata* at Playa Escondida and Laguna Encantada is a new species of *Passiflora*. It was found in 1978 by L. E. Gilbert, and he is in the process of describing it. In the remainder of the paper it will be referred to as *Passiflora*, sp. nov. It is an aberrant species which has a sticky puberulence on both the leaf surfaces. The species produces flowers from the tendrils, which is a characteristic of old world genera of Passifloraceae, such as *Adenia*, and some members of the new world subgenus of *Passiflora*, *Astrophea*. Most *Passiflora* produce flowers directly from leaf axils. There is a pronounced difference in the juvenile and mature vegetation: juvenile leaves have filiform petiolar nectaries and variegated leaves; leaves on older plants are unvariegated, less puberulent, and have large saucer-shaped petiolar nectaries. The vine can grow into the canopy of tall trees, but we were able to search only small plants in newly felled pastures. Adults seemed rare, but a concentration of adults occurred around a single canopy-level liana in a tree on the edge of a pasture. On 13 March 1980 a larva and pupal skin were discovered on the plant at Laguna Encantada. On 14 March we carefully searched leaves of young plants of *Passiflora*, sp. nov. at Playa Escondida and discovered one third-instar larva, three first-instar larvae, and three eggs of *E. lineata*. We also searched *P. serratifolia* Linn., common at the site, and found many eggs and larvae of *Eueides isabella* (Cramer) (young stages similar to those described by Beebe et al., 1960), but we found neither *E. isabella* on *Passiflora*, sp. nov. nor *E. lineata* on *P. serratifolia*. L. E. Gilbert (pers. comm.) has reared *E. lineata* at Monteverde (1300 m), Costa Rica, on an undetermined *Passiflora*. The association of *E.*

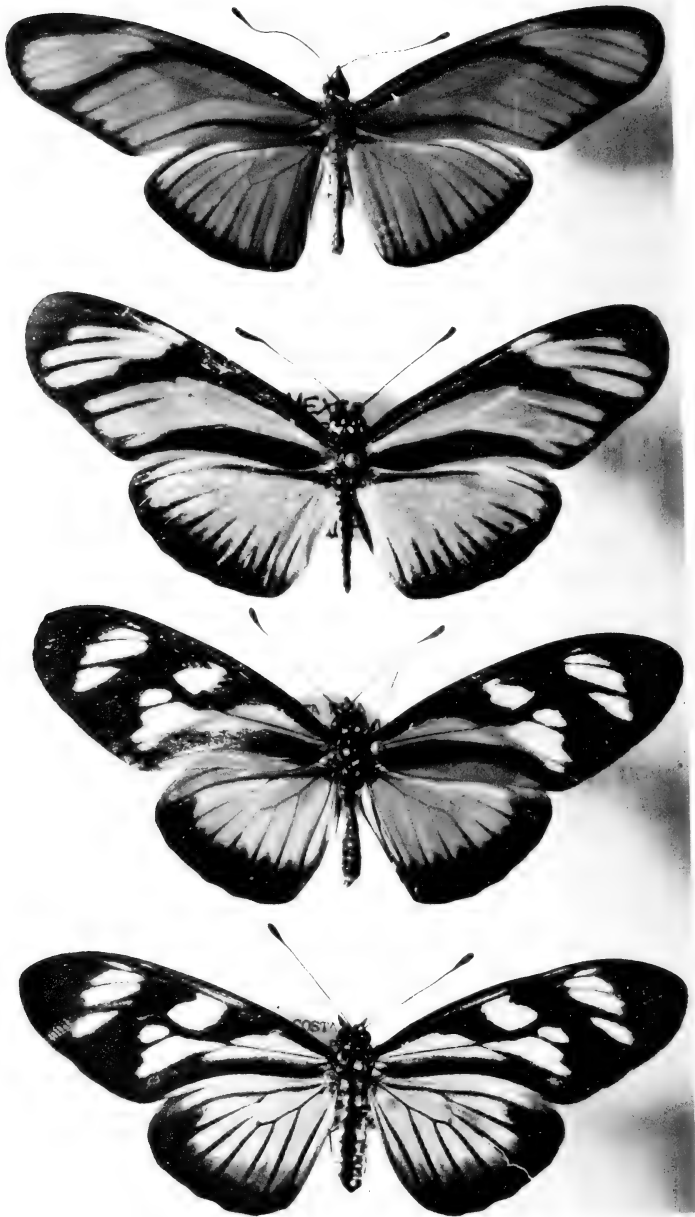


FIG. 1. Adults, top to bottom: *Eueides aliphera*, *E. lineata*, *E. vibia* (male), *E. vibia* (female).

lineata with such an atypical *Passiflora* in Mexico makes the discovery of *E. lineata*'s hostplants in lower Central America an exciting prospect.

C. The Egg

The egg of *E. lineata* is laid singly on the undersides of fully expanded, full-size leaves of the hostplant, a behavior common to many *Eueides*. The egg is greenish white, dome-shaped, and measures 0.83–0.84 mm high by 0.77–0.83 mm wide. It is similar in general shape to that of other *Eueides* spp. (Beebe et al., 1960), having indentations caused by the nurse cells during oogenesis and ridges between them. There are 10–11 horizontal ridges in total and 19–20 vertical ridges ($n = 3$).

D. The Larva

Larvae were reared in the laboratory on cut leaves (fresh daily) after being collected at Playa Escondida. Detailed measurements were made of fifth-instar larvae and pupae. Larval periods were measured (sample sizes in parentheses): egg to pupa, 21–22 days ($n = 3$); first-instar larva to pupa, 18–19 days ($n = 3$); third instar to pupa, 13 days ($n = 1$); fifth instar to pupa, 6 days ($n = 1$). The prepupal period lasts one day ($n = 2$), during which time the larva constructs a pad, changes to a pale yellow color, and hangs from the pad.

The fifth-instar larva ($n = 1$) (Fig. 2) has a maximum length of 24 mm. The head is 2.5 mm high and of the same width, is colored orange with black spots and white markings. The posterior dorsal and lateral border of the head capsule is black. A pair of black backwardly curved scoli, 3 mm in length, top the head. Dorsally, segments T1 to A7 are black and white in transverse stripes, four to a segment, A8 is dorsally orange, A9 and A10 are again black and white. Laterally there is a creamy-yellow line on T3–A8 that includes the spiracles. The underside is transparent greenish yellow, except the tips of the prothoracic legs, which are black. Dorsal scoli are black, paler medially; T2 = 2.5 mm, T3 = 2.75 mm, A1–A7 = 3.00 mm, A8–A9 = 2.75 mm. Lateral scoli are black, T2–T3 = 2.0 mm. Supralateral scoli are black, paler medially; A1 = 2.0 mm, A2–A5 = 3.0 mm, A6–A7 = 2.75 mm, A8 = 2.5 mm. Sublateral scoli are pale-translucent; A1 = 1.25 mm, A2 = 2.0 mm, A3–A6 = 2.25 mm, A7 = 2.0 mm, A8 = 1.75 mm. Anal scoli are black, 2.25 mm. The prothoracic plate is in the form of two hourglass-shaped plates placed transversely, one each side of the midline.

In the hanging prepupal stage, all body and head color is lost, the larva becoming pale greenish yellow. The black scoli color remains with black transversely oblong bases of the dorsal and supralateral abdominal scoli, except on A8 (scoli bases are here orange in the mature larva). The black head markings also remain.

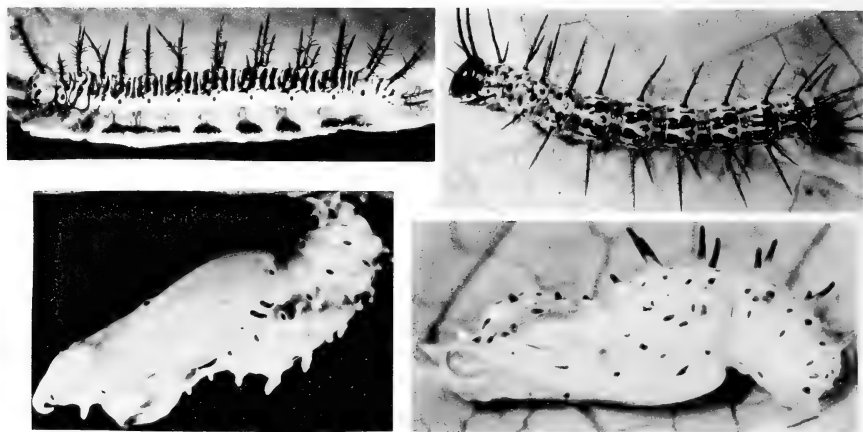


FIG. 2. Juvenile stages, clockwise from upper left: *Eueides lineata* (fifth-instar larva), *E. vibilia* (fifth-instar larva), *E. vibilia* (pupa), *E. lineata* (pupa).

E. The Pupa

(Fig. 2)

The pupal period seems variable in this species. We recorded periods of 9, 8, 8, 8, 7, 6, 6, and 5 days. In general outline the pupa of *E. lineata* is typical for *Eueides*, being bent ventrally so that it hangs horizontally.

The cephalic projections are 2.0 mm long, about the same as the diameter of the eye, without projections or scallops, smooth compressed laterally, curved dorsally and posteriorly, distally tapered and pointed. Antennae are without spines. Gold spots are absent. T2 has a median crest. The paired dorsal projections on T1 are about 0.5 mm long, on T2 nearly absent, and on T3 about 0.25 mm. There are no postmedian tubercles on the forewing. The three submarginal tubercles are well developed, the posterior two connected to the wing margin by a stripe of black pigment. The veins of the pupa are not marked with pigment. The profile of the antennae and wings projects little ventrally. The abdomen has paired dorsal projections as follows: A1 = 0.25 mm, A2 = 0.5 mm, A3–A7 = 1.0 mm. Tubercles on A3–A7 are directed anteriorly; evidence of bifidy is limited to a small bump on the posterior part of the stem. The general color is white marked with brown and olive green, especially a dorsal brown spot on A2–A3, and brown-marked scoli on the abdomen. There are some details in black, especially around the cremaster. The silk pad color is white. The total length is 15.5–17.0 mm (N = 5). The pupa differs from other *Eueides* in having dorsal paired tubercles A3–A7 short, homogeneous, anteriorly directed, and not darkly pigmented.

Eueides vibilia

A. Distribution and Adult Mimicry

In Central America the sexually dimorphic *E. vibilia* occurs as far North as the Sierra de Tuxtla in Mexico (Ross, 1967) and has the

subspecies name *vialis* Stichel. The orange and black male might loosely be described as a mimic of the "orange" mimicry group (see above under *E. lineata*). The female is yellower on the forewing medial region and has black ray markings on the hindwing, resembling *Actinote anteus* Doubleday (Acraeinae), with which it is sympatric in some areas of Costa Rica (P. DeVries, pers. comm.). We did not, however, find *A. anteus* in Corcovado. *E. vibilia* is a widespread species and is found south to Rio de Janeiro, Brazil, where *E. v. vibilia* females, *E. pavana* Menetries, and *Actinote* spp. participate in a mimicry ring (Brown and Mielke, 1972). The species is rare in Costa Rica, only being known from a handful of specimens. These specimens are all from lowland localities on both the Pacific and Atlantic drainages of Costa Rica.

B. The Hostplants

The three reported hostplants of *E. vibilia* in South America are *Mitostemma glaziovii* Mast., *Passiflora (Astrophea) costata* Mast., and *P. (A.) mansii* (Mart.) (Benson et al., 1976). In Costa Rica we discovered larvae on old leaves of another *Astrophea* species, *Passiflora pittieri* Mast., while searching at San Pedrillo for larvae of *Heliconius hewitsoni* Staudinger on 13 June 1980. *P. pittieri* is quite common at San Pedrillo and Sirena.

Although Sirena is only 24 km down the coast from San Pedrillo, we have found neither larvae nor the distinctive old-leaf skeletonizing damage of *E. vibilia* at Sirena. There is evidence that *P. pittieri* has a more or less continuous distribution between the two sites. This indicates great patchiness of *E. vibilia*, which clearly does not result from its hostplant distribution. *P. pittieri*, judging from the number of herbarium specimens available, is as rare as *E. vibilia*. *P. pittieri*'s rareness is an artifact of its growth form and reproduction (Longino, unpub. data). It flowers rarely, usually in the forest canopy, and it is vegetatively very cryptic, juveniles looking more like understory tree seedlings than *Passiflora*. *E. vibilia*'s rareness is no doubt real, since the Osa Peninsula has been visited for many years by lepidopterists and students of heliconiine biology (L. E. Gilbert, W. W. Benson, P. DeVries, J. Smiley), and this is the first report of *E. vibilia* on the Osa.

C. The Egg

A batch of 74 eggs is figured by Benson et al. (1976) which was laid on a mature *Passiflora mansii* leaf underside in Mato Grosso, Brazil. We have not observed oviposition, but assume from the gregarious larvae that *E. vibilia* lays eggs in batches in Costa Rica also. According

to Brown (1981) the eggs are red and white, measure 1.0 mm high by 0.8 mm wide, and have 14 vertical and 8 horizontal ridges.

D. The Larva

Larvae were reared on cut leaves after collection at San Padrillo. The larval periods were: third instar, 3 days, fourth instar, 3 days ($n = 1$ batch), fifth instar, 5–7 days ($n = 2$ batches). First-instar larvae were not observed. Second to fourth instar had shiny black head capsules and black head scoli, with pale yellowish-green bodies and pale body scoli. In this way they resembled the larvae of the sympatric *H. hewitsoni*, that also feed gregariously on *P. pittieri* in the same habitat. The young larvae of *E. vibilia* can be distinguished from those of *H. hewitsoni* by the larger head scoli of the former and their habit of skeletonizing older leaves, rather than eating young shoots. This is probably an example of larval mimicry. During the fourth instar the scoli and upper body surface begin to darken, and the fifth instar is non-mimetic.

The fifth instar ($n = 1$) (Fig. 2) extends to about 23 mm long. The head is 3 mm high and broad, is black and has a pair of black dorsal scoli about 4 mm in length. Dorsally, the larva is olive green with black patches. Laterally, there is a creamy-yellow line that includes the spiracles; ventrally, the color is translucent greenish yellow. The prolegs are: T1 = black, T2 = translucent with black tips, T3 = translucent. The dorsal scoli are black with large black (approx. 0.7 mm) tumescent bases. The supralateral, lateral, and anal scoli are also black but lack the tumid bases. Dorsal and supralateral scoli vary between 3–5 mm, the anal and lateral scoli are 3 mm. Sublateral scoli A1–A8 are colorless and measure 1.5–2.5 mm. The prothoracic plate is large, black and elliptical, divided into two by a pale line through the short diameter which is at the dorsal midline.

E. The Pupa (Fig. 2)

The pupa is similar to that of *E. lineata* and other *Eueides* in its ventrally bent position and general outline. It differs in the following characteristics.

Paired dorsal projections: T1 = 0.3 mm long, T2–A1 = 0.2 mm, A2 = 0.5 mm, A3–A4 = 2.0 mm, A5–A6 = 1.5 mm, A7 = 1.0 mm. Supralateral projections A3–A4 minute, 0.1 mm. There is no evidence of bifidy and these tubercles project out at right angles to the body surface. All three submarginal tubercles of the wing connect to the wing margin by a black pigmented region.

The general color is creamy-white marked with black spots. The dorsal scoli on T2–A6 are black-tipped, the rest are white. Silk pad color is white. Total length is 16–17 mm ($n = 6$). It differs from other *Eueides* in having simple dorsal projections on A3 and A4 that are not very different in length from those of A5 and A6.

DISCUSSION

Comparison of the young stages of *E. vibilia* and *E. lineata* with other published accounts reveals little in the way of taxonomic sig-

nificance, but this is partly caused by the dearth of larval descriptions available. The pupal morphology of *E. vibilia* and *E. lineata* differs from other described *Eueides* pupae in having almost homogeneous dorsal projections, rather than having giant dorsal projections on A3 and A4 as do *E. isabella*, *E. aliphera*, and *E. tales* Cramer (Beebe et al., 1960; Brown & Holzinger, 1973). Otherwise, the pupa of *E. lineata* is similar to that of *E. isabella* in having the dorsal projections partially bifid and by its mottled color pattern, and *E. vibilia* is more similar to that of *E. aliphera* in having simple spines and a black-spotted color pattern.

Benson (1978) presented evidence that heliconiines partition larval resources. The new hostplant data presented here are concordant with this hypothesis. We saw no other heliconiine using *Passiflora* sp. nov. in the Sierra de Tuxtla region. New growth and old leaves on *P. pittieri* are very different resources with respect to toughness, availability through time, and type and abundance of predators (Longino, unpub. data). Two allopatric species of *Heliconius* in Costa Rica feed on the new growth: *H. hewitsoni* on the Pacific side, and *H. sapho* Drury on the Atlantic side. *E. vibilia* feeds on the old leaves.

The possibility of larval mimicry is intriguing. At San Pedrillo three heliconiine species have gregarious larvae that look extraordinarily similar from a human perspective: *E. vibilia*, *H. hewitsoni*, and *H. sara* (Fab.). Their yellow and black larval color pattern is very different from all the solitarily feeding heliconiine larvae. Why the gregarious larvae should share one pattern and the solitary larvae have other patterns is not easily explained. One possibility is that gregarious and solitary larvae have exclusive sets of predators; thus, there is no selection for a common pattern. We have some data suggesting that vespids and predacious pentatomids are more detrimental to gregarious than to solitary larvae, but there is no indication that these predators are the least bit deterred by toxins or other defenses of the larvae. Alternatively, what is obvious to the human eye may be cryptic to a vespid or pentatomid eye, and the larvae may be converging on the pattern most cryptic to these generalized predators. *E. vibilia* and *H. hewitsoni* larvae occur at very low densities, but by occurring on the same hostplant they are, in effect, being concentrated with respect to the predators they experience. Thus, there could be selection for convergence to a common pattern if, when a bird ate one yellow caterpillar on a plant, it avoided all other yellow caterpillars on that plant. *H. sara*, however, is often much more abundant in a habitat, feeding on a more common, weedy *Passiflora*. Possibly, *H. sara* originally evolved the yellow and black pattern as a general aposematic display, and they were abundant enough to provide a community-

wide selective force for the evolution of similar patterns in the rare, gregariously feeding heliconiines.

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FOSSIL LEAF-MINES OF *BUCCULATRIX* (LYONETIIDAE) ON *ZELKOVA* (ULMACEAE) FROM FLORISSANT, COLORADO

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ABSTRACT. A fossil leaf of *Zelkova* from the Florissant formation was found to contain the mine of a species of *Bucculatrix*. This is compared to mines of extant species of *Bucculatrix* of the *ulmifoliae*-group.

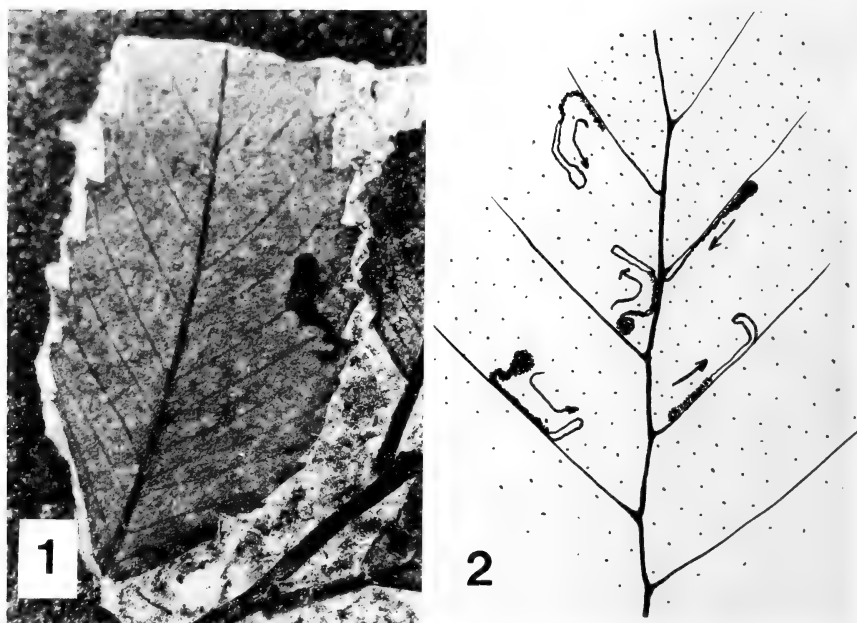
Leaf-mining insects, whose larvae feed between the cell layers of individual leaves, are found in four orders, i.e., Hymenoptera, Diptera, Coleoptera, and Lepidoptera (Needham et al., 1928). Among the Lepidoptera, the habit is most widespread among primitive superfamilies. Some families are composed entirely of leaf-miners, e.g., Eriocraniidae, Gracillariidae, Lyonetiidae, while others have both leaf-mining and external feeding representatives, e.g., Incurvariidae, Gelechiidae (Opler, 1974). Leaf-mining larvae feed in a stereotyped, conservative manner, and their workings may be readily identified to family, genus and even species, even after the responsible inhabitant has departed.

The discovery of identifiable mines on finely preserved fossil leaves has allowed biologists not only to gain insight into the evolution of Lepidoptera, whose fossil record is scant, but to trace back specific insect-host plant relationships into geological time (Lewis, 1969; Opler, 1973, 1974; Hickey & Hodges, 1975).

Opler (1973, 1974) provided evidence from fossil mines that several oak leaf-mining moths from western North America have probably survived virtually unchanged since the late Miocene epoch (18 million years b.p.). Subsequently, Hickey and Hodges (1975) reported that a *Phyllocnistis* (Phyllocnistidae) fossil mine on *Populus* of Eocene age was clearly *not* the same species as any modern *Populus*-feeding *Phyllocnistis*.

The present report is of *Buccalatrix* mines found on fossil leaves of *Zelkova drymeja* (Ulmaceae) (Fig. 1) from the Florissant formation in central Colorado, which is Oligocene age (30 million years b.p.). The host genus (*Zelkova*) has long since vanished from North America and today occurs only in temperate Eurasia. The mines are dissimilar to those made by any living North American species (Braun, 1963), but are recognizably similar to, but not conspecific with, *Bucculatrix ulmifoliae* Hg., which feeds on *Ulmus* in Europe and by *Bucculatrix ulmicola* Kuzn., which feeds on *Zelkova* in eastern Europe (Fig. 2).

This discovery is another important piece of evidence which dem-



FIGS. 1 & 2. *Bucculatrix* leaf mines. **1**, fossil leaf of *Zelkova drymeja* from Florissant formation with *Bucculatrix* mine (photograph by J. A. Powell); **2**, drawing of *B. ulmicola* mines on *Zelkova* sp. from Rodini, Rhodos, Austria (drawing by G. Deshka).

onstrates the historical fidelity of host relationships among the *Bucculatrix ulmifoliae* species group with Ulmaceae for at least 30×10^6 years. Whether the descendants of the Florissant moths eventually shifted their distribution to Eurasia as antecedents of the *Bucculatrix ulmifoliae* group or whether the Florissant mines represented an invasion from Eurasia which has since died out is indeterminate.

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LIZARD PREDATION ON TROPICAL BUTTERFLIES

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ABSTRACT. Iguanid lizards at Iguacu Falls, Brazil appear to make butterflies a major component of their diets. They both stalk sitting individuals and leap into the air to capture ones in flight. Butterfly species seem to be attacked differentially. These observations support the widespread assumption that lizards can be involved as selective agents in the evolution of butterfly color patterns and behavior.

Butterflies have been prominent in the development of ideas about protective and warning coloration and mimicry (e.g., Cott, 1940; J. Brower, 1958; M. Rothschild, 1972), and the dynamics of natural populations (Ford & Ford, 1930; Ehrlich et al., 1975). In spite of the crucial role that predation on adults must play in evolution of defensive coloration and may play in population dynamics, there is remarkably little information on predation on adult butterflies in nature. This lack is all the more striking, considering the large numbers of people who collect butterflies and the abundant indirect evidence from bird beak and lizard jaw marks on butterfly wings (e.g., Carpenter, 1937; Shapiro, 1974) that adult butterflies are quite frequently attacked.

Published field observations of predation on butterflies deal almost exclusively with the attacks of birds and consist largely of accounts of individual attacks (Fryer, 1913). Observations of natural predation by lizards are very rare, although "birds and lizards have long been considered to be the major selective agents responsible for the extreme diversity of unpalatable and mimetic forms of butterflies in nature" (Boyden, 1976). The following observations confirm the potential ability of lizards to place powerful selection pressures on butterfly populations.

A group of about seven iguanid lizards, *Tropidurus torquatus* (Wied), were observed on rocks adjacent to a walkway below the brink of Iguacu Falls in southwestern Brazil on 26 November 1980. The largest had a snout-vent length of about 15 cm; the others were about 10 cm or slightly smaller. While we were watching, a small, colorful nymphaline butterfly, *Callicore hydaspes* Drury, flew by about 50 cm above the lizards, several of which turned their heads to watch it pass. A few minutes later a small nymphaline (possibly *Dynamine artemisia* Felder) landed on the rocks about 15 cm from a lizard, which lunged at it, captured it, and ate it.

It subsequently proved possible to make roughly five person hours of undisturbed observations in sunny weather in the late mornings of

26 and 27 November. During that period we saw hundreds of lizard "reactions" to butterflies—flight-following with the head, short movements in the direction of a butterfly that had landed, or prolonged gradual stalking of sitting butterflies (Fig. 1). About 75 clear attacks were observed, consisting of a lunge that carried the lizard to or past the position previously occupied by the butterfly (Fig. 2) or a *leap clear of the ground* in the direction of a flying butterfly. Fifteen butterflies were captured and devoured. The butterflies eaten were the *Dynamine*, 1 *Eunica margarita* Godart, 6 *Callicore hydaspes*, 2 *Marpesia chiron* Felder, 1 *M. petreus* Cramer, and 1 *Dione juno* Cramer (all Nymphalidae: Nymphalinae); 1 yellowish-white pierid (possibly a female *Phoebis statira* Cramer); 1 small bluish skipper (Hesperiodea), and 1 large, powerful skipper (possibly an *Astraptes* or *Pyrrhopyge*).

The response of the lizards to different butterfly species was quite variable. They showed the greatest interest in *C. hydaspes*, which was also the commonest in the area. Its appearance in flight invariably invoked a reaction, even at a distance of a meter or more. When other butterflies passed by, however, very often there was no movement on the part of the lizards. Many of the butterflies landed on a small sandy patch next to the rocky area occupied by the lizards and showed classic "puddling" behavior (Fig. 1), probing the sand with their proboscides and dripping water from the anus—presumably acquiring salts (Arms et al., 1974), in this case possibly from lizard droppings. Generally lizards would stalk these butterflies until they were within 10–20 cm and then lunge at them. Butterflies that landed on the rock itself tended to elicit more rapid attacks, tempting one to speculate that the lizards had learned that butterflies not puddling were less likely to remain in place for an extended period. It also seemed that the presence of another nearby lizard prompted more immediate attack.

Leaps at passing butterflies were surprisingly frequent and roughly as successful as surface attacks (about 1 in 5). The *Dione* and one *C. hydaspes* were captured in mid-air, as was one large skipper, which, however, managed to wrench itself free and escape after the lizard had returned to earth. Lizards in other circumstances may attempt to catch flying butterflies—lizard jaw marks on only one wing may be evidence of this (L. Gilbert, pers. comm.) since butterflies normally sit with their wings held together over their backs (Fig. 1). Lizards have also been observed to leap clear of the ground to catch dragonflies on the wing (T. Schoener, pers. comm.). In experimental work on the palatability of butterflies to teiid lizards (*Ameiva ameiva* L.), Boyden (1976) found that when tethered butterflies "got stuck in tall grass above the lizard's head . . . the *Ameiva* would frequently jump



FIGS. 1-2. 1, *Tropidurus torquatus* stalking two *Marpesia chiron* (to the right of the lizard's head) and one *M. petreus* (below the lizard's head). Butterfly wingspreads approximately 50 mm. 2, an unsuccessful lunge, a moment after the photo in Fig. 1 was taken. Note that the *M. petreus* in the upper right (tip of its wing barely visible in Fig. 1) remains undisturbed.

distances greater than 0.4 m off the ground to attack the butterfly, pull it to the ground, and eat it." Nonetheless 13 of 15 *Tropidurus* captures observed by us were of sitting butterflies. This, not surprisingly, contrasts with the pattern of bird attacks, where more attacks seem to be aerial (Collenette, 1935; Carpenter, 1937; Bowers & Wiernasz, 1979). The vast majority of attacks observed by Shapiro (1974), however, were on sitting butterflies, and recently, evidence of heavy bird predation on resting *Euphydryas chalcedona* has been found (D. M. Bowers and I. L. Brown, in preparation).

Every butterfly captured at Iguaçu was completely devoured, so that no evidence of predation in the form of severed wings remained. In the process of swallowing the captured *Dione*, the lizard broke off a large piece of the butterfly's hindwing. After the rest of the butterfly was consumed, the lizard picked up the remaining piece of wing and swallowed it too. In contrast, wings are often removed by birds before the body is eaten (Collenette, 1935; Carpenter, 1937), and in at least one case of observed lizard attack on a temperate zone butterfly (*Vanessa cardui* L.), an iguanid (*Sceloporus graciosus* B.-G.) beat the butterfly against the ground to remove its wings before swallowing the body (Knowlton, 1953).

The *Dione* was the only butterfly attacked that, on the basis of its taxonomic affinities, might reasonably be expected to be at least somewhat unpalatable. Brower et al. (1963) found that close relatives of the *Dione* in the Heliconiini, *Dryas julia* Fabricius and *Agraulis vanillae* L., were unpalatable to silverbeak tanagers, although less so than members of the genus *Heliconius*. Several *Heliconius* passed within 1 m of the lizards we were observing but did not elicit the reactions that the smaller *Callicore* invariably did at the same distance. Boyden's work and greenhouse observations (L. Gilbert, pers. comm.) indicate that lizards find certain butterflies unpalatable and can learn to avoid them, and this seems a reasonable explanation for the behavior of *Tropidurus* toward *Heliconius*.

Although the lizards were also observed snapping at and catching small flies, during our observations butterflies were occupying most of their attention and in volume made up the vast majority of their intake. Butterflies are very abundant at Iguaçu because of extremely extensive forest-edge situations created by the falls and the facilities of Iguaçu National Park. They seemed especially common along the observation trails, frequently landing on wooden and metal handrails, presumably attracted by the salts left by sweating tourists. Lizards were abundant in precisely the same areas, and other insects were not conspicuous.

These observations indicate that, at least for some species such as

Callicore hydaspes, lizards may be significantly able to affect population size through predation on the adults. Since they evidently differentiate between butterfly species under natural conditions, they may well influence the evolution of butterfly color patterns and behavior.

ACKNOWLEDGMENTS

We thank M. D. Bowers, R. W. Holm, H. A. Mooney, D. D. Murphy and M. C. Singer for criticism of the manuscript. Keith Brown was helpful in identifying the butterflies; Richard Etheridge kindly identified the lizards. We are grateful to José and Sonia Rotenberg for support in the field.

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GENERAL NOTES

DISTINCTIVENESS OF *MEGISTO C. CYMELA* AND *M. C. VIOLA* (SATYRIDAE)

Megisto cymela Cramer is remarkable for its lack of geographic variation over a range that extends from Manitoba and Quebec to the Gulf Coast. The subspecies *M. c. viola* Maynard, described from Florida, is highly distinctive, differing chiefly by its larger size and rich coloration on the ventral hindwing. Most references (e.g., A. B. Klots, 1951, A Field Guide to the Butterflies, Houghton Mifflin, Boston, 349 pp.; W. H. Howe, 1975, Butterflies of North America, Doubleday, New York, 633 pp.) consider that the name *viola* refers to all peninsular Florida populations and that *M. c. cymela* and *M. c. viola* blend phenotypically in southern Georgia and northern Florida.

An examination by me of series in The Florida State Collection of Arthropods, Gainesville, Florida, indicates that this is not the case. There is no sign of a phenotypic "blend zone," and populations of both typical *M. c. cymela* and *M. c. viola* exist in northern and central Florida. In addition, on the basis of data labels in The Florida State Collection, *M. c. viola* exists apparently sympatrically with *M. c. cymela* in southern Louisiana (Weyanoke, West Feliciana Parish) and Arkansas (Little Rock, Pulaski Co.). Moreover, in Florida *M. c. viola* appears strictly univoltine with a flight from late March to May. In the same general area *M. c. cymela* may have up to four broods with flights in April (Shalimar, Okaloosa Co.; Alachua Co.), July (Alachua Co.), October (Gainesville, Alachua Co.), and December (Sebring, Highlands Co.). The two entities thus may well be separate species.

Larvae of Pennsylvania *M. c. cymela* and Florida *M. c. viola* differ in life history in the laboratory. Although the pattern of larval markings is similar, larvae of *M. c. cymela* are a much darker shade of brown than *M. c. viola*. Broods of *M. c. cymela* derived from univoltine populations in Allegheny and Fayette Cos., Pennsylvania, develop without diapause and emerge as adults in 90 to 100 days when reared under conditions of 27°C days, 24°C nights and 16 hr light/24 hr. This correlates well with the three to four months between flights of *M. c. cymela* in Florida. Under the same conditions, however, growth of *M. c. viola* larvae from a Gainesville population differs greatly. Larvae hatched from eggs in early April 1979 grew at a very slow but steady rate and pupated and eclosed as adults in late February and early March 1980. This also correlates well with the flight time of *M. c. viola* in Florida if the cooler winter temperatures in nature are taken into consideration.

Larvae of both entities were reared on potted *Poa pratensis* L., a grass native to the northern U.S. This could be a natural foodplant of *M. c. cymela*, but *M. c. viola* occurs south of its natural range. Nevertheless, *M. c. viola* larvae fed freely and produced adults of a size comparable to wild material. I consider it highly unlikely that differences in development time were related to foodplant suitability.

Collectors in the Gulf Coast states should watch for localities where *M. c. cymela* and *M. c. viola* are sympatric and attempt to gather data on possible ecological differences.

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LONG MATING FLIGHTS BY MALE
HYALOPHORA CECROPIA (L.) (SATURNIDAE)

Distances from which male moths can find the pheromone-emitting females have been determined for a few species by releasing marked males and recapturing them in traps baited with females. For example, Rau and Rau (1929, Trans. Acad. Sci. St. Louis 26:81-221) recovered about 11% of the male cecropia moths released 4.8 km from their trap. Distances of over 10 km have been recorded with other species (Shorey, 1976, Animal Communication by Pheromones, Academic Press, New York). (Also see below.)

These and similarly obtained data (including ours) are not a measure of the distance over which males can perceive the sex attractant pheromone. The males' flights will, of course, include random searching as well as directed movement to the pheromone—probably via anemotaxis (Kennedy, 1977, pp. 67-91 *In*: Chemical Control of Insect Behavior, H. H. Shorey and J. J. McKelvey, Jr., eds., John Wiley, New York). Neither do such data represent the entire distance flown by the males. Their actual flight paths are unknown, but are probably almost always longer than the straight line distance between the release and recapture points. Furthermore, data such as these are only minimum estimates of the straight line distance over which males can find females. If males are released at even greater distances, some may eventually be recovered; Toliver and Jeffords (1981, J. Lepid. Soc., in press) recaptured a male *Callosamia promethea* (Drury) 36.5 km from the release point.

Exceptionally long mating flights may usually be uncommon events, but they are probably important in promoting gene flow to distant populations, and they may make it possible for populations to survive at very low densities. Since information on long mating flights is scarce, we here present data that were obtained in the course of another study.

We used three traps baited with virgin female cecropia (Sternburg and Waldbauer, 1969, Ann. Entomol. Soc. Amer. 62:1422-1429) to catch wild males in, and near, the contiguous cities of Champaign and Urbana, Illinois, from 14 May to 10 July. One trap was at the home of JGS near the eastern edge of the cities, another was at the home of GPW near the western edge of the cities, and the third was east of the cities at Trelease Woods. Straight line distances between the traps appear in Table 1. Males came to the traps just before dawn. Later they were consecutively numbered on the underside of the hindwing with a felt pen—a different color for each trap—and released at the capture site. They dispersed, but we don't know how far they went. However, they usually flew out of sight even in daylight, and presumably made another dispersal flight at dusk, several hours before the females again emitted pheromone (Waldbauer and Sternburg, 1979, Amer. Midland Nat. 102:204-208).

We caught 1069 wild males and recaptured 390 (36.5%) of them one or more times. Twenty (5.1%) of the latter were recaptured at a more distant trap (Table 1), including one reared male (not in Table 1) released at a park in Champaign and recaptured 10.1 km away at Trelease.

Wind direction and velocity are important factors in the dispersal of pheromones. They determine the direction in which the male will fly and affect the distance that he can fly. We cannot determine the wind conditions that prevailed while the males made their way to the recapture sites. Wind direction and velocity may vary from hour to hour, and all but two of the nineteen recaptured males in question had from two to eight days to reach the recapture sites (Table 1). Thus, the winds almost certainly varied as these males moved toward the traps on any one of several nights or on some combination of two or more nights. Weather records for our area include the mean daily wind velocity and direction; these generally varied from day to day between the day of release and the day of recapture.

The frequency of occurrence of long flights may change with the population density of the wild moths. At lower densities than prevailed during our experiment, more long flights should occur because wandering males will be less likely to encounter the aerial

TABLE 1. Number of male *Hyalophora cecropia* recaptured at sites other than the release point, the distance between these points, and the number of days that elapsed between release and recapture.

Trap at which male was:		Distance (km) between traps	No. males	Days (or range) between captures
Released	Recaptured			
JGS	GPW	6.8	8	3-8
GPW	JGS	6.8	8	1-7
Trelease	JGS	6.8	1	1
JGS	Trelease	6.8	1	2
GPW	Trelease	12.5	1	8

pheromone trail of a wild female before encountering a trail from one of the traps. Similarly, in natural situations (without traps), the average distance flown by males searching for females should increase as the population density decreases. Our data (Table 1) suggest that for male cecropia moths these distances may be very long, and that reproduction could, therefore, continue even at very low population densities.

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HINDTIBIAL DEFENSIVE SPURS IN THE NEOTROPICAL SPHINX MOTH *AMPLYPTERUS GANNASCUS*?

A noticeable morphological feature of most adult Sphingidae is the double pair of elongate spurs on the tibia of the hindlegs (W. Rothschild and K. Jordan, 1903, A Revision of the Lepidopterous Family Sphingidae, *Novitates Zool.*, Vol. 9, Suppl.). There is usually a proximal and terminal pair of these spurs, which are modified spines. The functional role, if any, of these structures is unknown. However, they are conspicuously long and rigid in some sphingid taxa. In this note I wish to suggest a possible defensive role of these hindtibial spurs in sphingids, based upon my being jabbed by the spurs of *Amplipterus gannascus* (Stoll) to the point of considerable bleeding.

On the evening of 19 June 1980 at about 1600 hours, I collected several freshly-eclosed adults of various sphingids resting on the lighted wall of a "cacao beneficio" building at "Finca Experimental La Lola," a large cacao plantation along the railroad line connecting Guapiles with the Caribbean port city of Limon, Limon Province, Costa Rica. Upon picking up one of the largest specimens, I suddenly felt a very painful stab into one of my fingers. At first I thought it was a wasp sting, thinking that I had inadvertently picked up a wasp in the shadows along with the moth. A copious flow of blood told me that I had been jabbed with something very sharp. The moth turned out to be *A. gannascus* and close examination revealed very long (10 mm) and stout hindtibial spurs (Fig. 1) capable of piercing soft tissues without hindrance. The spurs were present only on the hindtibiae of the moth.

Amplipterus gannascus is widespread throughout Central and South America and the Caribbean (A. Seitz, 1924, *Macrolepidoptera of the World*, Vol. 5, American Rhopalocera, Stuttgart) and it is one of the larger sphingids attracted to lights in lowland



FIG. 1. **Above:** *Amplypterus gannascus* from Finca Experimental La Lola, in southeastern Costa Rica, dorsal view; **Below:** hindtibial spurs of *A. gannascus* pointing upward and just to the left of the tarsal region.

tropical rain forest areas. Being a large insect, the moth, as well as other sphingids, may be a target for predatory vertebrates that forage at lights in the tropics. The grass and lower vegetation at the base of lighted walls is often littered with large toads that readily could take moths in the act of alighting. Certain species of bats may also take adult moths as they fly around lights. Both groups of insectivorous predators are abun-

dant in the tropics. Although sphingid moths commonly accumulate at lights along with many other insects in the wet tropics, the kind of defense suggested here would be adaptive when away from lights as well. Moths flying through darkness might be picked off by foraging bats. Some Neotropical insectivorous bats readily respond to wing-flapping noises from large moths confined to the same cages (M. D. Tuttle, pers. comm.). Successful capture of a large sphingid results in the predator obtaining a large protein- and lipid-rich food morsel.

The presence of hindtibial spurs of varying size in sphingids may represent an adaptation to defense against predators. When jabbed with the spurs, my reaction was to immediately release the captured insect, permitting its escape. Similar behavioral responses might occur if spurs can successfully lodge in soft tissues around or just inside the mouth of a predator. Alternatively, these pronounced spurs may have little or no direct defensive function *per se*, and perhaps are non-functional, or are used in other activities such as courtship or feeding, but, secondarily can be used opportunistically in defense. Closer scrutiny of the functional role of these spurs, in sphingids in general, is needed. Studies, including analyses of distribution among sexes within a species, spur sizes, and frequency of occurrence in tropical and extra-tropical taxa, should be done.

I thank Susan S. Borkin for technical assistance and Dr. Merlin D. Tuttle for sharing with me his knowledge of moth predation by Neotropical bats.

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TWO SPECIES OF SKIPPERS COLLECTED AT ANTIFREEZE-FILLED PITFALL TRAPS IN ARIZONA

During a research trip to the Southwestern Research Station, American Museum of Natural History, Portal, Arizona 85632 in 1978, the senior author was able to collect hundreds of skippers in antifreeze-filled pitfall traps. The skippers were subsequently determined by the junior author as *Atrytonopsis python* (Edwards) and *A. deva* (Edwards).

Four pitfall traps (plastic cottage cheese containers) were placed, flush with the ground, 10'-20' apart around a pond that had a heavy red algal bloom. The traps were placed 3'-4' from the water's edge with the intention of collecting ground dwelling beetles near the water's edge. The traps were $\frac{3}{4}$ filled with Dowguard® antifreeze for specimen preservation. The traps were checked every 2-3 days, emptied and new antifreeze put in to bring the trap level back up to $\frac{3}{4}$ full.

During the month of June, hundreds of the two above mentioned skippers were found in the traps, preserved in the antifreeze. A select number of the skippers were removed from the antifreeze traps and taken to the lab. They were carefully washed with 75% ETOH and placed on paper towel to dry. When the alcohol absorbed by the towel had dried, the specimens were pinned and spread. No adverse effects on scale coloration of the specimens were noted.

To the author's knowledge, this is the only known record of skippers being attracted to antifreeze. As ethylene glycol is present in both the antifreeze and the insects (Somme, 1964. *Canad. Jour. Zool.* 42:87-101), it may be acting as a "cue" to attract the skippers to the traps. Skippers of this genus generally are attracted to flowers, sometimes in swarms, according to Howe (1975, *The Butterflies of North America*, Doubleday & Co., Garden City, N.Y.). Use of this type of artificial lure may be a useful method

of collecting these and other *Atrytonopsis* species. Specimens of both species have been deposited in the Michigan State University collection.

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A ONE-FOURTH GYNANDROMORPH OF *AGRIADES RUSTICA RUSTICA*
(EDWARDS) FROM WYOMING (LYCAENIDAE)

On a recent collecting trip to the Bighorn Mountains of Wyoming, an unusual single specimen of *A. r. rustica* (W. H. Edwards) was collected. The coloration of the wings, together with their relative size, clearly shows the left hindwing to be male, with the other three wings being female. In this respect it is similar to the specimen of *Strymon bazochii* (Godart) illustrated by Riotte [1978 (1979), *J. Res. Lepid.* 17(1):17-18.]. Examination of the external features suggests that the abdomen is that of a female specimen. While no other gynandromorphic Plebejinae are known to me from the Nearctic region, Ford (1945, *Butterflies*, London, pp. 193-195) illustrates a number of interesting forms from the Palearctic region.

Nielson (1977, *J. Res. Lepid.* 16(4):209-211) has pointed out that there has been a recent increase in publications dealing with gynandromorphism in the Lepidoptera.

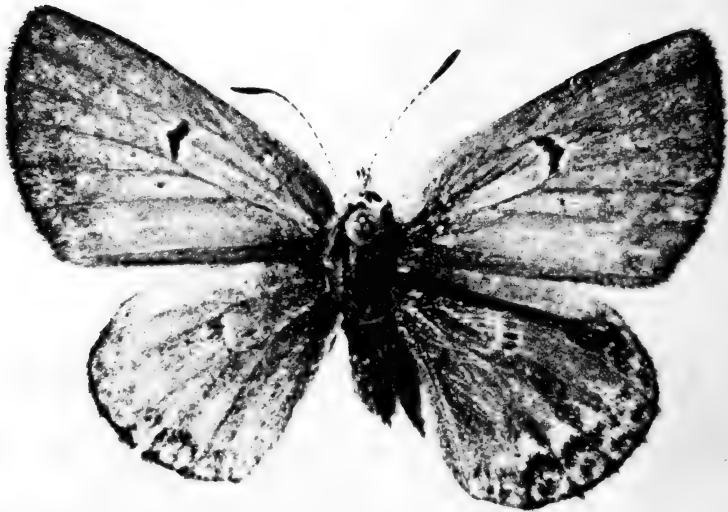


FIG. 1. Gynandromorph of *Agriades rustica rustica* from Wyoming. (Photo credit: Steve Lewis)

Examination of his literature citations, as well as those of Perkins and Perkins (1972, *J. Res. Lepid.* 11(3):195–196) indicates that the last twenty years have seen the appearance of a larger proportion of papers on that subject than in the decades preceding 1960. Whether or not this indicates an increase in the frequency of gynandromorphism or merely an increased awareness in the occurrence of the phenomenon is still a matter of speculation. It seems, however, that the interests of earlier collectors and authors for varieties and aberrations would have disclosed more examples from the Nearctic than are apparent at present.

The data for the specimen illustrated are as follows: Johnson County, Wyoming, Bighorn Mountains, Powder River Pass, 9660', 23 July 1980. At present, the specimen is in the author's collection.

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CHANGE IN STATUS OF *CATOCALA ANDROMACHE* RACE "BENJAMINI" (NOCTUIDAE)

Few specimens of the *andromache* complex of *Catocala* were available in collections in the early nineteen thirties when Dr. Foster H. Benjamin and I stood together in the U.S. National Museum and he suggested that I describe a unique portion (*benjamini*) of the complex as a race of *andromache* Hy. Edw, which I subsequently did (Brower, S. E., 1937, *Bull. Brooklyn Entomol. Soc.* 32(5):185–186). The unique type of *andromache* is considerably worn, and at the time we were considering this problem, quite a few collectors seemed to feel that there were already too many specific names in the *Catocala*. *C. benjamini*, NEW STATUS, is more uniformly brown-gray, with broader more prominent lines, than others of the complex, and most specimens lack to some degree the greenish shade characteristic of many *andromache*. No polymorphism in *benjamini* is evident to me in the material at hand. When I wrote the original description of the latter, the known ranges of the two entities were allopatric; however, I currently have data showing sympatry over portions of their ranges.

Based on an examination of the features mentioned above relative to significant series of all recognized species in the *andromache* complex, I conclude that *benjamini* Brower should be elevated to species level. I am making the change at this time so the new status will be available for use in detailed biological studies on this complex by J. W. Johnson and E. Walter now awaiting publication.

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A RECORD OF *ITAME ABRUPTATA* (GEOMETRIDAE) FROM WISCONSIN

Hoebeke (1980, *J. Lepid. Soc.* 34:132) reported the first occurrence of *Itame abruptata* (Walker) in New York and noted that it was "not well represented in North American collections," as cited in McGuffin's work (1977, *J. Lepid. Soc.* 31:269–274). McGuffin included Wisconsin in the range of the foodplant, but indicated no records of the moth from that state. Among material I received from Irwin Leeuw and determined for me by F. H. Rindge, American Museum of Natural History, New York, were the following: one male and one female, taken 9 July 1979 in Grant Co., Wisconsin.

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NEW HOSTPLANT RECORDS FOR *AGONOPTERIX CLEMENSELLA*
(OECOPHORIDAE)

As is the case for most of the Oecophoridae, details of the biology of early stages of *Agonopterix clemensella* (Chambers) are poorly known. Hodges (1974, Gelechioidea Oecophoridae, Moths of America North of Mexico, Fascicle 6.2, E. W. Classey, Ltd., London) reports that "the larva has been reared from parsnip, *Pastinaca sativa* L. and undoubtedly feeds on native umbels." Exhaustive sampling of Umbelliferae in Tompkins County, New York, during the spring and summer months of 1977 through 1979, revealed that *A. clemensella* utilizes a broad range of both native and introduced species (Table 1). The host list includes representatives of two subfamilies and five tribes in the family Umbelliferae; ten of the sixteen species are native to North America. The host plants occur in a variety of habitats, ranging from rich woods to waste places; clearly, *A. clemensella* is a family and not a habitat specialist.

The only umbellifer examined that is consistently avoided by *A. clemensella* is *Conium maculatum* (poison hemlock); in fact, caterpillars confined to the foliage invariably died. *C. maculatum*, however, is the sole host for *A. alstroemeriana*, a recently introduced European species (Berenbaum and Passoa, in preparation).

Larvae can be collected throughout June; adults emerge in late June and early July, approximately 10–14 days after pupation. Caterpillars on each plant species were reared through to the adult stage to verify their identity. Identifications were made by J. Franclemont and R. Brown of the Department of Entomology at Cornell University; representative specimens are on deposit in the Cornell University Collection, Lot 1023, Sublot 41B. This work was supported by National Science Foundation research grant DEB 76-20114 to P. Feeny.

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TABLE 1. Hostplants of *Agonopterix clemensella* in Tompkins County, New York. (Species arranged according to Drude, 1898, Umbelliferae, in *Die natürlichen Pflanzenfamilien* 3:63–250.)

Saniculoideae		
Saniculeae	* <i>Sanicula gregaria</i>	Damp woods
Apioideae		
Scandicinae	* <i>Osmorhiza longistylis</i>	Damp woods
Carinae	<i>Apium graveolens</i>	Greenhouse
	* <i>Zizia aptera</i>	Dry woods
	* <i>Zizia aurea</i>	Damp woods
	* <i>Cicuta maculata</i>	Wet meadows
	* <i>Cryptotaenia canadensis</i>	Damp woods
	* <i>Taenidia integerrima</i>	Dry woods
	<i>Aegopodium podagraria</i>	Waste places
	* <i>Sium suave</i>	Wet meadows
Peucedaneae	* <i>Angelica atropurpurea</i>	Wet meadows
	<i>Levisticum officinale</i>	Waste places
	<i>Pastinaca sativa</i>	Waste places
	* <i>Heracleum lanatum</i>	Waste places
	<i>Heracleum mantegazzianum</i>	Waste places
Dauceae	<i>Daucus carota</i>	Waste places

* Species considered native to North America (according to Fernald, 1950, Gray's Manual of Botany, 8th edition, American Book Co., New York).

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——— 1961a. Some contributions to population genetics resulting from the study of the Lepidoptera. *Adv. Genet.* 10: 165-216.

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Cover illustration: Mature Larva of *Eumorpha fasciata* Sulzer (Sphingidae) feeding on *Ludwigia* sp. (Jussiaea) in southern Florida, where this hawk moth is generally found throughout the year. Original drawing by Mr. John V. Calhoun, 382 Tradewind Ct., Westerville, Ohio 43081, USA.

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SOIL- AND PUDDLE-VISITING HABITS OF MOTHS¹

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ABSTRACT. Ninety-three species of moths representing ten families were recorded probing at soil and mud puddles over a four year period in central Pennsylvania. Nearly 99% of the 3417 individuals observed were males. Observations of Gracillariidae and Lyonetiidae (97% males) are the first records for these families at soil. The natural history of the soil-visiting habits is described. Special mention is given those species of Geometridae and Notodontidae that pass large volumes of water through their gut as they drink from very wet substrates. Evolution of the soil-visiting habits and their relationship to animal excreta are discussed.

The feeding habits of adult Lepidoptera are extremely diverse yet poorly understood. Gilbert and Singer (1975) stated that adults are more opportunistic and less specific in diet than larvae. The list of adult lepidopteran dietary sources other than floral nectar or extrafloral nectar (Downes, 1968) is extensive. Such sources include mud puddles, soil, and dung (Norris, 1936; Bauer, 1953; Sevastopulo, 1959, 1974; Downes, 1973); urine (Owen, 1971); crushed bodies of conspecifics (Reinthal, 1966); moist campfire ashes (Howe, 1975); carrion (Reed, 1958; Payne & King, 1969; Shields, 1972; Downes, 1973; Nielsen, 1977); saliva (refs. in Norris, 1936); exposed heads of basking turtles (D. L. Pearson, pers. comm.); soap suds (Farrell, 1979); lachrymal secretions and pus (Bänziger & Büttiker, 1969; Bänziger, 1972); perspiration (Collenette & Talbot, 1928); plain salt (Skertchly, 1889); blood (Bänziger, 1971, 1975); frog-hopper larval secretion (Lane, 1960); aphid honeydew (Manson, 1931); nectar gland secretion of lycaenid larvae (Gilbert, 1976); rotten fruit (Young, 1972); sound fruit (Hargreaves, 1936); cocoa seeds (Young, 1979); rotten seeds (Frost, p. 188,

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1959); fermented milk (Howe, 1975); rotten cheese (Norris, 1936); borage plants (Pliske, 1975); tree sap (Tutt, 1897; Scott, 1973); red wine (Gomez, 1977); ink (Poulton, 1913); honey (d'Herculais, 1916); and pollen steeped in nectar (Gilbert, 1972).

The present study surveys the soil- and puddle-visiting habits of moths in central Pennsylvania and presents notes on related feeding habits. Among most families of butterflies this behavior, usually referred to as puddling, is extensively documented. However, only a few papers (Fassnidge, 1924; Collenette, 1934; Downes, 1973) indicate that moths, and particularly the nocturnal contingent, also visit soil and puddles. Norris (1936) and Downes (1973) summarize the families of Lepidoptera in which soil visitation occurs.

In nearly all cases the Lepidoptera that do visit soil, puddles, carrion, and animal excreta are predominantly males (review in Norris, 1936). For example, Collenette (1934) found only 3% females among moths at damp sand in Brazil, and Downes (1973) observed 4.4% females among moths and butterflies at mud puddles in Ontario. One notable exception involves noctuids at perspiration in Brazil, where females represented 31% (Collenette, 1934). Females found at soil are usually old and worn (Clark, 1932).

Arms et al. (1974) showed that the sodium ion stimulated puddling behavior in males of *Papilio glaucus* Linnaeus, and established that amino acids obtained from soil are incorporated into body proteins. Recently, Adler and Pearson (1982) demonstrated a difference in the total body sodium levels of male and female *Pieris rapae* Linnaeus, a species in which they likewise found a positive response to sodium.

Lepidoptera that feed on dry substrates first moisten it with a bead of saliva passed down the proboscis and then reimbibe the solubilized nutrients in the manner described by Downes (1973). On the other hand, individuals that drink from wet substrates may discharge water droplets from the tip of the abdomen as they drink.

As early as 1883, Dukinfield-Jones recorded that the Brazilian geometrid, *Panthera apardalaria* Walker, drank from wet stones in a stream for three hours and passed about 200 times its volume in liquid. Guppy (1952) observed *Venusia cambrica* Curtis drink from a bucket of water and pass the liquid in such a fashion as to resemble a "living siphon." Clench (1957), in his observations of the geometrid, *Dyspteris abortivaria* Herrich-Schaeffer, and the drepanid, *Drepana arcuata* Walker, referred to the activity as "pumping."

The discharging of liquid while at wet soil and puddles has also been observed in the Pyralidae (Welling, 1958); HesperIIDae (Roever, 1964); Papilionidae (e.g., Reinthal, 1963; Welling, 1958; Jobe, 1977); Pieridae (Layard, 1883); and Lycaenidae (Tutt, 1897; pers. obs. of

TABLE 1. Summary of moths that visited soil and puddles during the summers of 1977-1980. Species indicated by D consistently discharged droplets of liquid while drinking. Those marked I infrequently discharged. All others were not observed to discharge. Species are arranged alphabetically within families.

	Males	Females	Dis- charging behavior
Gracillariidae			
<i>Agrocercops</i> perhaps <i>striginifinitella</i> (Clem.)	15	—	
<i>Caloptilia cornusella</i> Ely.	4	—	
<i>C.</i> perhaps <i>stigmatella</i> (F.)	4	—	
<i>Leucospilapteryx venustella</i> (Clem.)	4	—	
<i>Parornix</i> sp.	3	—	
Lyonetiidae			
<i>Bucculatrix</i> sp.	—	1	
Gelechiidae*			
Genus, species unknown	1	—	
Tortricidae (including Olethreutidae)			
<i>Ancylis metamelana</i> (Wlk.)	4	—	
<i>Cenopsis reticulatana</i> Clem.	—	1	
<i>Grapholita eclipsana</i> Zeller (diurnal)	3	—	
<i>Olethreutes albiciliana</i> (Fernald) (diurnal)	4	—	
Pyralidae			
<i>Anania funebris glomeralis</i> (Wlk.) (diurnal)	8	—	
<i>Argyria nivalis</i> (Dru.)	3	—	
<i>Blepharomastix ranalis</i> (Gn.)	1	—	
<i>Crambus turbatellus</i> Wlk.	2	—	
<i>Desmia funeralis</i> (Hbn.)	29	—	
<i>Mutuuraia mysippusalia</i> (Wlk.)	3	—	
<i>Ostrinia nubialis</i> (Hbn.)	15	—	
<i>Pyrausta pertextalis</i> Lederer	1	—	
<i>Sylepta fluctuosalis</i> (Lederer)	103	—	
Pyralid sp.	1	—	
Pterophoridae			
<i>Oidaematophorus homodactylus</i> (Wlk.)	4	—	
<i>O. monodactylus</i> (Linn.)	1	—	
Drepanidae			
<i>Eudeilinea herminiata</i> (Gn.)	4	—	
Geometridae			
<i>Anacamptodes ephyraria</i> (Wlk.)	4	—	
<i>Anagoga occiduaria</i> (Wlk.)	147	—	D
<i>Anavitrinella pampinaria</i> (Gn.)	4	—	
<i>Antepione thisoaria</i> (Gn.)	5	1	
<i>Biston betularia cognataria</i> (Gn.)	39	—	D
<i>Cepphis armataria</i> (H.-S.)	9	—	
<i>Chlorochlamys chloroleucaria</i> (Gn.)	7	—	D
<i>Coryphista meadii</i> (Pack.)	1	—	
<i>Cyclophora myrtaia</i> (Gn.)	1	2	
<i>C. packardi</i> (Prout)	—	1	
<i>Dyspteris abortivaria</i> H.-S.	672	—	D

TABLE I. Continued.

	Males	Females	Dis- charging behavior
<i>Dystroma hersiliata</i> (Gn.)	1	—	
<i>Ectropis crepuscularia</i> (D. & S.)	1	—	
<i>Euchlaena irraria</i> (B. & McD.)	7	—	
<i>Euphyia unangulata intermediata</i> (Gn.)	14	—	I
<i>Eupithecia</i> sp.	1	—	
<i>Eusarca confusaria</i> Hbn.	69	—	
<i>Haematopsis grataria</i> (Fab.)	1	—	
<i>Heliomata cycladata</i> Grote (diurnal)	2	—	
<i>H. infulata</i> Grote (diurnal)	1	—	
<i>Heterophleps triguttaria</i> H.-S.	44	—	D
<i>Homochlodes fritillaria</i> (Gn.)	—	1	
<i>Hydrelia lucata</i> (Gn.)	11	—	D
<i>Hydria prunivorata</i> (Ferguson)	90	—	I
<i>Hydriomena perfracta</i> Swett.	1	—	
<i>Idaea demissaria</i> (Hbn.)	1	1	
<i>Iridopsis larvaria</i> (Gn.)	12	1	
<i>Itame argillacearia</i> (Pack.)	76	—	
<i>I. pustularia</i> (Gn.)	3	2	
<i>Lobophora nivigerata</i> Wlk.	28	—	
<i>Lomographa semiclarata</i> (Wlk.) (diurnal)	700	25	
<i>Melanolopia canadaria</i> (Gn.)	14	—	
<i>M. signataria</i> (Wlk.)	1	—	
<i>Mesoleuca ruficillata</i> (Gn.)	24	—	
<i>Metanema determinata</i> Wlk.	36	—	I
<i>M. inatomaria</i> Gn.	33	—	I
<i>Metarranthis angularia</i> B. & McD.	10	—	
<i>Nematocampa limbata</i> (Haw.)	19	—	D
<i>Nemoria bistrifaria</i> Hbn.	4	—	
<i>N. rubrifrontaria</i> (Pack.)	1	—	
<i>Orthonama centrostrigaria</i> (Wollaston)	57	—	I
<i>Plagodis alchoolaria</i> (Gn.)	16	—	
<i>P. fervidaria</i> (H.-S.)	13	—	
<i>P. phlogosaria</i> (Gn.)	33	—	
<i>Probole alienaria</i> H.-S.	72	—	D
<i>P. amicarica</i> (H.-S.)	91	—	D
<i>Scopula inductata</i> (Gn.)	18	—	
<i>S. limboundata</i> (Haw.)	85	2	
<i>Semiothisa bisignata</i> (Wlk.)	—	1	
<i>Sicya macularia</i> (Harr.)	5	—	
<i>Synchlora aerata</i> (F.)	14	—	
<i>Xanthorhoe ferrugata</i> (Clerck)	58	—	I
<i>X. lacustrata</i> (Gn.)	15	—	
<i>Xanthotype urticaria</i> Swett.	118	—	I
Notodontidae			
<i>Clostera albosigma</i> Fitch	210	—	D
<i>Gluphisia septentrionis</i> Wlk.	227	—	D
Noctuidae			
<i>Bomolocha baltimoralis</i> Hbn.	13	—	
<i>Enargia decolor</i> Wlk.	3	—	

TABLE 1. Continued.

	Males	Females	Dis- charging behavior
<i>Hypena humuli</i> Harr.	5	—	
<i>Hyperstrotia</i> sp.	1	—	
<i>Lithachodia carneola</i> (Gn.)	—	1	
<i>Orthosia</i> sp.	—	1	
<i>Palthis angulalis</i> Hbn.	2	—	
<i>Psychomorpha epimenis</i> Dru. (diurnal)	1	—	
<i>Renia discoloralis</i> Gn.	1	1	
<i>R. factiosalis</i> (Wlk.)	1	—	
<i>R.</i> sp.	—	2	
<i>Tarachidia erastrioides</i> (Gn.)	2	—	
<i>Zale undularis</i> (Dru.)	—	1	

* R. L. Mangan (pers. comm.) commonly observed the pink bollworm, *Pectinophora gossypiella* (Saunders) feeding from soil in irrigated cotton fields of Arizona on very warm days.

Celastrina argiolus pseduoargiolus (Boisduval & LeConte)). Bänziger (1972) and Reid (1954) provide examples of nocturnal Lepidoptera discharging drops of liquid while feeding on the eye secretions of various animals. Certain hesperiids turn their abdomens anteroventrally and expel a drop of liquid in order to moisten a substrate and subsequently imbibe the drop (refs. in Norris, 1936; Hessel, 1966; Jobe, 1977; pers. obs. of *Erynnis juvenalis* Fabricius and *E. baptisiae* (Forbes)).

STUDY AREA AND METHODS

I observed nocturnal Lepidoptera with the aid of a head lamp from June through the third week of August each year from 1977 to 1980 (2130–0130 EDST). All field work was conducted in the Scotia Barrens of Centre County, Pennsylvania (approximately 5.7 km west of State College) along a 2.4 km stretch of gravel-dirt road leading south of Ten Acre Pond. The soil of the Scotia Barrens is characterized as Morrison loamy-sand.

Only those individuals with their proboscis extended to the substrate were counted. Individuals were sexed in the field and several representatives of each species were collected for identification.

RESULTS

During the four years of observation encompassed by this study I recorded 3417 moths, representing 93 species in ten families, at damp soil, puddles, ponds and their edges (Table 1). Observations of Gracillariidae and Lyonetiidae at soil are new family records. Females probing at damp soil comprised 1.3% of all individuals and repre-

sented only 16 species. Notably, half of these species were unrepresented by males.

All females in Table 1, with the exception of *Zale undularis* Drury, were old and worn; whereas, many of the males appeared fresh. However, senescent males of some species were common at damp soil. For example, 40% of *Eusarca confusaria* Hübner males ($n = 63$) were fresh (less than two days old), as determined by the wing condition of marked-recaptured individuals, while 31% were middle-aged and 29% were old (more than seven days old). A mark-recapture study of *E. confusaria* revealed that the same male may visit soil on more than one night.

Although flowers (*Asclepias syriaca* L., *Melilotus alba* Desr., *Achillea millefolium* L., *Spiraea latifolia* (Ait.) Borkh., *Solidago* spp., and *Eupatorium* spp.) bloomed plentifully in the study area, soil visitation was far more frequent than nocturnal flower visitation among males of all species in Table 1, except *E. confusaria*. I observed 303 *E. confusaria* males feeding during July 1977 but only 19.8% of these at damp soil. All 171 *E. confusaria* females found feeding were at flowers.

Some areas of the soil visited by moths were intimately associated with the recent presence of animals. Nocturnal Lepidoptera fed on bird droppings (males of *Heterocampa manteo* Doubleday and *E. confusaria*), dead frogs and rabbits, animal urine, and in the footprints of deer. (Although five males of *Prochoerodes transversata* (Drury) fed on the exudates of a dead rabbit, they were never observed at soil.) Aggregates of nocturnal moths were sometimes associated with animal-related substrates and restricted patches of moisture.

I often found nocturnal moths probing on soil-related substrates such as the damp walls, floors, and ceilings of crumbling cement structures in the abandoned (since the 1920's) community of Scotia. Most species found on the cement also visited soil with the exception of two female *Catocala ultronia* Hübner, one female *C. ilia* Cramer, one female *Euparthenos nubialis* Hübner, and one female *Amphipyra pyramiodoides* (Guenée). Although the observations of the latter four species are unique, it is of note that these species often rested on the cement structures during the day.

The species that visited soil and puddles could generally be characterized as those that passed droplets of liquid as they drank (Figs. 1 and 2), those that did so infrequently (less than 10% of the individuals of a given species), or those that did not (Table 1). Species that habitually discharged invariably drank from puddles or soil with a thin film of water. Non-discharging and infrequently discharging species preferred damp soil without standing water and sometimes



FIG. 1. Male *Dyspteris abortivaria* Herrich-Schaeffer, a typical discharging species, at wet soil. Arrow indicates formation of a droplet of liquid at the tip of the abdomen.

drank from the cracked bottoms of drying puddles. I observed no female of any species discharge while at soil.

The position in which moths held their wings while at soil or puddles was characteristic for each species. Among geometrids, approximately 80% including all discharging species held their wings toward the perpendicular (Fig. 3). Other geometrids such as *Hydria prunivorata* (Ferguson), *Lobophora nivigerata* Walker, both *Metanema* spp., and *Scopula limboundata* (Haworth) held their wings against the substrate.

Individuals that settled at soil or puddles generally remained stationary for several hours. The formation of liquid droplets at the tip of the abdomen and/or antennal palpation was often the only visible activity. All individuals were seemingly unaffected by light or close proximity of the observer. When moths completed their drinking or were touched they were capable of immediate flight except *Gluphisia septentrionis* Walker and *Clostera albosigma* Fitch, which vigorously vibrated their wings before actual flight.

G. septentrionis and *C. albosigma* restricted their drinking to areas of soil associated with a puddle or pond. *C. albosigma* often drank from scum and algal mats that floated on the surface, as well as from the edges of the water. This moth occasionally floated on shallow water while drinking. *G. septentrionis* frequented pond and puddle edges, where I observed individuals drink for more than an hour on

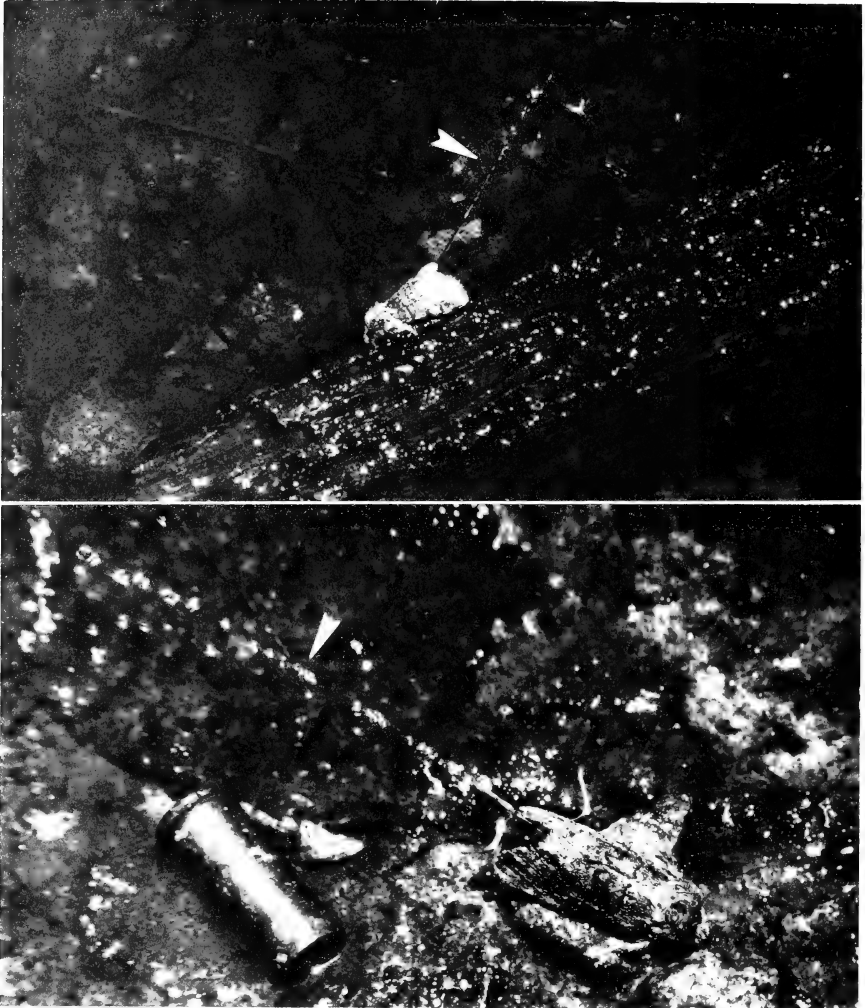


FIG. 2. Male *Gluphisia septentrionis* Walker discharging a jet of water (indicated by arrow). **Above**, substrate is a wet board. **Below**, rifle (.22 caliber) shell case indicates size.

wet boards, stones, moss, or head-down on the stems of emergent vegetation. All observations indicated that these species discharged water from the tip of the abdomen at a very rapid rate. *G. septentrionis* forcibly expelled rhythmic jets that traveled distances up to 30 cm (Fig. 2) whereas *C. albosigma* discharged large drops that diffused into the surrounding water. Among the geometrids that discharged liquid,



FIG. 3. Male *Dyspteris abortivaria* Herrich-Schaeffer showing usual position of the wings while visiting soil. Only the apical portion of the proboscis is applied to the water film.

drop size was generally proportional to body size, and when water was freely available, drops were produced at the rate of one or two per second. Suspended soil particles were also passed with the water.

No other species at this site passed water through its system as rapidly and in such quantities as *G. septentrionis*. A typical individual on a wet cinder road discharged 5.7 ml in 40 minutes (15 jets/min) along with 10.0 mg (dry weight) of particulate. An individual brought into the lab and offered a 10 μ M solution of NaCl passed 22.7 ml in 78 minutes (35 jets/min or 510 times its wet weight in liquid). Bromophenol red placed in the drinking water of three moths in the field was passed with the first ejection, i.e., within three to five seconds.

DISCUSSION AND CONCLUSIONS

The preceding results emphasize the highly developed habit of soil and puddle visitation in the ditrysian Lepidoptera, while a synopsis of the literature (Norris, 1936) reveals the widespread geographical nature of the habit. This attraction to soil and puddles probably evolved from water-drinking, a behavior necessary for maximum fitness in most Lepidoptera (Norris, 1934, 1936). The drinking behavior may have acquired further significance as individuals that satisfied their water requirements at soil or puddles accrued additional benefits, despite predation risks (Morris, 1953; pers. obs. of Chipping, Song and White-

crowned Sparrows and Eastern Towhees on *Lomographa semiclarata* (Walker) and *Erynnis juvenalis* and Common Grackles on *Pieris rapae*).

Common (1975) believes that the simple haustellate mouthparts of Lepidoptera predated the appearance of Angiosperms and further notes that the evolution of a functional proboscis would have allowed the early Lepidoptera with mandibles to move into drier places if they imbibed moisture droplets. If, in fact, the soil-visiting habits evolved from the habit of water-drinking, one would expect the more primitive Lepidoptera with a functional proboscis to visit soil.

Until the previously unrecorded observations of the Gracillariidae and Lyonetiidae (Table 1), soil visitation was believed generally restricted to the higher families of Lepidoptera. With the addition of these records, the habit assumes significance as a more widespread behavioral and physiological character. As in the higher Lepidoptera, a paucity of female soil visitors is evident among the Gracillariidae and Lyonetiidae, and may be considered characteristic of the soil-visiting Ditrysia.

The results of this survey increase the numbers of Geometridae that are known to characteristically discharge droplets of liquid while drinking from soil and puddles and provide the first records of this behavior for the Notodontidae. Drinking at dry or damp soil and drinking at open puddles appear to be variants of the same behavior. Whether or not a discharge occurs is related to the choice of microhabitat (often species-specific), which is, in turn, a function of water availability. This behavior is quite similar to that of aphids which pass copious amounts of plant juices in order to extract nutrients present in trace quantities (Mittler, 1958). I have also seen scores of *Halysidota tessellaris* (Smith) imbibe superfluous volumes of dilute *Asclepias* nectar just after a rain and discharge large droplets of liquid but have not observed this situation on nights without rain.

An anatomical and histological study of the alimentary tract of *G. septentrionis*, including a comparative study of the sexes, with respect to the rapid and forceful passage of large quantities of liquid would be informative. My preliminary dissections suggest that, superficially, the gut of the male does not differ markedly from that of an actively feeding noctuid, *Plusia gamma* Linnaeus (Mortimer, 1965).

All feeding habits associated with animal excreta probably evolved from the habit of visiting soil, and Downes (1973) is probably correct in assuming that animal excreta provide higher levels of attraction than soil and puddles. Sodium represents one common factor linking soil and puddles with animal excreta as nutrient substrates and has been suggested (Poulton, 1917) and implicated (Arms et al., 1974;

Adler & Pearson, 1982) as the feeding stimulus. However, the exclusively lachryphagous noctuid, *Lobocraspis griseifusa* Hampson, serves as a caveat that not all lepidopteran feeding habits associated with animal excreta involve uptake of similar nutrients. The fact that both sexes are commonly involved (Bänziger, 1975), and the species is unique among Lepidoptera thus far studied in producing proteinases (Bänziger, 1972), sets it apart from typical soil and animal associated Lepidoptera.

Viewed as a whole, there seems little question that soil and puddle visitation represent an integral part of the biology of many taxonomically diverse Lepidoptera. Species such as *G. septentrionis* that discharge large volumes of liquid as they drink afford excellent subjects for quantifying the dietary aspects of soil and puddle visitation through determination of substances in the imbibed medium versus the discharge.

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REDUNDANCY IN PIERID POLYPHENISMS: PUPAL
CHILLING INDUCES VERNAL PHENOTYPE IN
PIERIS OCCIDENTALIS (PIERIDAE)

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ABSTRACT. Chilling young pupae of Sierra Nevada *Pieris occidentalis* induces the vernal-alpine "calyce" phenotype as effectively as rearing on short days. Temperatures of 6°C or less sustained for 10 days or more appear equally efficacious. This redundancy in phenotypic-induction mechanisms parallels that found in various other butterflies, and is underlain by apparent genetic variation in sensitivity within populations.

The Western white, *Pieris occidentalis* Reakirt, has two seasonal phenotypes once considered separate species (Edwards, 1876). Shapiro (1973) demonstrated that rearing on a short day (10L:14D) without chilling induced the heavily-marked phenotype "calyce" in Boreal Ridge, California stock, and that temperatures of 10°C were ineffective in doing so under long-day (14L:10D) conditions. Later, Shapiro (1978) demonstrated that redundancy existed in the phenotypic-induction systems of various multivoltine Pieridae, including the closely-related species *P. protodice* Boisduval and LeConte. This discovery prompted a re-evaluation of thermal influences in phenotypic determination in *P. occidentalis*; specifically, chilling of long-day pupae at lower temperatures than used heretofore.

Ova were obtained from a single wild female collected in Donner Pass, of the Sierra Nevada, Nevada County, California (2100 m), 7 August 1980. This locality is about 4.5 km from Boreal Ridge and at similar elevation. Rearing was done under our standard conditions (Shapiro, 1975) with continuous light at 25°C on *Lepidium virginicum* L. var. *pubescens* (Greene) Thellung (Cruciferae), a natural host at Donner Pass. Allocation of pupae to treatments was randomized to obviate effects of the sequence of oviposition on offspring quality. Control pupae were held at the rearing conditions. Experimental pupae were refrigerated as close to eight hours after pupation as possible (effectively ± 1 h) and held in one of four regimes: 6°C for 10 days; 5°C for 14 days; 2°C for 14 days; 10 days at 6°C followed by 2 days at 25°C followed by 7 days at 2°C. After chilling, the pupae were returned to 25°C and allowed to develop and eclose. Mortality was negligible (4/154). Adults were classified into three phenotypic grades based on the degree of melanization of the ventral hindwing; standards are shown in Fig. 1 and correspond to those used by Shapiro

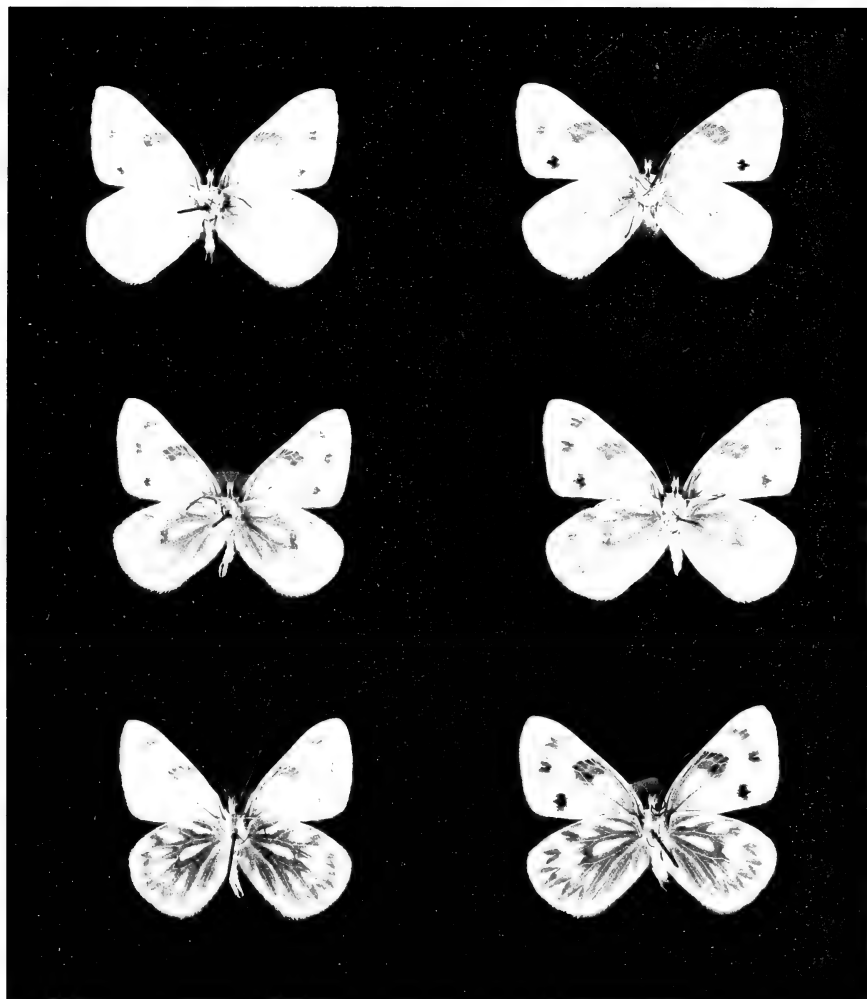


FIG. 1. Phenotypic standards for *Pieris occidentalis*, ventral surfaces, males at left. **Top row**, light; **middle**, intermediate; **bottom**, dark. All bred ex Donner Pass.

(1973). The results are given in Table 1. They were analyzed as follows: a log-linear model (Fienberg, 1977) was fitted to the 5×3 contingency table for pooled sexes. Using the large-sample distribution of the natural logarithms of the frequencies, it was possible to express the subsequent tests in terms of linear contrasts. When the hypothesis that the treatments have no effect on the phenotypic distribution was tested (pooled treatments vs. controls), the resulting χ^2 statistic was

TABLE 1. Phenotype distributions in a brood of 150 *Pieris occidentalis* from one Donner Pass, CA, female, reared on 24L/25°C, subjected to five different pupal temperature regimes.

Treatments:	Males			Females			Both sexes		
	Dark	Inter- mediate	Light	Dark	Inter- mediate	Light	Dark	Inter- mediate	Light
A. Control (unchilled)	4	12	15	1	10	21	5	22	36
B. 10 days at 6°C	2	11	4	4	5	1	6	16	5
C. 14 days at 5°C	4	6	0	7	6	1	11	12	1
D. 14 days at 2°C	3	6	0	4	6	0	7	12	0
E. 10 days at 6°C, then 2 days at 25°C, then 7 days at 2°C	5	3	2	3	3	1	8	6	3
Σ chilled	14	26	6	18	20	3	32	46	9

Statistical comparisons (pooled sexes):

A × B: $\chi^2_3 = 11.09$ ($0.01 < P < 0.025$);
 A × C: $\chi^2_3 = 18.25$ ($P < 0.005$);
 A × D: $\chi^2_3 = 13.88$ ($P < 0.005$);
 A × E: $\chi^2_3 = 13.64$ ($P < 0.005$);
 B × E: $\chi^2_3 = 3.12$ ($0.1 < P$);
 C × D: $\chi^2_3 = 0.59$ ($0.1 < P$).

33.89 (df = 8, $P < 0.005$). Comparisons between the control and the individual treatments were all significant (Table 1), while two sample comparisons were not. I therefore concluded that the phenotype of *P. occidentalis* is inducible by pupal temperature exposure but that it behaves as a threshold phenomenon with the switch occurring at some temperature between 10°C and 6°C.

Though further refinement of the effects is likely using larger samples and perhaps analyzing the sexes separately, it is evident that *P. occidentalis* adheres to the pattern of *P. napi* L., *P. protodice*, and *Colias eurythyme* Bdv. in having built-in redundancy in its phenotypic-induction system, with short days irreversibly determining dark phenotype but, with long day-light phenotype decisions reversible by subsequent chilling. Also, the response is not all-or-none; some seemingly inappropriate phenotypes are produced in most groups, and the distribution of this phenomenon exceeds the variance in age at refrigeration. Thus differences in sensitivity to chilling, as to photoperiod, may be genetically determined. Extreme "calyce" phenotypes (Shapiro, 1978) probably represent the combination of larval short-day exposure and post-diapause pupal chilling. Since my 1973 paper I have examined many populations of this complex from the Rocky Mountains, the Sierra Nevada, and Alaska, all of which retain both "calyce" and estival *occidentalis* phenotypes.

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ROOST RECRUITMENT AND RESOURCE UTILIZATION: OBSERVATIONS ON A *HELICONIUS CHARITONIA* L. ROOST IN MEXICO (NYMPHALIDAE)

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ABSTRACT. A communal roost of individually marked *Heliconius charitonia* L. (Nymphalidae) butterflies was observed over a three week period in southern Mexico. Pollen plants (*Anguria*, Cucurbitaceae), which serve as adult resources for these butterflies, were monitored for butterfly visits during this time. Roost members were generally using separate pollen plants from non-roost member *H. charitonia*. Predation on a roost member was observed at one of these plants. Fresh *H. charitonia* were observed associating with roost members first at a pollen plant during the day and later that evening at the roost site, indicating that the new recruits followed the older butterflies to the roost. Observations are discussed in regard to current hypotheses about gregarious roosting.

Many species of birds, solitary bees and wasps, bats and butterflies roost communally. In most cases, members depart from the roost on a circadian schedule to forage, returning to the site to sleep. Roosts may be diurnal or nocturnal, seasonal or permanent, mono- or multi-specific.

There are two major hypotheses concerning why animals roost together. One hypothesis suggests that communal roosts protect members from predation, either because animals in groups are quickly alerted to predator presence (Gadgil, 1972), or because the species is unpalatable (Benson, 1971; Turner, 1975). The second hypothesis proposes that roosts serve as centers of information exchange about food resources (Ward & Zahavi, 1973; Gilbert, 1975). At present, there are too few data on roost dynamics in any species to fully assess the relative importances of these two hypotheses.

Some species of the brightly-colored Neotropical *Heliconius* (Nymphalidae) butterflies characteristically form nocturnal communal roosts. Members of these roosts often home repeatedly to the same site every night (Benson, 1971). Gilbert (1975) has suggested that new recruits to *Heliconius* roosts follow experienced roost members from the roost site when they forage in order to learn the locations of pollen plants, which serve as important adult food sources for these long-lived butterflies (Dunlap-Pianka et al., 1977). Following behavior by conspecific *Heliconius* has often been observed in the field, but there is no information on following by members of the same roost. Similarly, there is no substantial information on patterns of resource utilization by roost members of *Heliconius* butterflies.

In our study of a *Heliconius charitonia* L. roost in Mexico, we observed fresh butterflies associating with roost members first on a pollen plant during the day, and later that evening at a roost site, indicating that the new recruits found the roost site by following the older butterflies. We also obtained evidence that roost membership is closely tied to resource use.

METHODS

Heliconius Butterflies

Heliconius are aposematic Neotropical butterflies with limited home ranges (Ehrlich & Gilbert, 1973). Individuals often live and reproduce for six months or longer. Both sexes make repeated visits to adult food plants for pollen and nectar, and to larval host plants for ovipositions (females) and mate-finding (males). It is therefore possible to monitor home range movements and resource utilization by individual roost members.

Heliconius charitonia is a brown and yellow zebra-striped inhabitant of forest edge and secondary growth habitats. This species forms low, cryptic nocturnal roosts, sometimes with other *Heliconius* species.

Study Site

Observations were made at the Estación de Biología Tropical "Los Tuxtlas" UNAM, near the town of Catemaco, Veracruz, Mexico. The Station is located on 700 ha of primary tropical rainforest and secondary growth. Altitude ranges from 150 m to 530 m. The mean annual temperature is 24°C, and the average precipitation is 4560 mm per year. This study was conducted in July and August 1978, approximately one month into the wet season.

Roost

The roost observed during this study was located next to a stream bed in a clearing that had been created by a tree fall (see Fig. 1). Two adjacent but discrete subroosts were used by the butterflies; these were approximately 3 and 4 meters high, respectively. Butterflies occasionally roosted high in branches above both subroosts.

Adult Food Plants

Anguria tabascensis Donn. Smith (Cucurbitaceae) lianas were the major pollen sources for *H. charitonia* at the Station. Eight of these plants were monitored for visits by *Heliconius* butterflies. Plants A1, A2, A3, A4, A5, A7 and A8 were flowering at eye level, and numbers of butterfly visitors could be read off the wings without disturbing

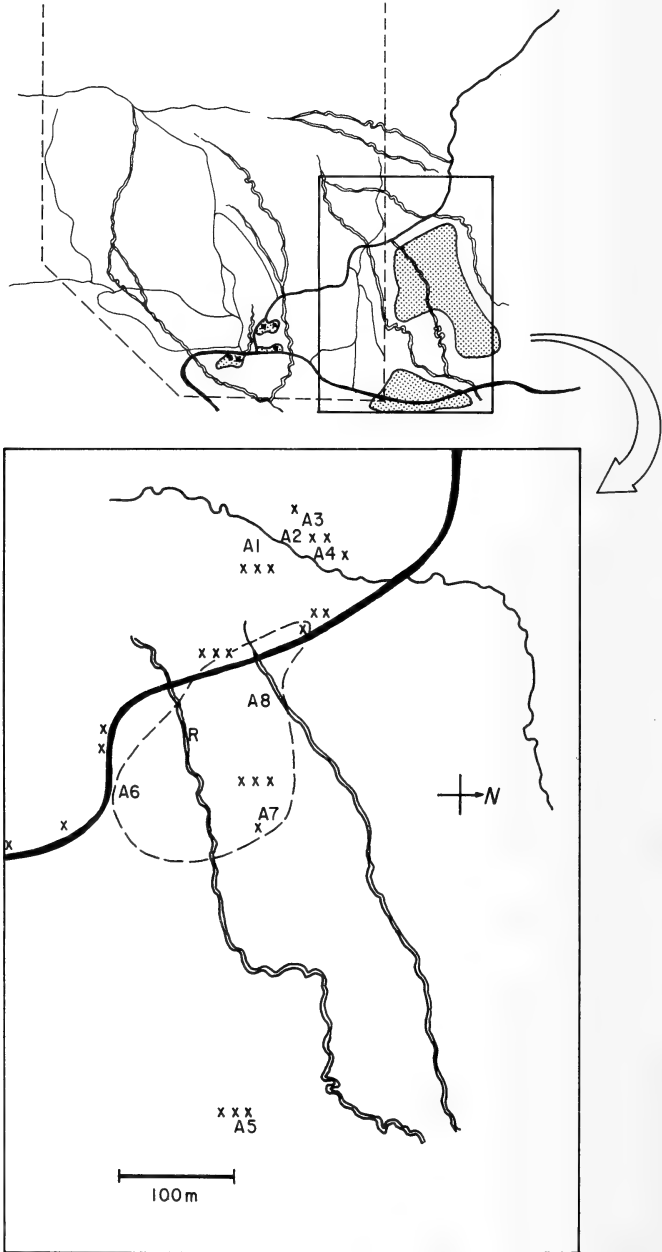


FIG. 1. Map of roost and surrounding area at the Estación Biológica Tropical "Los Tuxtlas" UNAM, Veracruz, Mexico, including locations of *Anguria* pollen plants A1, A2, A3, A4, A5, A6, A7 and A8. Roost member *H. charitonia* captures and sightings

the butterflies. A6 was a large vine flowering 22 meters in the canopy. Butterfly visitors to A6 were identified using binoculars and a Questar 3 telescope. Fig. 1 shows the locations of the roost and of *Anguria* plants A1-A8.

Procedure for Observation

Butterflies were observed on the roost through binoculars mornings and evenings from 18 July-6 August 1978, and evenings only from 6 August-10 August 1978. Roost members were caught at *Anguria* plants during the day, or netted as they left the roost in the morning. They were numbered at these times on the forewings with black marking pen. Butterflies were scored for sex and wingwear as fresh (F: less than 1 month old), intermediate (I: between 1 and 3 months old), or worn (W: over 3 months old), following Ehrlich and Gilbert (1973).

RESULTS

Roost Fidelity

When the roost was first discovered on 17 July 1978, it was composed entirely of worn and intermediate butterflies. No fresh butterflies were observed at the roost site until ten days later on 27 July.

Individual butterflies were highly faithful to the roost (see Fig. 2). The average roost member spent 11.4 nights on the roost during the three week period. Of those butterflies that spent more than one night on the roost (24 out of 27 butterflies), the average roost member was on the roost 87% of the nights during the time the butterfly was first and last observed at the site. Other studies of *H. charitonia* roosts have found roost membership to be less constant (Young & Carolan, 1976; Young, 1978). We attribute some of the high fidelity we observed to our avoidance of disturbing roosting animals for marking. It has been established that capture may drastically affect recapture of mud-puddling butterflies (Singer & Wedlake, 1981).

Resource Utilization

Another factor that may have contributed to the high roost fidelity observed in this study was the presence of a large pollen source 50 m from the roost site. This *Anguria* plant, A6, was located 22 m in

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were confined within the dotted line surrounding the roost site. Non-roost member *H. charitonia* captures and sightings are indicated by x's. Dark solid lines represent roads and paired wavy lines represent streams. (We thank Alejandro Estrada for access to this map which was made by his group for howler monkey population studies.)

#	S	C	July											August													
			18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11
2	M	Wtat	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	M	I	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
10	F	VWtat	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
12	M	F	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
14	M	IW	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
15	M	F	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
22	F	F	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
24	F	IWtat	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
26	F	I	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
28	M	W	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
30	M	W	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
32	M	I	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
34	F	W	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
36	M	W	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
38	M	IWtat	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
40	M	W	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
42	M	IW	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
44	M	Wtat	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
46	M	Wtat	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
48	M	IF	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
58	F	F	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
60	F	F	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
62	M	F	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
66	F	F	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
68	M	F	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
72	F	F	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
73	F	F	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Fresh unmarked butterflies			6	7	3	11	15	14	15	14	14	14	13	11	14	12	11	15	14	15	11	9	12	13	11	4	4
Total of Marked Butterflies on Roost			7	8	8	14	19	18	18	18	17	16	15	14	17	15	15	16	15	15	14	14	14	14	13	4	4
Total of Marked Roost Members Known Alive																											

FIG. 2. Mornings (M) and evenings (E) butterflies were observed on the roost. Sex (S) and condition (C) of roost members are indicated.

the canopy and bore more than 33 male inflorescences. More than half of the roost members (11 of 19 marked butterflies at the time of observation) were seen visiting flowers at A6, often repeatedly. A6 was observed for a total of six hours over three separate days.

Other butterfly species, including other heliconiines, also visited A6. However, with the exception of one worn, unmarked butterfly, the *H. charitonia* observed at A6 were all roost members. The almost exclusive use of this resource by roost members was especially striking since non-roost member *H. charitonia* were repeatedly observed flying in the road below A6.

Roost members also visited two *Anguria* that were growing at the edge of a cultivated field just north of the roost site. In four hours of observations (three separate days), seven roost members (Numbers 7, 10, 12, 15, 24, 26, and 42) were seen at A7. Only one non-roost member was caught and marked at A7. In over three hours of observations (four separate days), two *H. charitonia* roost members (Numbers 24 and 58) made repeated visits to A8. Most of the roost members at A7 were also seen in the canopy at A6 (Numbers 7, 10, 12, 26, and 42), but visitors to A8 were never seen at A6.

Anguria plants A1, A2, A3, A4 and A5 were monitored for *Heliconius* visits throughout the study. *Heliconius erato*, *H. doris*, *H. ismenius*, and *H. charitonia* were caught and marked at these plants from 7 July 1978, through 7 August 1978. No roost members were ever

observed to visit these flowers, and none of the 21 *H. charitonia* marked at these plants appeared at the roost site.

Predation at Resource

One worn roost member (Number 46, W male) was killed but apparently not eaten in the presence of roost mates at A6 by a tanager (Thraupidae). This observation made with the Questar suggests that, through their use of the same favorite pollen plants, roost mates provide a context for the operation of visual selection by predators, even away from the roost. This is in accord with Benson's (1971) and Turner's (1975) models that link roosting behavior with distastefulness and aposematic coloration in *Heliconius* butterflies.

Roost Recruitment

On the morning of 27 July 1978, two fresh *H. charitonia* butterflies appeared at A6 in the canopy, one with a distinct reddish cast to its wings. These fresh butterflies associated with roost members No. 38 (I male) and No. 40 (W male) on the flowers. That evening, two fresh butterflies, one with a distinct reddish cast to its wings, appeared at the roost site for the first time since the commencement of observations 10 days previously. One new recruit roosted with the group, and the other roosted with No. 38 on a branch away from the other butterflies. Although it cannot be documented that the two fresh butterflies sighted at A6 were the same that joined the roost in the evening, the circumstantial evidence strongly suggests that they were.

DISCUSSION

Our observations indicate that roost members were using separate pollen sources from those of non-roost member *H. charitonia*. Whether or not roost members learn the locations of these plants from each other remains to be investigated. This finding does suggest, however, that roost membership is somehow tied to patterns of adult resource utilization. If roost members associate in space and time at pollen plants, then predators need not visit the roost to learn or reinforce avoidance of one roost member through experience with another.

New recruits associated with roost members first on a pollen plant, and later at the roost site, apparently following the experienced butterflies to the roost. This observation suggests a mechanism for roost recruitment. Mature butterflies continually canvass larval host plants (*Passiflora* spp., Passifloraceae), with females in search of oviposition sites and males in search of female pupae. New butterflies emerging in the vicinity of *Passiflora* plants may be attracted to older butterflies when they visit and follow them to flowers and then to the roost or perhaps directly to the roost site. They might also seek out pollen

plants and follow experienced butterflies from there to the roost. However, it is not likely that a new individual would locate a plant like A6 easily without following other butterflies, since *Anguria* are generally inconspicuous, at least to human observers. Later foraging from the roost by experienced individuals may not involve the same following behavior which led to the roost's discovery. Indeed, we did not observe following between established roost mates.

These brief observations indicate the feasibility of relating roost membership to foraging behavior, interindividual interactions, and predation of individually numbered *Heliconius* butterflies in the field. We suspect that the major hypotheses for site-constant gregarious roosting (predator protection versus information center) in *Heliconius* will be difficult to clearly distinguish since, regardless of the reason for the evolution of the habit, other advantages to communal roosting may arise secondarily. The most certain conclusion is that *Heliconius* roosting behavior remains one of the major mysteries of lepidopteran biology and as such, deserves further study.

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EVOLUTIONARY STUDIES ON CTENUCHID MOTHS OF THE
GENUS *AMATA*: 2. TEMPORAL ISOLATION AND NATURAL
HYBRIDIZATION IN SYMPATRIC POPULATIONS OF
AMATA PHEGEA AND *A. RAGAZZII*

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ABSTRACT. *Amata phegea* and *A. ragazzii* are two sibling species which occur sympatrically in several areas of Central and Southern Italy. The occurrence of certain enzyme loci, electrophoretically diagnostic (PGM, HK, EST-5), allowed the correct identification of all individuals, including hybrids. Population studies in the field carried out in sympatric areas of Central Italy revealed the occurrence of seasonal displacement in the flight period acting as a premating isolating mechanism between the two species, in spite of a partial overlapping. Premating behavior of homospecific and heterospecific pairs investigated in the laboratory showed the existence of isolating mechanisms also at the ethological level, which lowers the mating success of the heterospecific pairs. The frequency of hybrids in different localities varies from 0 to 0.053; the highest rates of hybridization were found in biotopes recently altered by man. Hybrid frequencies, similar in larval and adult stages, suggest a normal viability of the hybrids.

The ctenuchid moths *Amata phegea* (Linnaeus, 1758) and *A. ragazzii* (Turati, 1917) are two sibling species, so far scarcely investigated from the genetic, ecological, ethological and zoogeographical points of view. *A. phegea* is widely distributed in Central Western Europe (with the exception of the Iberian peninsula) and is particularly abundant and widespread in Italy; while *A. ragazzii* is endemic in Central Southern Italy. The latter species has to date been observed in Calabria, Campania, Lucania, Molise, Lazio and Umbria.

The two species presumably diverged through geographical isolation in warm refugia during the Pleistocene. They successively expanded their range in the post-glacial era following the spread of the deciduous broad-leaved forest. Areas of sympatric occurrence have been identified in the Alban Hills, in the Fioio Valley (Simbruini Mountains), near Leonessa (Rieti), at S. Polo dei Cavalieri (Sabine Mountains), at Mount Faito (Campania), at Viggiano (Lucanian Apennines) and in other areas of Central and Southern Italy.

At the morphological level identification of the adult of the two species may be difficult, particularly in females. On the other hand, allozyme separation by electrophoresis enables us to identify all individuals, both larvae and adults (Bullini et al., 1981). Using this

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method we were able to discover some hybrids in the overlapping areas although no evidence of introgression has been detected. This seems to indicate the existence of highly effective isolating mechanisms.

We are investigating these mechanisms both in the laboratory and in the field. In this paper we will present data showing patterns of temporal displacement in the flight period of the two species, probably representing an effective premating isolating mechanism; a further premating mechanism is also reported operating at the ethological level. In addition, we will present data on the occurrence of natural hybridization in some areas.

STUDY SITES, MATERIALS AND METHODS

As previously reported, a number of localities have now been identified in Central Italy where *A. phegea* and *A. ragazzii* occur sympatrically. In most of them the phenology of the two species was investigated by frequent observations over several years. More detailed information came from five localities near Rome, where periodic observations and counts were carried out.

The first locality is situated at a height of 850 m near Camerata Nuova, a village 50 km north east of Rome at the foot of the Simbruini Mountains. This site is characterized by a *Quercetum* association and represents the middle-lower part of the biotope described in detail by Sbordoni et al. (1979). The remaining four sites, namely Zagarolo, San Cesareo, Rocca Priora and Monte Cavo, were selected along an altitudinal transect 14 km long from 300 to 900 m above sea level within an area including the Alban Hills about 30 km south east of Rome. Most of this area is characterized by chestnut woods.

Observations were carried out from 1967 to 1980; reported data refer to 1974, which can be considered representative of the overall period. Direct counts of adult moths were employed to describe the phenology of *A. phegea* and *A. ragazzii*. Mark-release-recapture methods were also utilized to estimate absolute populations sizes of the two species (see Sbordoni et al., 1979).

Starch gel electrophoresis applied to three diagnostic enzyme loci: phosphoglucosmutase (*Pgm*), hexokinase (*Hk*) and esterase (*Est-5*) was utilized to identify morphologically doubtful specimens and to discover hybrids (see Fig. 3). Electrophoretic techniques were, with minor modifications, those described by Ayala et al. (1972) for phosphoglucosmutase and hexokinase, and by Selander et al. (1971) for esterase.

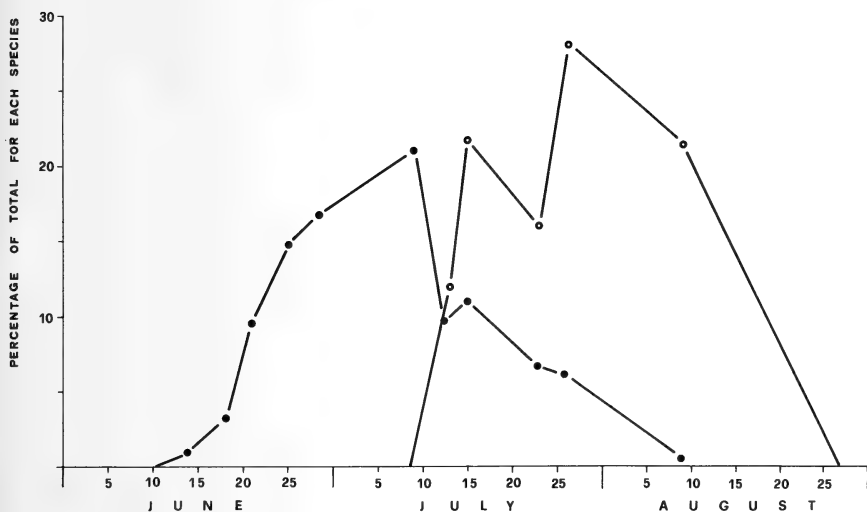


FIG. 1. Phenology of adult populations of *Amata phegea* (black circles) and *A. ragazzii* (white circles) at Camerata Nuova, Simbruini Mountains, 850 m, showing temporal displacement in the flight period.

RESULTS AND DISCUSSION

Temporal Displacement in Flight

By scattered observations and preliminary collection data we noted that the two species emerge at different times. This trend is clearly apparent from the data reported here.

At Camerata Nuova *Amata phegea* emerges about one month before *A. ragazzii* (Fig. 1). In the Alban Hills the emergence dates of the two species are separated by about 20 days, regardless of altitude (Fig. 2). Similar phenological data were observed in other localities in Central Italy. The degree of overlapping depends on the relative population sizes of the two species, which vary according to the localities. At Camerata Nuova *A. phegea* greatly outnumbers *A. ragazzii* and the ratio between the population sizes is approximately 30:1 (Sbordoni et al., 1979). More balanced situations were found in the localities of the Alban Hills. Here, consistent overlapping is limited to 10–15 days.

In both species males are first to emerge. Females are generally inseminated a few hours after their emergence (Stauder, 1927; Obraztsov, 1941). Female sex attractants are probably related to the anal papillae, which are rhythmically displayed by the virgin females (Obraztsov, 1966). Several males generally attempt to mate a single virgin female (Rasetti and Rasetti, 1921). Among adults the sex ratio is def-

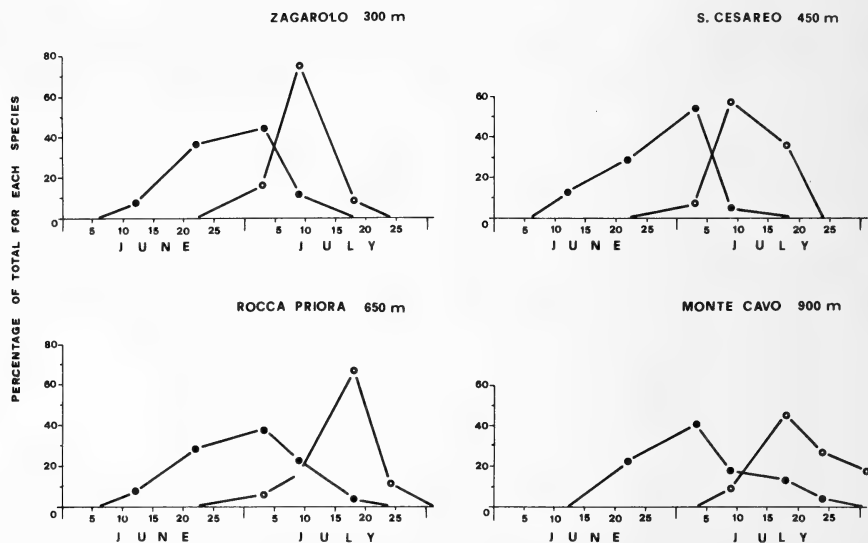


FIG. 2. Phenologies of adult populations of *Amata phegea* (black circles) and *A. ragazzii* (white circles) in 4 localities along an altitudinal transect south east Rome.

initely in favor of the males (80–85% in both species). According to these behavioral traits and the sex ratio, it seems improbable that a female of *A. phegea* could be inseminated by a male of *A. ragazzii*. On the other hand, old males of both species show an erratic behavior, and they tend to wander from their usual habitat in forest edges, open woods, etc. to open fields; also, this behavior limits the opportunities of mating between males of *A. phegea* and emerging females of *A. ragazzii*.

These observations led us to conclude that seasonal displacement may act as a premating isolating mechanism between *A. phegea* and *A. ragazzii*, although partial temporal overlapping occurs. This barrier would be particularly effective if monogamy were present in both species. However, this latter point needs to be tested.

Similar temporal displacement occurs also in other sympatric combinations of related *Amata* species. We observed this phenomenon in Istria and Dalmatia between *A. marjana* (Stauder, 1913) and *A. phegea*. In such instances, *A. marjana* is the first to fly, and the emergences of the two species are separated by about one month.

Premating Behavior

Besides the temporal displacement, an ethological isolating mechanism was also detected by preliminary laboratory experiments. *A.*



FIG. 3. Phosphoglucumutase (PGM) electrophoretic patterns of *Amata phegea*, *A. ragazzii* and their hybrid. *A. ragazzii* (specimens 1-4 and 10-14, from left to right) shows an anodic band migrating faster than *A. phegea* (specimens 5 and 7-9), whereas the hybrid (specimen 6) shows the two bands characteristic of the parental species.

phegea males isolated with conspecific virgin females are strongly attracted and approach the partner with a characteristic zig-zag flight. When the male touches the female she stops flying and the male lands on her. He repeatedly touches the costal area of her anterior wings with his antennae; the female, keeping her wings spread, raises her abdomen. Then copulation takes place. When *A. ragazzii* males are isolated with virgin *A. phegea* females, precopulatory behavior always begins later. Furthermore, the female often doesn't stop when touched and moves away. This generally interrupts a male's precopulatory behavior. Even when copulation takes place, the female frequently lays unfertilized eggs.

Natural Hybridization Between *A. phegea* and *A. ragazzii*

In this section we will present data demonstrating the occurrence of natural hybrids between the two *Amata* species occurring sympatrically in areas of Central Italy.

As reported in the materials and methods section, detection of hybrids by electrophoresis was made at some enzyme loci, which are diagnostic for *A. phegea* and *A. ragazzii* (*Pgm*, *Hk*, *Est-5*). At these loci no common allele is shared between the two *Amata* species studied. Hybrids are characterized by heterozygous patterns at each of these loci.

In Fig. 3 an example of a zymogram is shown, illustrating the pattern of *A. phegea*, *A. ragazzii* and their hybrid, at the *Pgm* locus.

Table 1 shows the numbers of *A. phegea*, *A. ragazzii* and hybrids in samples from some sympatric areas in Central Italy. Samples tabulated were collected during periods of temporal overlapping of the two species. However, if samples are collected over the whole period of flight of the two species, rates of hybridization may appear lower,

TABLE 1. Rates of natural hybridization between *A. phegea* and *A. ragazzii*, as revealed by electrophoresis on samples of adult moths from some sympatric areas of Central Italy.

Study site	Date of sampling	Number of specimens scored			Relative frequency of hybrids
		<i>A. phegea</i>	<i>A. ragazzii</i>	Hybrids	
Camerata Nuova	3-23 July 1974	173	21	1	0.005
Camerata Nuova	7 July-6 August 1975	891	99	3	0.003
Leonessa	25 July-8 August 1976	205	25	1	0.004
Montoro	25 June-23 July 1979	53	50	1	0.009
San Polo	4-19 July 1976	71	114	1	0.005
San Cesareo	8 July 1974	7	12	1	0.053
Tuscolo	8 July 1974	1	11	—	—
Monte Compatri	16 June-9 July 1974	39	10	—	—
Monte Porzio Catone	3-30 July 1975	10	202	1	0.004
Monte Cavo	30 July 1975	40	58	2	0.02

because all the hybrids detected were in flight relatively later, together with *A. ragazzii*.

Table 2 shows the data obtained from samples of larvae collected in three sites of the Alban Hills.

A comparison between the two tables do not reveal substantial differences in the frequency of hybrids between adult and larval stages from the same locality, suggesting normal viability of hybrids.

The frequency of hybrids varies from 0 to 0.053, but several values are around 0.004. The high rate of hybridization detected at San Cesareo, both from larval and adult samples observed in two distinct generations, may be tentatively related to the man-made alteration of their biotope. At the collection sites a wide zone of chestnut wood was replaced by *Rubus* sp.

Cases of sympatric hybridization are often associated with habitat alteration (Woodroof, 1973). In the case of *A. phegea* and *A. ragazzii* habitat alteration could affect the rate of hybridization and even the occurrence of sympatry between the two species. This working hypothesis requires further investigation.

TABLE 2. Rates of natural hybridization between *A. phegea* and *A. ragazzii*, as revealed by electrophoresis on samples of larvae from some sympatric areas of Central Italy.

Study site	Date of sampling	Number of specimens scored			Relative frequency of hybrids
		<i>A. phegea</i>	<i>A. ragazzii</i>	Hybrids	
San Cesareo	February 1975	50	107	6	0.038
Tuscolo	27 January 1975	5	113	1	0.008
Monte Compatri	February 1975	62	65	—	—

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COCOONS OF *CALLOSAMIA PROMETHEA* (SATURNIIDAE): ADAPTIVE SIGNIFICANCE OF DIFFERENCES IN MODE OF ATTACHMENT TO THE HOST TREE

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ABSTRACT. The cocoons of *Callosamia promethea* (Drury) (Saturniidae) are wrapped in a leaf and hang from a twig of the host tree by a silken peduncle that sheathes the leaf petiole and by a silken anchor that sheathes a variable length of the woody twig. It is proposed that in winter the cocoon's height above ground tends to protect it from mice and that its flexible attachment to a thin twig tends to protect it from woodpeckers. The anchor is usually about 2 cm long, but on thin twigs it may be much longer, sometimes extending past the next fork of the branch. The extension of the anchor seems superfluous on most of *promethea*'s hosts, trees with simple leaves where anchoring the petiole to the adjoining twig is sufficient to assure the cocoon's continued attachment to the tree after leaf fall. However, some of *promethea*'s hosts, the ashes (*Fraxinus* spp.), have compound leaves, and on these trees the cocoon will fall with the leaves in autumn unless the anchor is extended from the leaflet petiole up the rachis to encircle the adjoining woody twig.

Pupae of *Callosamia promethea* (Drury) (Saturniidae) overwinter in cocoons that dangle freely from a strong flexible silken peduncle anchored to a twig of the host tree (Fig. 1). In spinning the cocoon the larva first rolls a leaf along its midrib, fastens it at the margins, and lines it with silk to form an open-ended tube. It then spins a peduncle and anchor that are continuous with the lining of the leaf tube, the peduncle sheathing the leaf petiole and the anchor sheathing a variable length of the adjoining twig. Finally, the larva reenters the leaf-tube to spin a tough double-walled cocoon with a valve for the emergence of the adult at its top, where the petiole joins the leaf blade (Haskins & Haskins, 1958). The cocoons are usually fixed to thin terminal twigs well above the ground at the periphery of the tree's crown. They do not fall with the leaves in autumn. The enveloping leaf usually weathers away in winter, but the peduncle and anchor remain intact, securely attaching the cocoon to the tree (Ferguson, 1972).

The cocoon's height above ground probably tends to protect it from mice and its flexible attachment to a thin terminal twig, from woodpeckers. Accordingly, we present data on the predation pressure on *promethea* moth pupae, comparing it with the predation pressure, determined in other studies, on the pupae of a sympatric saturniid, *Hyalophora cecropia* (L.), whose larger cocoon often occurs in the same habitat but is immovably fixed to the stem or branch of a woody plant, usually near ground level (Scarborough et al., 1972a). We also

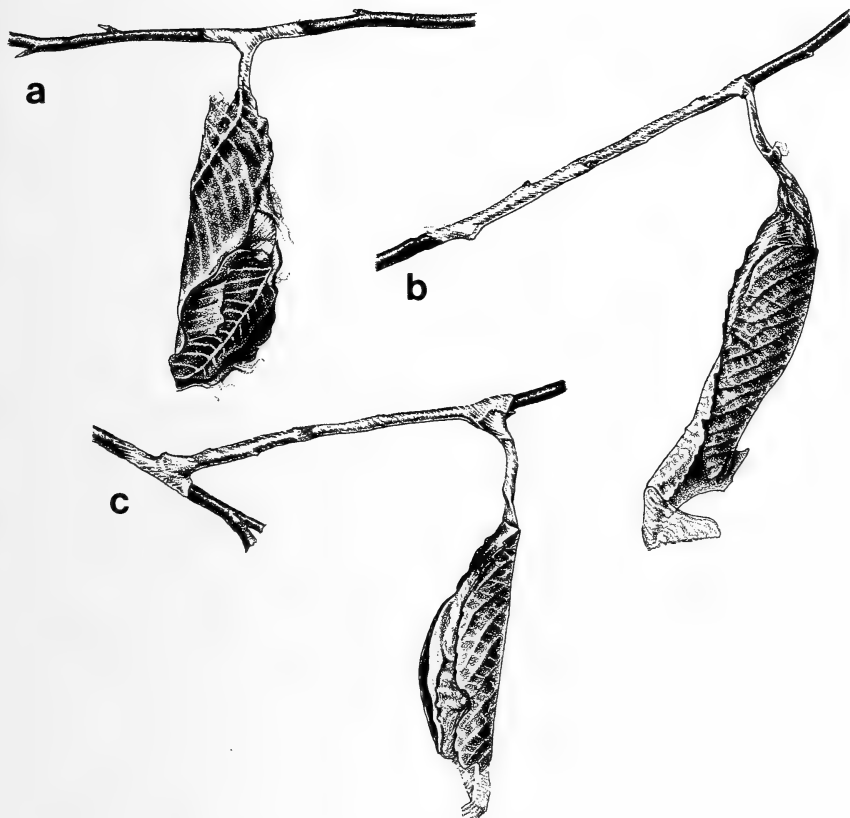


FIG. 1. *Callosamia promethea* cocoons showing the variations in the mode of attachment to the host tree. **A**, a short anchor, the usual mode of attachment; **B**, an extended anchor that does not reach past a fork; **C**, an anchor that extends past the next fork of the branch.

present data on the extent of the *promethea* cocoon's anchor. It is usually short but may be long, sometimes even extending up the twig past the first fork to sheathe a more proximal and thicker part of the branch (Fig. 1, Table 2).

MATERIALS AND METHODS

We collected *promethea* cocoons in east central Illinois from Danville south to Interstate Highway 70, and in northwestern Indiana from I-70 north to Medaryville. All were found on black cherry (*Prunus serotina* Ehrh.) or sassafras (*Sassafras albidum* Nees.) saplings that were seldom more than 3 to 4 m tall and were usually in fence rows in agricultural areas.

TABLE 1. Total *Callosamia promethea* cocoons collected, and the number and percent dead from various causes including unidentified parasites. Cocoons from Indiana were collected on 4 March 1972, and cocoons from Illinois were collected on 28 March 1972.

	Total collected	Cause of death							
		Unknown		Parasite		Woodpecker		Mouse	
		No.	%	No.	%	No.	%	No.	%
Medaryville, IN	200	17	8.5	4	2.0	9	4.5	1	0.5
Reynolds, IN	121	6	5.0	0	0	0	0	1	0.8
Charleston, IL	91	5	5.5	20	22.0	4	4.4	0	0
Total or percent of total	412	28	6.8	24	5.8	13	3.2	2	0.5

Random samples of *promethea* cocoons for estimates of predation pressure were collected at the localities and on the days in March shown in Table 1. Most predation had probably occurred prior to collection; Sternburg et al. (1981) found that 82.4% of the woodpecker attacks on cecropia moth cocoons had occurred by 4 March. Non-random samples of cocoons for determining the dimensions of the anchors and of the supporting twigs were clipped from trees with the anchor intact on 29 December 1969 near Medaryville, Indiana. We tried to find as many as possible of the relatively scarce cocoons with long anchors.

Length was measured with a rule and diameter with a micrometer. Dimensions of the distal part of the anchor (Table 2) were analyzed with a one-way ANOVA followed by the Student-Newman-Keuls test (Sokal & Rohlf, 1969). The mean lengths of the distal portions of anchors extending past the first fork (Fig. 1) cannot be legitimately compared with each other or with shorter anchors because, by definition, the lengths of the former are determined by the distance to the fork, while the lengths of the latter are not so determined.

RESULTS AND DISCUSSION

Thirteen (3.2%) of the *promethea* pupae had been killed by woodpeckers and only two (0.5%) by mice (Table 1). We found predation to be similarly light on several thousand cocoons collected in ten years at or near the same localities. However, on 1 March 1982, after two months of unusually deep snow cover, about 48% of the *promethea* cocoons that we found along 8 km of roadside near Medaryville had been attacked by woodpeckers, although *promethea* cocoons in nearby areas had not been attacked.

The similarity of the damage on these *promethea* cocoons to damage of known origin on cecropia cocoons leaves no doubt that the

TABLE 2. Mean length of the anchor and mean diameter of the anchor plus twig (cm \pm S.E.) of cocoons of *Callosamia promethea* collected from two host plants in the vicinity of Medaryville, IN on 29 December 1969. "Long anchor" means an extended anchor that does not reach beyond the first fork.

	N	Distal part of anchor		Proximal part of anchor	
		Diameter	Length	Diameter (twig)	Length
Sassafras					
Short anchor	97	0.364 \pm 0.010 ^a	1.419 \pm 0.048 ^a	—	—
Long anchor	34	0.246 \pm 0.009 ^b	5.490 \pm 0.390 ^b	—	—
Anchor extends					
Past first fork	65	0.213 \pm 0.007 ^c	5.024 \pm 0.310	0.417 \pm 0.018	1.135 \pm 0.053
Wild black cherry					
Short anchor	49	0.319 \pm 0.012 ^a	1.581 \pm 0.072 ^a	—	—
Long anchor	21	0.180 \pm 0.008 ^b	7.636 \pm 0.778 ^b	—	—
Anchor extends					
Past first fork	37	0.163 \pm 0.006 ^c	4.814 \pm 0.378	0.366 \pm 0.022	1.257 \pm 0.128

In each column, separately for the two host plants, means not followed by the same letter are significantly different, $P \leq 0.05$.

former were attacked by woodpeckers and mice. The downy (*Dendrocopus pubescens* (L.)) and the hairy (*D. villosus* (L.)) woodpeckers pierce the cocoon, making a small hole through which their barbed tongues remove the viscous pupal contents (Waldbauer et al., 1970). Both of them are common in promethea's habitat in winter (Bent, 1964). The mice *Peromyscus maniculatus* (Wagner) and *P. leucopus* (Raf.) remove the entire pupa through a large hole which they chew in the cocoon (Scarborough, 1970; Scarborough et al., 1972b). They are also common in promethea's habitat (Hoffmeister & Mohr, 1972). We found only one type of damage that may have been caused by another predator. A few cocoons were crimped and the pupae partly crushed, as if pinched by the bill of a bird. One of us (J.G.S.) saw a blue jay (*Cyanocitta cristata* L.) in January pinch and then desert a promethea cocoon that was later found to contain only exuviae.

Although cecropia is largely urban (Scarborough, 1970) and promethea is largely rural (Sternburg & Waldbauer, unpublished), both species feed on black cherry and may occur in the same rural fence rows. We have found that cecropia cocoons often fall prey to woodpeckers and mice in this habitat.

Although we do not have comparable predation data for these two species from the same area, there is no doubt that both woodpeckers and mice generally take a far heavier toll of cecropia than of promethea. In both urban and rural areas woodpeckers regularly kill about 90% of the cecropia pupae in cocoons 45 cm or more above the ground (Waldbauer & Sternburg, 1967a, b). In rural areas mice destroy as many as 60% of the cecropia pupae near ground level (Scarborough, 1970; Scarborough et al., 1972b).

The far lower level of predation on promethea cocoons suggests that their greater height above the ground, flexible attachment to a thin twig, and perhaps their smaller size may be adaptive responses to predation by vertebrates. Although *Peromyscus leucopus* are somewhat arboreal, they rarely attack high cecropia cocoons (Scarborough et al., 1972b) or promethea cocoons (Table 1). Woodpeckers may perch directly on the large immovable cecropia cocoons (Waldbauer et al., 1970), but they are probably reluctant to perch on the far smaller and free swinging promethea cocoon. Nielsen (1977) saw a downy woodpecker hang from a promethea cocoon as it pierced the pupa, but our data (Table 1) indicate that this is uncommon. The larger hairy woodpecker may find it even more difficult to perch on promethea cocoons than does the smaller downy. The thin twigs that support promethea cocoons may not be secure perches for woodpeckers. Even if a woodpecker does find a perch near a cocoon, it may not be able to pierce it because the cocoon, hanging by its flexible peduncle, swings away

when it is pecked. About 77% of the woodpecker-attacked cocoons listed in Table 1 had been pierced down through the valve into the head of the pupa. About 34% of a sample of 38 woodpecker-attacked *Promethes* cocoons collected in 1982 had been similarly attacked. Woodpeckers may tend to attack in this way because the force of a peck directed down into the valve does not cause the cocoon to swing away.

The length of the anchor of *Promethes* cocoons varies greatly (Table 2). Those with short anchors (2 cm or less) are most common; those with long anchors (up to 19 cm) that do not extend proximad past the first fork in the twig are much less common; and those with long anchors (up to 15 cm total length) that do extend past the first fork are the least common. Note that the numbers in Table 2, not based on random samples, do not reflect the relative abundance in nature of these three anchor types.

The data in Table 2 indicate that a cue associated with the diameter of the supporting twig stimulates *Promethes* larvae to spin an extended anchor. Cocoons with anchors extending past the first fork of the twig were on the thinnest twigs, those with long anchors not extending past the fork were on somewhat thicker twigs, and those with short anchors (2 cm or less) were on the thickest twigs. The mean diameters of twigs in each category are significantly different on both black cherry and sassafras (Table 2). Whether spinning larvae extend the anchor in response to the relative thinness of the twig, or to some other property associated with thinness, perhaps greenness, cannot be determined from the data at hand. While green twigs are probably thinner than woody twigs on the same tree, they are also softer; and *Promethes* larvae may extend the anchor in response to a relatively soft-textured supporting twig.

It is reasonable to hypothesize that the extension of the anchor is intended to prevent the cocoon from falling to the ground where it can be found by mice. However, extension of the anchor on black cherry or sassafras, trees with simple leaves, seems superfluous since even a short attachment to the adjoining woody twig is sufficient to prevent the cocoon from falling with the leaves in autumn. Woody twigs seldom fall spontaneously from these trees, and there appears to be no present danger from predators that might be better able to sever a thin twig than a thick one.

We suggest that the extension of the anchor is actually an inappropriate manifestation of a behavior that evolved as an accommodation to host plants with compound leaves. The rachis of a compound leaf is green and softer than a woody twig, and it is shed in winter. The anchor must extend up the rachis to the woody twig to keep the co-

coon from falling with the leaves. The promethea host plants listed by Ferguson (1972) and Tietz (1972) include only one group with compound leaves, the ashes (*Fraxinus* spp.). We do not find promethea cocoons on ash, but Comstock and Comstock (1916) found them to be abundant on ash. Promethea may have been more common on ash, or may even have used other plant species with compound leaves, when the capacity to extend the anchor evolved. This behavior might also be adaptive on any of the willows (*Salix* spp.) that shed some of their woody twigs. Ferguson (1972) and Tietz (1972) list willows as promethea food plants, and Vestal (1913) found their cocoons abundantly on willow near Havana, Illinois.

Cocoons on wild cherry are on thinner twigs, regardless of the length of the anchor, than are cocoons on sassafras (Table 2); these differences in mean diameter are significant ($P \leq 0.05$, Student's *t* test). If we are correct in our conjecture that promethea larvae respond to green twigs by spinning a long anchor, then these differences reflect only the greater mean diameter of sassafras twigs. If, on the other hand, the larvae actually respond to thinness *per se*, then these differences suggest that the larvae compare the thickness of the supporting twig with the thinner leaf petiole or with thicker twigs traversed enroute to the spinning site.

Pammer (1966) found that another saturniid, *Samia cynthia* Drury, is adapted to cope with compound leaves. Cynthia larvae feed on *Ailanthus altissima* (Mill.) Swingle (Ferguson, 1972), a tree with large, singly compound, deciduous leaves. The caterpillars spin cocoons that, like promethea cocoons, are wrapped in a leaflet and have a peduncle extending up the petiole. Larvae of the summer generation anchor the leaflet only to the rachis; they emerge as adults before the leaves fall. Larvae of the overwintering generation, however, ensure their continued attachment to the tree by extending the anchor up the rachis to the adjoining woody twig.

Promethea is partly bivoltine in the southern part of our collecting area, but it is yet to be determined if second generation larvae are more likely to extend the anchor than are first generation larvae.

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NOTES ON THE ACOUSTIC SIGNALS OF A NEOTROPICAL SATYRID BUTTERFLY

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ABSTRACT. Acoustical signalling is documented for the satyrid, *Pharneuptychia* nr. *pharnabazos*. The clicking sounds are produced during specific flight behaviors. The sounds have been identified from males only to date, but no structures or mechanisms for producing the sounds were identified.

Sound production in butterflies is a sporadic phenomenon, largely reported in the genus *Hamadryas* (Nymphalidae) (Darwin, 1871; Fruhstorfer, 1924; Ehrlich & Ehrlich, 1961; Ross, 1963). Audible clicking sounds in flight are characteristic of this group, hence the common name of "crackers." The nature of their sound producing mechanism is as yet unresolved (Swihart, 1967). Acoustic signalling has also been observed in *Neptis hylas* (Linnaeus) (Nymphalidae) (Scott, 1968), which produces a slow clicking sound by snapping together its forelegs while in a resting position. This paper presents the first documented evidence of acoustic signalling in a satyrid butterfly. The signals consist of bursts of clicking sounds emitted during ritualized flight behavior. The butterfly was identified as *Pharneuptychia* nr. *pharnabazos* by Dr. Keith Brown; however, the specimens appear quite similar to the plates in Seitz, Volume 5 (Plate 48d) called *Eupptychia pharella* (Butler) (Satyridae). For the purposes of discussion, I will call it *Pharneuptychia* nr. *pharnabazos*, although the identity is uncertain at this point.

Field Site and Method

Sound production was documented in the adult *Pharneuptychia* nr. *pharnabazos* between 0800 and 1000 h from 31 March to 4 April 1980 near the town of Senador Pompeu in the state of Ceará in northeastern Brazil (6°S latitude, 39°W longitude). A recording of the acoustic signals was made from 0900 h on 31 March with a Uher 4000L tape recorder, a Sony C-22 FET condenser microphone and parabola from a distance of 0.5 to 1.0 meter. Sound spectrograms were made on a Kay Electric Co., Type 6061-A sonograph using FL-1, linear scale, and wide-band filter settings. A copy of the recording was deposited in the Cornell Library of Natural Sounds and the Arquivo Sonoro Neotropical (cut S. Kane no. 17/1) of the Universidade Estadual de Campinas, São Paulo, Brasil. Voucher specimens were deposited in the American Museum of Natural History.

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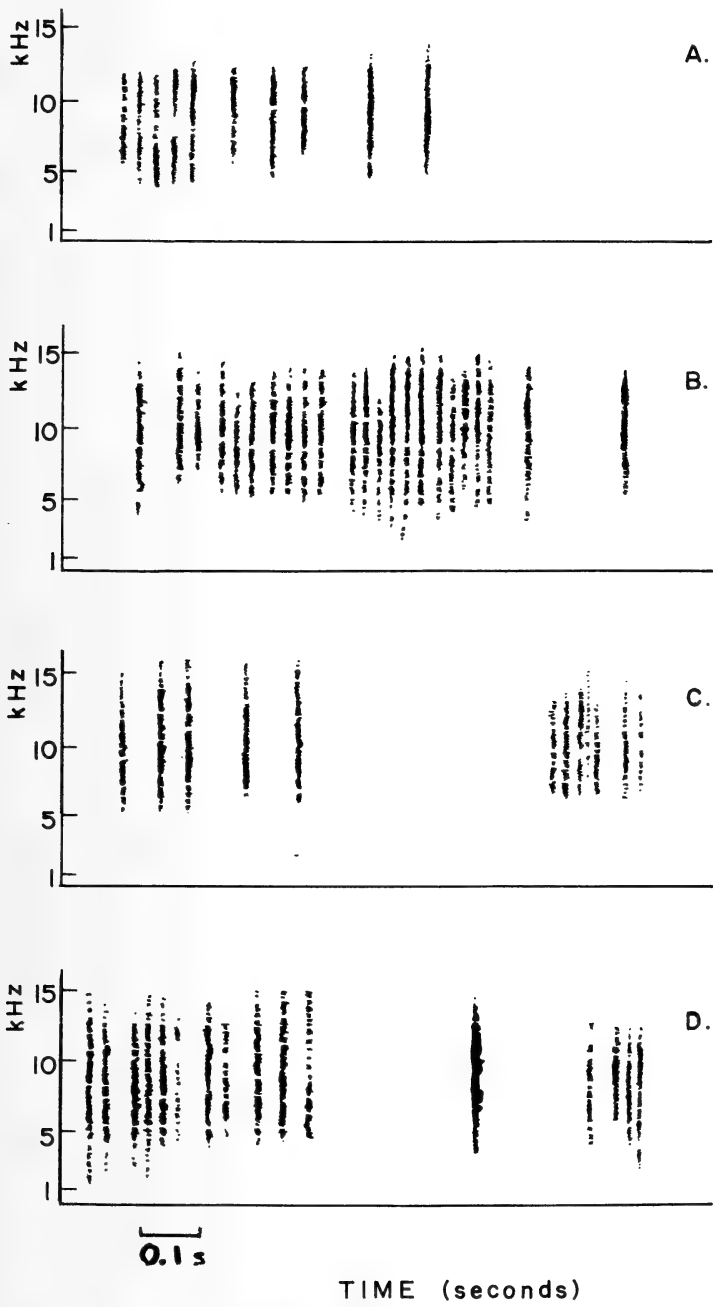


FIG. 1. Sound spectrograms representing 1.2 s segments of the acoustic signals of *P. nr. pharnabazos*.

Table 1. Bioacoustic Data

signal #	signal duration (sec.)	spectrogram	frequency range of spectrogram (kHz)	click rate of spectrogram (click/sec.)
1	1	A	4 - 13	19.6
2	4	B	5 - 15	28.4
		C	6 - 15	12.8
3	2	D	2 - 15	17.2

Fresh fruit of the Juazeiro tree (*Zizyphus juazeiro* Mart., Rhamnaceae) was cut up and distributed on rocks about 30 cm apart on the ground in a sunlit forest clearing. This attracted *P. nr. pharnabazos* and two other common fruit visiting species, *Hamadryas ferentina* Godart and *Anaea moretta* Druce (Nymphalidae). Intra- and inter-specific behavioral interactions were thereby observed with facility. Similar behavioral interactions were also observed along paths, other open woodland areas, and near fruiting trees.

Bioacoustic Analysis

Original recordings were made at 7½ ips. The spectrograms represent 1.2 s segments of recorded signals in the range of 800 to 16,000 Hz (see Fig. 1). The total recording duration is 32 s and consists of three signals from one or two individuals. The mean signal duration ($n = 3$) = 2.33 ± 1.53 s. The mean inter-signal duration ($n = 2$) = 12.5 ± 0 s. A signal is defined as one or more groups of clicks separated by neighboring groups by 12.5 s. The click is a broad band sound pulse with a range of frequencies between 4.25 kHz to 14.5 kHz for the greatest part of the amplitude of sound. Mean click rate per spectrogram = 19.5 clicks/s (see Table 1).

The sound producing mechanism is uncertain. It may be associated with wing beat, but this cannot be verified from the data presented, especially since, in some cases, two individuals may have been recorded simultaneously. A file system could produce the sounds as in crickets (Alexander, 1967). Unfortunately, the specimens had been crushed by the time they were examined microscopically and neither sound-producing, nor sound-receiving organs were apparent.



FIG. 2. Model of flight patterns of **A**) circling behavior and **B**) follow and chase behavior of 2 individual *P. nr. pharnabazos* butterflies. Relative strength of line indicates corresponding positions of individuals. Sounds are produced discontinuously throughout the movements.

Behavioral Notes

Auditory signals accompany ritualized flight behavior of two or three individuals. Sounds are produced discontinuously during circling and/or during follow and chase behavior (see Fig. 3). *P. nr. pharnabazos* usually flies about 10 cm off the ground, going up to 20 and 30 cm during the circle dance. Of six individuals collected, all are males. Three of these were clicking at the time of capture. It is not known if females produce sounds. Intraspecific encounters of another satyrid, *Erebia epipsodea* Butler (Brussard & Ehrlich, 1970), include ascending spiral flights and chasing behavior. These behaviors are also part of the intraspecific male territorial defense repertoires of *Archonias tereas* (Godart) (Pieridae) (Gilbert, 1968), *Papilio zelicaon* Lucas (Papilionidae) (Gilbert, pers. comm.; also described in Maynard Smith & Parker, 1976), and *Pararge aegeria* (Linnaeus) (Nymphalida) (Davies, 1978). Other genera of butterflies having male-male spiral chases are *Adelpha* (Nymphalidae), *Epiphile* (Nymphalidae), *Catasticta* (Pieridae), and some *Cissia* species (Satyridae) (pers. comm., Philip DeVries).



FIG. 3. Upper and under sides of the voucher specimen *Pharneuptychia* nr. *phar-nabazos*.

The intra- and interspecific interactions described below strongly suggest that the acoustic signals of *P. nr. pharnabazos* accompany agonistic behavior in the presence of food and/or mates. These signals may also function as part of an intraspecific recognition code, maintaining contact between male and female individuals of a mobile group.

Intraspecific encounters of *Pharneuptychia nr. pharnabazos*:

1. Individual (A) approaches posed individual (B). A clicks briefly. A and B fly off, clicking while following and circling each other. Both pose again.

2. Two males in flight. There is clicking during alternating circle and follow behavior.

3. Two individuals (A, B) are posed. A third individual (C) approaches A, clicking and circling, chases off C.

4. Two individuals (A, B) encounter one another in flight. They fly soundlessly in the same direction until a third individual (C) appears. A separates from B and chases C, clicking. B and C pose near one another, flashing wings.

5. Individual (A) is feeding. Individual (B) approaches and waits 1 to 2 minutes. B then clicks and flies closely around A, crashing into A. B leaves and poses nearby for 2 minutes. B comes back and A is still feeding. B flies off to another piece of fruit some distance away but does not feed.

6. Individual (A) is feeding. Individual (B) is posed close to A. B clicks as a third individual (C) approaches. C flies away.

Interspecific interaction between *Pharneuptychia nr. pharnabazos* and *Hamadryas ferentina*:

1. *H. ferentina* (H) approaches two individual *P. nr. pharnabazos* butterflies (A, B). A takes off and flies, clicking around H. A third individual *P. nr. pharnabazos* (C) joins A, both click and fly after H. B remains feeding.

RESUMO

Este trabalho apresenta a primeira evidência de sinalização acústica de uma borboleta da família Satyridae, identificada como sendo *Pharneuptychia* aff. *pharnabazos* do nordeste do Brasil. Os sinais constituem-se em estálidos em séries, emitidos em ritual de vôo entre dois ou três indivíduos. Análise bioacústica dos sons gravados e as descrições de comportamento estão incluídas.

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RELATIONSHIPS BETWEEN PUPAL SIZE AND SEX IN GIANT SILKWORM MOTHS (SATURNIIDAE)¹

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ABSTRACT. Weights and dimensions are given for pupae of *Callosamia promethea* (Drury), *Eupackardia calleta* (Westwood) and *Hyalophora cecropia* (Linnaeus). Significant sex-related differences were observed in sample means for all characteristics studied, except antenna length in *C. promethea*. Discriminant function equations were derived for predicting sex in individual pupae of *E. calleta* on the basis of weight and antenna width data; and individual pupae of *H. cecropia* on the basis of circumference and antenna width data. Reliable discriminant function equations could not be derived for determining sex in individual *C. promethea* pupae. Within species, significant differences were observed for male and female antenna surface areas. Between species, antenna length to width ratios did not differ significantly for individuals of the same sex.

The ability to determine sex in lepidopterous pupae precludes the need to await adult emergence to identify individuals for breeding or experimentation, or to determine sex ratios or individual sexes. For lepidopterous pupae the dimensions of the antennae and the morphology of the genital openings have been the most reliable and widely used characteristics for determining sex. Other characteristics such as coloration, body size, and even behavior have been used for certain species. The fact that female pupae are generally larger than males has been noted by many lepidopterists, but such differences have not been quantified. (Mosher, 1914, 1916a, 1916b; Butt & Cantu, 1962; Solomon, 1962; Ehrlick et al., 1969; Villiard, 1969; Kean & Platt, 1973; Jennings, 1974; Muggli, 1974).

Mosher (1914, 1916a, 1916b) is the best available reference on sex-related characteristics of giant silkworm moth pupae; providing detailed descriptions of external morphology, length to width relationships for male and female antennae, and dimensional and weight data. The dimensional and weight data are of limited value, however, because she mentions neither the number of pupae examined nor the sex. Mosher (1916a, Plates V & VI) also illustrates genital openings for a few species but does not discuss these structures.

In some giant silkworm moths, such as *Eupackardia calleta* (Westwood) and *Hyalophora cecropia* (Linnaeus), pupae can be sexed cor-

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rectly in almost every instance because of consistently distinct differences in both the size of the antennae (Figs. 1-2) and the morphology of the genital openings (Figs. 5-6). In pupae of *Callosamia promethea* (Drury) the dimensions of male and female antennae are not sufficiently different to permit reliable sex determinations (Figs. 3-4). Mosher (1916b) reported that the antennae of male *C. promethea* pupae are slightly longer and wider than those of the female, but that the antenna length is never more than three times the width in either sex. Also, the morphology of the genital openings can be highly variable in *C. promethea*. For certain groups of wild and reared pupae many individuals cannot be correctly sexed by examining these structures. The usual genital opening morphology for *C. promethea* pupae is shown in Figs. 7-8.

Although there are observable differences in the size of male and female pupae of *E. calleta*, *H. cecropia*, and *C. promethea*, no information has been found in the literature to indicate that such differences have been quantified or studied to determine their value in discriminating sex. Therefore, certain size characteristics of the pupae of these three species were examined to: (1) quantitatively define sex-related differences in weights and dimensions and; (2) determine statistically whether such differences can be used singly, or in combination, to discriminate sex.

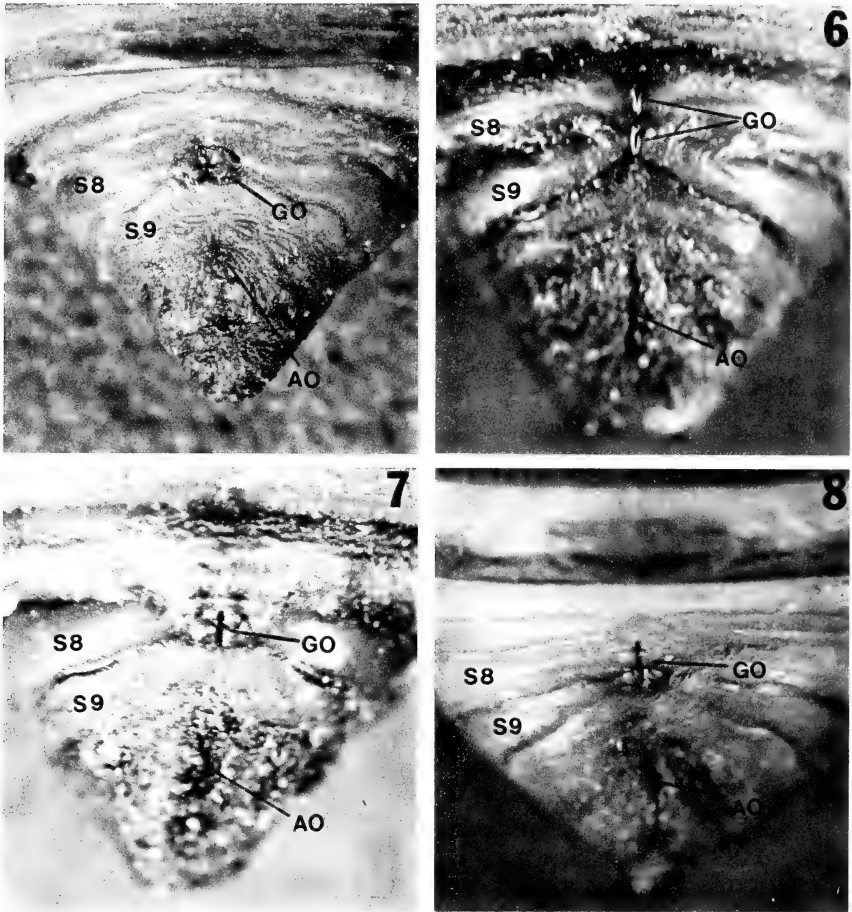
MATERIALS AND METHODS

Measurements made during the study were: body weight (WT); body length (BL); body width (BW); circumference (CE); antenna length (AL); and antenna width (AW). Weights were determined to the nearest 0.01 gram using a Mettler H542 Analytical Balance. Measurements of BL, BW, and AW were made to the nearest millimeter using a vernier caliper. Body length was the distance from the vertex of the head to the posterior end of the abdomen; BW was the width at the 4th abdominal segment; and AW was the maximum width measured perpendicular to the flagellum. Measurement of CE was made by placing a fine thread around the 4th abdominal segment and then measuring the thread on a metric ruler. Measurement of AW was made by placing a piece of monofilament nylon along the length of the flagellum and then measuring the piece of nylon on a metric ruler. Descriptive statistics (mean and 95% confidence interval) were cal-

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FIGS. 1-4. Ventral views of pupae. **1**, male *H. cecropia*; **2**, female *H. cecropia*; **3**, male *C. promethea*; **4**, female *C. promethea*. ANT, antenna; GO, genital opening; AO, anal opening.





FIGS. 5-8. Details of genital openings. **5**, male *H. cecropia*; **6**, female *H. cecropia*; **7**, male *C. promethea*; **8**, female *C. promethea*. S8 and S9, 8th and 9th abdominal segments; GO, genital opening; AO, anal opening.

culated to quantitatively define sex-related differences. Data were subjected to discriminant function analysis (Freese, 1964) to determine whether combination measurements, or ratios of measurements, were better discriminators of sex than individual measurements. Discriminant function analysis was used to estimate coefficients for a series of pupal measurements. Discrimination of sex is based on the magnitude of the discriminant function (Y) calculated from the formula $Y = a_1X_1 + a_2X_2 + a_3X_3 \dots + a_nX_n$, where X_i is a pupal measurement and a_i is a coefficient. The method assumes for each type of

measurement that the variance is approximately the same for males and females. Generally, only those measurements that improve discrimination are used in the model. By using statistical tests (e.g., F) it is possible to determine, through sequential testing of pupal measurements, which coefficients differ from zero and should be included in the model. The sequential testing of coefficients assumes the normal distribution. In addition to the single pupal measurements discussed earlier, the following ratios were examined by discriminant function analysis: WT/AL, BL/AL, CE/AL, WT/AW, BL/AW, CE/AW, and AL/AW. Sources of specimens from which data were collected were various reared and wild specimens as follows: *C. promethea* were diapausing pupae collected in Harford County, Maryland, during the winter of 1973–74 ($n = 34$) and diapausing pupae collected in Portage County, Ohio, during the winter of 1974–75 ($n = 43$); *E. calleta* were diapausing pupae collected in various south Texas counties during the fall of 1974 ($n = 48$); *H. cecropia* were diapausing pupae reared in Harford County, Maryland, during the summer of 1973 ($n = 65$). Pupae that were later used to test the various discriminant function equations were either specimens reared in Frederick County, Maryland, or wild specimens collected in Frederick and Harford counties, Maryland, or various counties in south Texas.

RESULTS AND DISCUSSION

Pupal weights and dimensions for *C. promethea*, *E. calleta*, and *H. cecropia* are summarized in Table 1. Within species the sample means for males and females are significantly different ($P < 0.05$) for all measurements, except antenna length in *C. promethea*. The statistics shown in Table 1 are sample means, ± 95 percent confidence intervals; they define an interval for population means but not individuals in the population. Thus, the interval statistics characterize the values of male and female pupae of these three species but will not validly discriminate sexes in individual pupae.

Discriminant function equations derived for determining sex in individual pupae of the three species are shown in Table 2. The discriminant function analysis program derived numerous equations; those shown in Table 2 are judged the most predictive calculation for each species. The validity of these equations was tested by using them to predict sexes in groups of wild and reared pupae. For *E. calleta*, we collected the appropriate data from individuals in two groups of reared pupae and one group of wild pupae from south Texas. The discriminant function equation ($DF_{ec} = -10.19WT + 39.22AW$) correctly calculated that there were 16 males and 16 females, and 7 males and 12 females, respectively, in the two groups of reared pupae,

TABLE 1. Weights and dimensions of giant silkworm moth pupae.¹

Measurement	<i>Callosamia promethea</i>		<i>Eupackardia calleta</i>		<i>Hyalophora cecropia</i>	
	Male	Female	Male	Female	Male	Female
Number (n)	44	33	27	21	37	28
Weight (WT)	1.23 ± 0.08	1.83 ± 0.16	2.80 ± 0.12	4.03 ± 0.20	3.87 ± 0.13	5.16 ± 0.29
Length (BL)	21.77 ± 0.74	25.18 ± 0.74	29.18 ± 0.45	35.52 ± 0.55	34.30 ± 0.45	37.92 ± 0.91
Width (BW)	10.06 ± 0.31	11.90 ± 0.37	13.77 ± 0.32	15.57 ± 0.34	15.61 ± 0.20	17.25 ± 0.36
Circumference (CE)	32.63 ± 0.93	36.96 ± 1.09	42.44 ± 0.74	47.85 ± 1.06	45.19 ± 0.69	52.07 ± 1.11
Antenna length (AL)	10.65 ± 0.32	10.51 ± 0.39	14.18 ± 0.38	12.66 ± 0.54	18.38 ± 0.31	16.35 ± 0.34
Antenna width (AW)	3.68 ± 0.10	3.06 ± 0.08	4.94 ± 0.07	3.75 ± 0.24	7.08 ± 0.12	5.00 ± 0.00

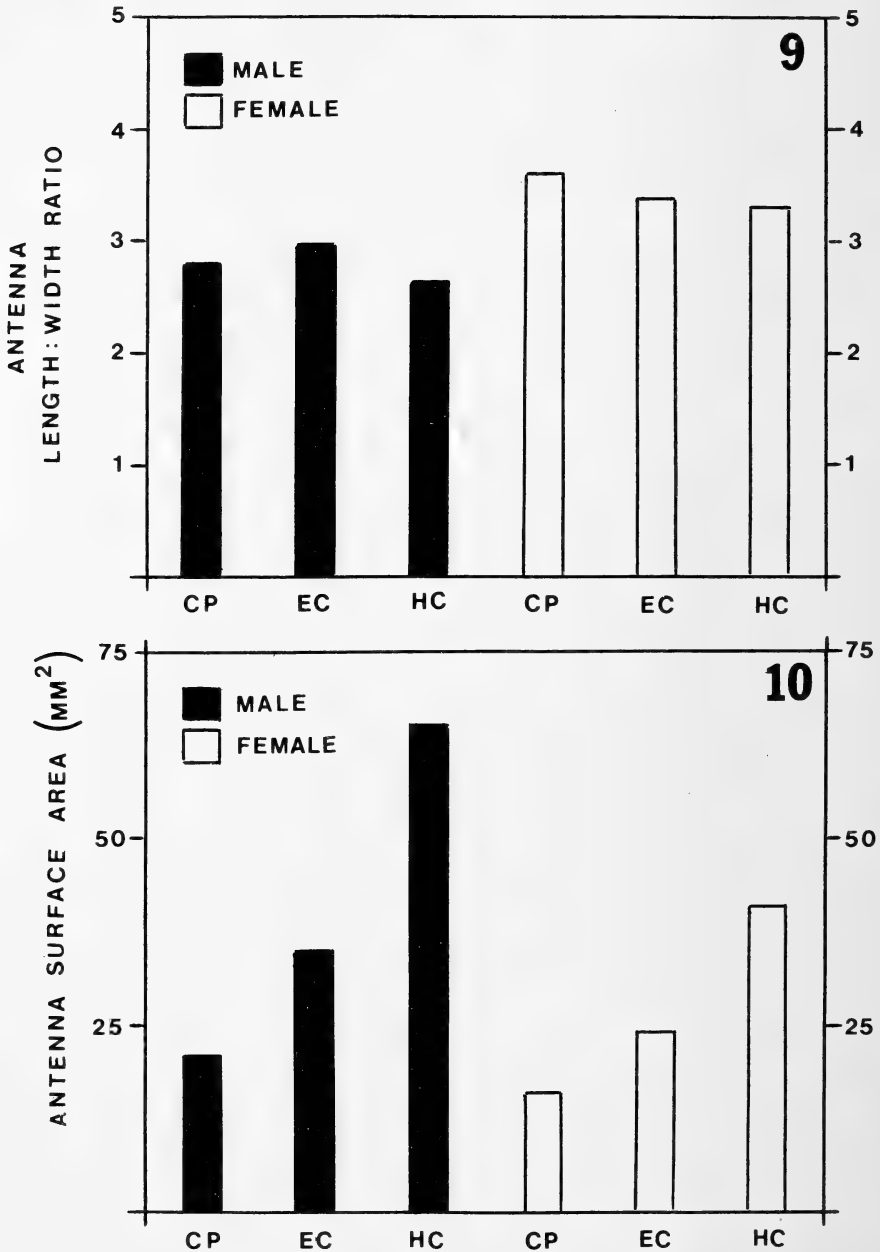
¹ Values are sample means ± 95% confidence intervals; weights in grams; dimensions in millimeters.

TABLE 2. Discriminant functions for determining the sex of giant silkworm moth pupae.

Discriminant function equation	Decision value
<i>Callosamia promethea</i> :	
$DF_{cp} = -2.69BW + 11.42AW$	female < 9.97 > male
$DF_{cp} = 3.66(CE/AL) + 5.35(BL/AW)$	male < 49.33 > female
<i>Eupackardia calleta</i> :	
$DF_{ec} = -10.19WT + 39.22AW$	female < 135.60 > male
<i>Hyalophora cecropia</i> :	
$DF_{hc} = -2.25CE + 33.08AW$	female < 90.28 > male

as confirmed by adult sexes at emergence. Similarly, 11 wild pupae of *E. calleta* were correctly sexed as 5 males and 6 females. For *H. cecropia* we examined an additional 11 reared pupae. This group contained 7 males and 4 females, as calculated by the discriminant function equation ($DF_{hc} = -2.25CE + 33.08AW$) and confirmed at the time of adult emergence. For *C. promethea* we examined two additional groups of pupae containing 16 and 10 reared individuals, respectively; and a third group containing 33 wild individuals. The discriminant function equation ($DF_{cp} = -2.69BW + 11.42AW$) misclassified 2 females in the first reared group, 7 females in the second reared group, and 5 females in the wild group, as determined by adult sexes at emergence. These misclassifications appeared to be due to a shift in the mean of some measurement used in the equation. Therefore, we used a similarly established predictive equation containing ratio information ($DF_{cp} = 3.66(CE/AW) + 5.35(BL/AW)$) to determine whether ratios might remain relatively constant when mean values were shifting. Using this second equation to calculate individual sexes of these three additional groups of *C. promethea* pupae resulted in similar misclassifications.

These studies have quantified differences in the weights and dimensions of male and female pupae of *C. promethea*, *E. calleta*, and *H. cecropia*. Antenna length in *C. promethea* was the only characteristic that was not significantly sex-related. This may account for the fact that antenna size in male and female individuals of this species is not a good discriminator of sex. Mosher (1916b) discusses antenna dimensions in terms of length to width ratios, but does not present data on absolute sizes. There is no known published information on the origin of describing lepidopterous antennae using ratios. The characteristic actually being perceived by an observer is the antenna surface area, and an approximation of that characteristic would seem



FIGS. 9-10. Antenna size relationships in pupae of *C. promethea* (CP), *E. calleta* (EC), and *H. cecropia* (HC). 9, comparative length to width ratios; 10, comparative surface areas.

to be more valuable than the length to width ratio. The antenna surface area (SA) can be approximated ($SA = 0.5(AL \times AW)$) from the length to width information. Antenna length to width ratios and antenna surface areas are compared for male and female pupae in Figs. 9-10. The comparison quantifies the fact that there is less visually-perceptible difference in male and female antennae in *C. promethea* than the other two species and thus, more difficulty in discriminating sex on the basis of antenna size in *C. promethea*. Another point apparent from the length to width information is that for each sex the ratios do not differ significantly among the three species. Whether these very similar ratios for each sex have a relationship to the sensory function of the antennae in the adult moths is not known.

CONCLUSIONS

In *C. promethea* neither the combination measurements nor the ratios of dimensions used in the discriminant function analysis resulted in reliable equations for determination of individual sexes. Examination of the genital openings appears to be the best available way of determining sex in individual *C. promethea* pupae.

For *E. calleta* pupae, weight and antenna width were reliable indicators of individual sex when used in the discriminant function equation derived for this species.

For *H. cecropia* pupae, discriminant function analysis demonstrated that circumference and antenna width data are the most reliable dimensions for discriminating sex in individuals.

ACKNOWLEDGMENT

We acknowledge the assistance of R. S. Peigler in providing wild *Eupackardia calleta* (Westwood) pupae from south Texas; with these we were able to verify the discriminant function equation for that species.

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BOOK REVIEW

MICROLEPIDOPTERA, by Elwood C. Zimmerman. 1978. Insects of Hawaii, volume 9, xxiv + 1903 pages, 1355 cuts. Price: U.S. \$60. University of Hawaii Press, Honolulu.

The first 200 pages are an overview of the Lepidoptera that includes a) classification, b) identification keys to the immature stages of the species found in Hawaii and separate keys to the larvae and pupae found in specific habitats, c) morphology of the immatures and adults, and d) techniques for preparing and handling adults and immatures for collections and for wing and genital studies. A checklist of the described (only previously described or misidentified species are treated) genera and species and list of nomenclatural changes are useful. Fourteen of the 80 genera and 605 of the 681 species are endemic. A synopsis of the distribution of genera and species by island illustrates the high degree of species' endemism; however, lack of adequate collecting makes the tables preliminary.

The systematic treatment is a good survey of the microlepidoptera of Hawaii. Illustrations are abundant and cover the immature as well as the adult stages. Zimmerman has developed identification keys to most of the taxa. A notable exception is to the species of *Hyposmocoma* Butler. New generic names are proposed and defined when necessary. He has brought together published drawings of structural parts of adults and larvae of as many species as possible and reproduced them in this volume; so, the user has before him much of the extant illustrative material.

Zimmerman proposes a relatively conservative higher classification at the family level within the so-called microlepidoptera that is particularly noteworthy in the Gelechioidea. He places the Oecophorinae, Ethmiinae, Xyloryctinae, Blastobasinae, Chrysospeleinae, Momphinae, Cosmopteriginae, and Gelechiinae as subfamilies of the Gelechiidae. Based on strict priority of family-group names, the superfamily and family should be Oecophoroidea and Oecophoridae (Bruand, 1850), not Gelechioidea and Gelechiidae (Stainton, 1854). I agree with Zimmerman's philosophy on the inflation of the classification of the microlepidoptera but not with all of his conclusions. However, the final word definitely is not written on classification, particularly that of the Gelechioidea. Some major differences are the following: *Thyrocopa* Meyrick is in the Autostichinae of the Oecophoridae rather than in the Xyloryctinae of the Gelechiidae. *Chedra* Hodges and *Batrachedroides* Zimmerman are in the Batrachedrinae of the Coleophoridae rather than in the Momphinae, Gelechiidae. Momphidae, *sensu stricto*, do not occur in Hawaii. Cosmopterigidae have two subfamilies in Hawaii, Cosmopteriginae with four genera, and Chrysospeleinae with one introduced species and genus. Symmocinae are a subfamily of Blastobasidae rather than a tribe of the Gelechiinae. The correct spelling for Dichomerini is Dichomeridini. *Sitotroga* Heinemann and *Pectinophora* Busck are in the Chelariinae rather than the Gelechiinae. *Merimnetria* Walsingham is in the Anomologinae rather than the Aristoteliini.

Defining the limits of genera is often one of the most difficult problems that taxonomists face. Zimmerman's perplexion in dealing with the extremely large genus *Hyposmocoma*, with an estimated 500+ species endemic to Hawaii, is understandable. He synonymized 13 generic names under *Hyposmocoma* after finding no consistent differences to separate groups associated with the previously proposed generic names. Six hundred thirty pages of the two-volume work are devoted to the 350 described species of *Hyposmocoma*. I strongly recommend this section as an example of the morphological diversity that can occur in a genus. Zimmerman states that a life's work could be spent on this genus. With a projected 150 undescribed species and without an identification key to the described species, determination of species is problematical, but a far greater start has been made to deal with them than ever before. He lists a number of criteria that he discovered to be significant and that may be helpful to the person who attempts to devise such a key.

The text is written in a highly readable style. It is often interspersed with biting comments relative to lack of support for this immense project that, without personal knowledge of his situation, may appear incongruous. I strongly agree with his oft-made observation that Hawaii has been visited by many, but our knowledge of the microlepidoptera that occur on the islands is so inadequate as to be appalling—the same is true for the continental United States. From the vantage point of a systematist working at the U.S. National Museum of Natural History and considering that Hawaii is one of the States, I am a bit troubled that nearly all of the specimens reside in the British Museum of Natural History.

By and large typographic errors are few. The most annoying feature of the book is that often the text is cut up and separated by illustrations, in one instance with 124 pages of them. But, I can understand the view of wanting to have the illustrations near the associated text. I am puzzled by the large number of illustrations of adult morphology that do not accompany any text. The wealth of information about Lepidoptera in general and the microlepidoptera specifically is welcomed. All students of the Hawaiian biota and of the microlepidoptera will find much of interest, many facts to digest, and many leads for further research. I congratulate Zimmerman on a fine accomplishment.

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CLASSIFICATION AND LIFE HISTORY OF *ACSALA ANOMALA* (ARCTIIDAE: LITHOSIINAE)

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ABSTRACT. The immature stages and female of *Acsala anomala* Benjamin are described for the first time from material collected in the Yukon Territory, Canada, during 1980. The position of the genus within the Noctuoidea is reassessed on the basis of adult and larval characters. It is concluded that the genus *Acsala* should be transferred from the Lymantriidae to the subfamily Lithosiinae in the Arctiidae. The life history of *Acsala anomala* is described and the immature stages illustrated.

In 1980 J.D.L. had the opportunity to collect in the Yukon Territory with Dr. D. M. Wood, also of the Biosystematics Research Institute. The purpose of the trip was to initiate a study of the insects and arachnids of northwestern North America, particularly those of the unglaciated Beringian refugium area.

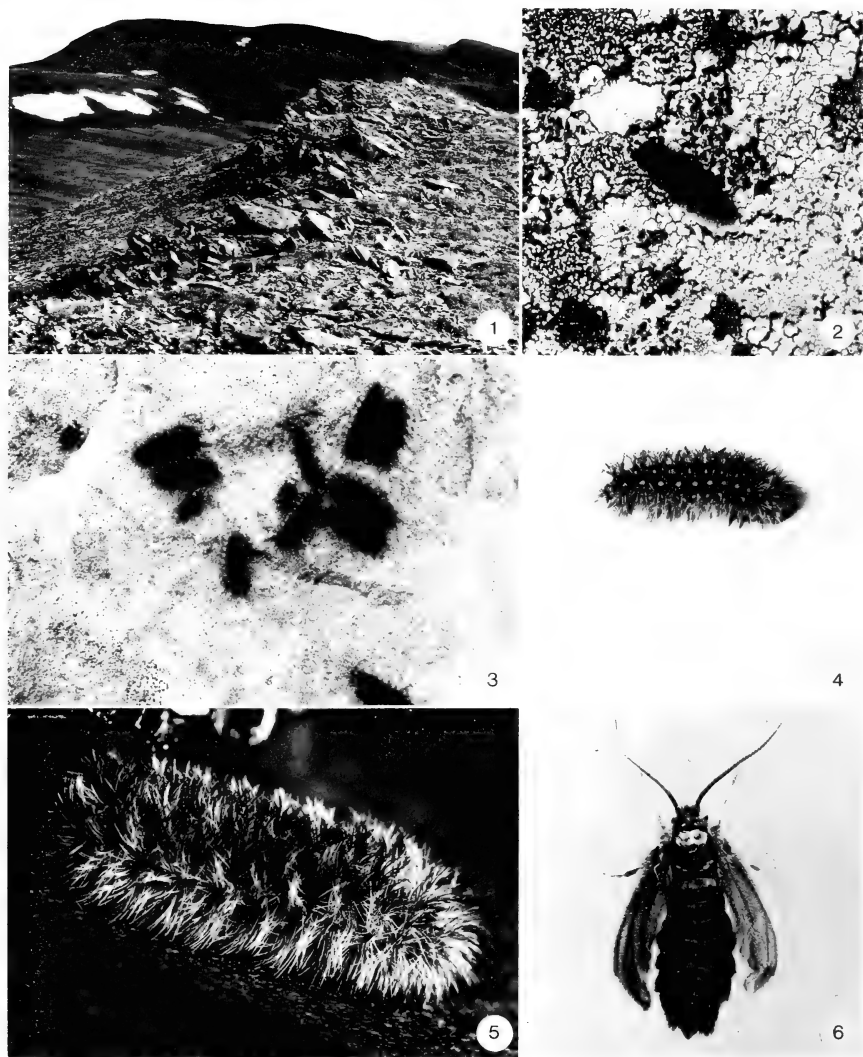
During the summer, Lafontaine and Wood devoted a considerable amount of time to a study of the immature stages of the little known moth *Acsala anomala* Benjamin. This was done because of uncertainty of the phylogenetic position of *Acsala* within the Noctuoidea based on characters of the adult male and because of interest in its classification by J.G.F. and D.C.F. Previous to 1980 the species was known from less than a dozen specimens, all males. Collections of *Acsala anomala* were made in the northern Ogilvie Mountains in north-central Yukon and in the Richardson Mountains in northern Yukon. Adults of both sexes and immature stages were collected and their habits were recorded in the field. The following discussions on the classification and life history of *Acsala anomala* are based on these specimens and field data.

CLASSIFICATION

Benjamin (1935) in describing *Acsala* put it in the Arctiidae, although he suggested that it should probably be in a separate family.

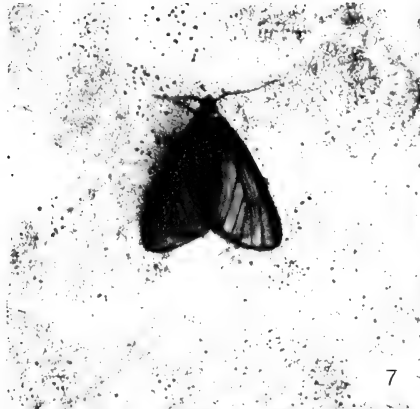
Benjamin believed that *Acsala* was a remnant of a primitive group that gave rise to the Arctiidae and Lymantriidae. McDunnough (1938) put *Acsala* in the subfamily Arctiinae next to *Dodia albertae* Dyar, presumably because of convergent similarities resulting from similar adaptations to an arctic environment (e.g., dark coloration; hairy, translucent wings; aborted proboscis). Ferguson (1978), however, showed that structural characters do not support classification of *Acsala* within the Arctiinae. Lack of ocelli, a character of *Acsala*, is a distinguishing feature of the arctiid subfamily Lithosiinae and of the Lymantriidae. Wing venation of *Acsala* could be either arctiid or lymantriid. It has a long discal cell, sometimes regarded as a character of the Lithosiinae and of other Arctiidae, but various exotic Lymantriidae (e.g., species of *Eloria* Walker) have discal cells that are as long or longer. Characters more clearly suggesting an affinity with the lithosiines are: presence of an orange prothoracic collar and lack of long terminal spinules on the male antenna; the female antenna is filiform. Ferguson classified *Acsala* within the Lymantriidae on the basis of venation, especially the relationship of veins Sc and R in the hind wing, which is unusual for an arctiid; however, he expressed considerable reservation, pointing out that characters of the larva were needed in order to resolve the problem.

The discovery of the larva makes possible a reassessment of the position of *Acsala*; the larval characters resolve the dilemma, "Arctiidae or Lymantriidae?," that so troubled Benjamin (1935) and Ferguson (1978). The larva is a lithosiine arctiid. The general appearance, at first glance, is that of an ordinary arctiid (Fig. 5); the setae are barbed and arise from verrucae. It differs from known lymantriid larvae in that there are no dorsal glands on abdominal segments six and seven. The distinctive character that it shares with other known lithosiine larvae is the possession of a conspicuous mola on the inner face of the mandible at the base (Fig. 15). The mandible of a member of the Arctiinae (Fig. 16) is illustrated for comparison. Gardiner (1943) seems to have been the first to notice this character and to have stressed its importance in characterizing the lithosiines. *Acsala* larvae, like those of some other lithosiines, e.g., *Eilema* species and *Lithosia quadra* (Linnaeus), have the crochets heteroideous (Fig. 13) as do the larvae of the Arctiinae and Ctenuchinae. It must be noted that many Lithosiinae, e.g., *Asura anomala* (Elwes), *A. calamaria* (Moore), *Chionaema bianca* (Walker), *C. detrita* (Walker), *C. peregrina* (Walker), *Hypoprepia miniata* (Kirby), *Clemensia albata* Packard, *Eudessmia* species, *Crambidia* "white species," and *Agylla* species, have the larval crochets homoideous. However, in all these larvae the man-

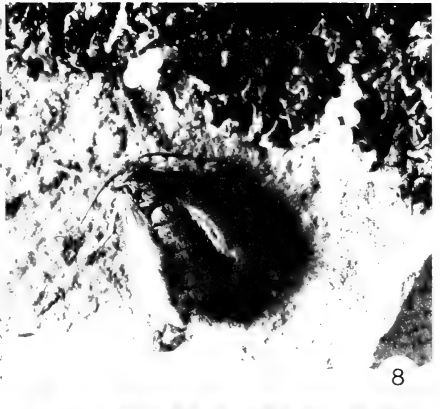


FIGS. 1-6. *Acsala anomala*. **1**, habitat—Km 465 Dempster Hwy., Yukon Territory; **2**, larva feeding, 1.5 \times ; **3**, larvae resting under rock, 0.6 \times ; **4**, third instar larva, 2.5 \times ; **5**, mature larva, 4 \times ; **6**, adult female, 3 \times . (Photographs by J. D. Lafontaine and Biographic Unit, Agriculture Canada.)

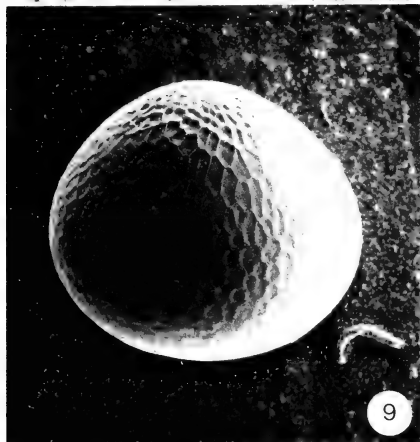
FIGS. 7-12. *Acsala anomala*. **7**, adult male, 1 \times ; **8**, female laying eggs, 1.7 \times ; **9**, lateral view of egg, 40 \times ; **10**, dorsal view of egg, 40 \times ; **11**, details of egg microsculpture, 80 \times ; **12**, micropylar region at apex of egg, 400 \times . (Photographs by J. D. Lafontaine and Biographic Unit, Agriculture Canada.)



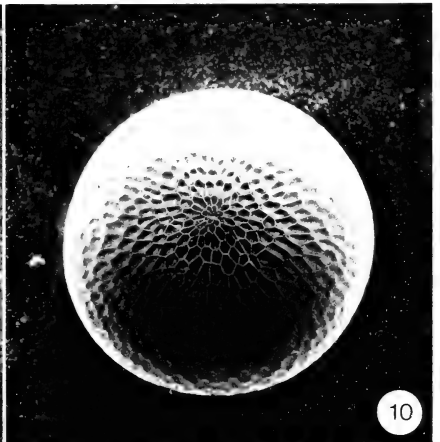
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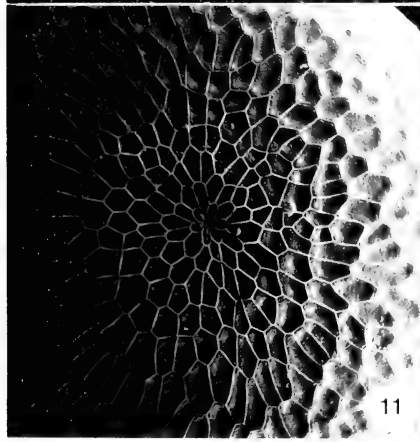
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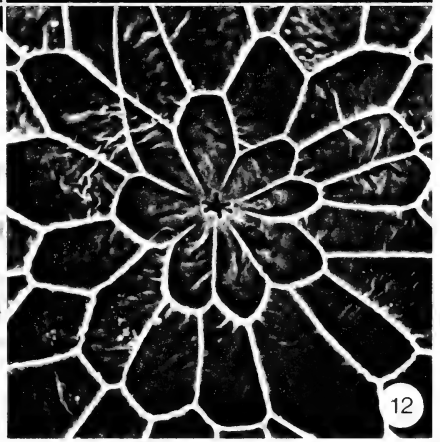
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dible has a basal mola. The larval foodplants, various species of lichens, are also typical of lithosiine arctiids.

The first instar larva of *Acsala* has single, barbed setae arising from inconspicuous, raised pinacula; there are two prespiracular setae on T_1 , and each of the thoracic segments has two setae, group vii or vi, above the leg.

In the last larval instar T_1 has a moderately large prespiracular verruca with many setae. T_3 has one dorsal verruca, that is there are two verrucae above the prespiracular line and two below the prespiracular line and above the leg. A_3 has three verrucae above the spiracle, a small verruca just behind and slightly below the spiracle, and two large verrucae below the spiracle and above the proleg, the latter with numerous secondary setae. There is no indication of viii on the four proleg bearing segments. Verruca pattern on A_3 is similar to that shown for *Eilema* sp. by Gardiner (1943, Fig. 9) but the small verruca behind the spiracle has several setae. A_1 and A_2 as in A_3 , but with small verrucae at the vii and viii positions. A_7 and A_8 similar to A_1 and A_2 .

On the basis of our analysis of larval characters, the genus *Acsala* was transferred in the North American Lepidoptera check list from the Lymantriidae to the subfamily Lithosiinae in the Arctiidae (Franclemont, in press).

In the adult only the venation seems to warrant consideration because Benjamin and Ferguson discussed other characters so thoroughly. Considerable emphasis has been placed on the relative position of Sc and R of the hind wing in the Noctuoidea. However, it becomes evident when many species of the various families are studied that this relationship is more variable than keys and characterizations of the venation would imply. In the lithosiines the relationship is highly variable; the base of R is missing, or fused with Sc, in most lithosiines but in the genus *Hypoprepia* the base of R is present but weak. In *Acsala anomala* the venation is variable within the species. In 23 of 40 specimens examined, Sc makes a sharp bend down to R, touches, and then separates immediately before the middle of the discal cell; in nine specimens the relationship is much as described by Benjamin, Sc and R are connected by a bar. The drawing in Ferguson (1978) shows Sc with a sharp bend, but it does not touch R; this condition occurs in eight specimens. Except for the relationship of Sc and R, the hind wing venation of *Acsala* is similar to that of the lithosiine *Clemensia albata* Packard; in most specimens R and M_1 of the hind wing are long-stalked, separating a short distance before the wing margin. In one specimen vein R is absent and in another vein M_3 is missing. The forewings have no accessory cells in about one quarter of the specimens. Many specimens show differences in length

of stalking and in size of the accessory cell in the wings on the opposite sides of the same moth. Such variation in wing venation may be related to a tendency toward flightlessness in both sexes. The female is flightless (Fig. 6) and wing size in males is variable. The wing venation of the female is similar to that of the male but the veins are crowded together because of smaller size.

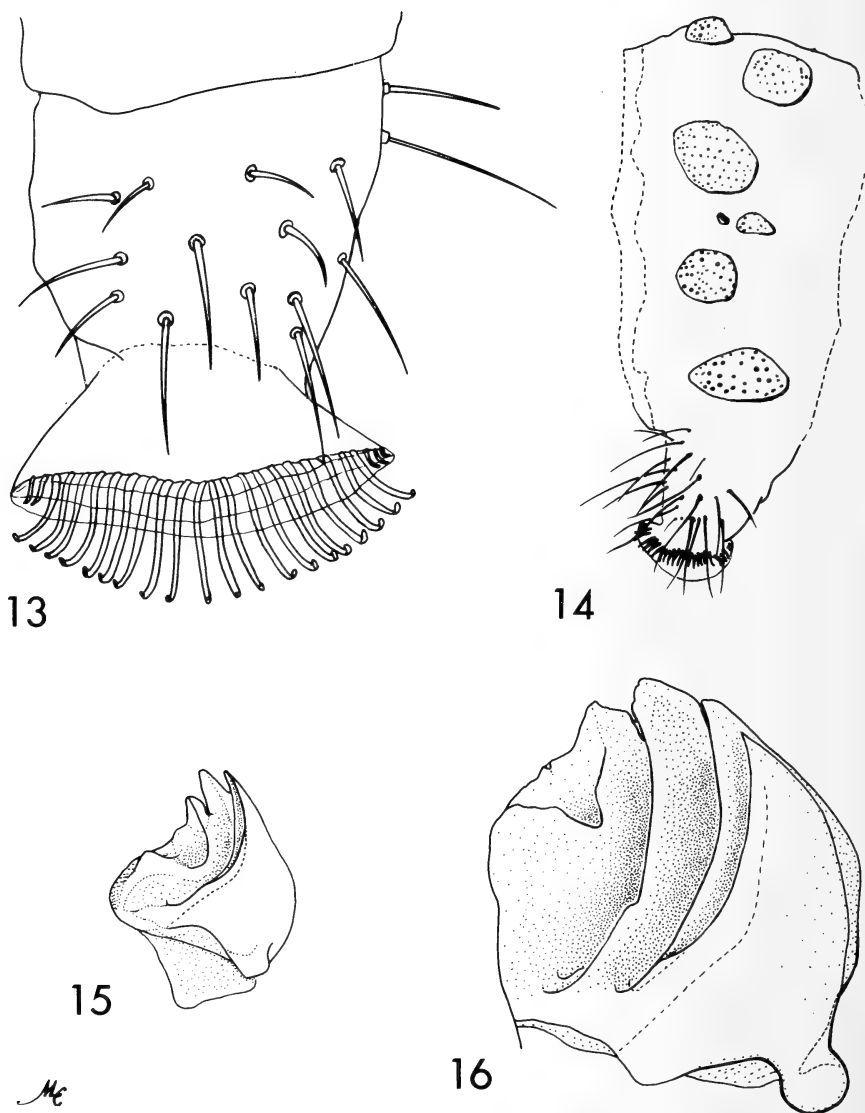
Interpretation of Characters of *Acsala*

Although many of the characters of *Acsala* are typical of the Arctiidae, most of them cannot be used, at present, for phylogenetic interpretation. The absence of dorsal glands on abdominal segments six and seven is a character state of the larvae that is primitive in the Noctuoidea and cannot be used for phylogenetic interpretation within the superfamily. Other character states of *Acsala*, the configuration of larval verrucae, male antennae characters, and adult wing venation characters, may be derived in the Arctiidae and phylogenetically significant. Assessment of these characters will not be possible until the relationship of the Arctiidae and the Lymantriidae has been determined. Two definitive character states of *Acsala* that allow it to be placed in the lithosiine arctiids are the heteroideous crochets of the larva (Fig. 13) and the presence of a mola on the inner face of the mandible (Fig. 15). These derived character states are restricted to the Arctiidae and the Lithosiinae respectively. The absence of ocelli is more difficult to interpret because their loss may have occurred a number of times in the Noctuoidea.

LIFE HISTORY

When Lafontaine and Wood arrived in the Ogilvie Mountains in north-central Yukon on 18 June, males were already in flight. The flight season lasted until late June at low elevations (800–1000 meters), but adults were collected as late as 21 July at high elevations (1600 meters). Males fly over loose, rocky slopes and hilltops where vegetation is sparse (Fig. 1). Butterflies commonly found in association with it are *Erebia magdalena mackinleyensis* Gunder and *Boloria (Clossiana) astarte distincta* (Gibson). The flight of the moth is weak and fluttering, similar to that of a large caddisfly. In spite of this, they are hard to catch because of difficult footing on the rocky slopes and because males tend to move along rapidly in the wind. Most activity is confined to bright, sunny periods. Males rest during cloudy periods and at night when the sun is low on the horizon.

After collecting a series of males, an attempt was made to find a female. Males were followed in the hope that they would go to a female; however, after several days none was found. In late June we



FIGS. 13-16. Details of larval characters of *Acsala anomala*. **13**, inside view of A₃ proleg showing heteroideoous crochets; **14**, lateral view of A₃; **15**, inner surface of mandible showing mola; **16**, inner surface of mandible of Arctiinae, *Spilosoma vagans* (Boisduval) for comparison.

traveled north to the Richardson Mountains where eggs, larvae, empty cocoons, and several females were found by searching under rocks on rocky slopes and hilltops. Females spend most of the time under rocks but probably crawl onto the upper surface to mate. One female that had just mated was observed on top of a rock with a male. Egg batches of 6 to 30 eggs are laid in a single layer on the underside of a rock. Eggs are reddish orange when laid. They turn pale orange after about a week. Several hours before hatching, the black larval head capsule is visible through the eggshell. Details of egg sculpturing are shown in Figs. 9–12.

Larvae hatch from the eggs in eight to ten days, eat their eggshell, and then begin to feed on lichens. The first instar larva has a yellow-orange body with a black head and is about 2 mm long. The larvae hide during the day (Fig. 3); they feed on lichens during the evening and at night when the sun is lower (Fig. 2). The larvae apparently feed almost exclusively on black colored, low, foliose lichens (*Paramelia stygia* (L.) Ach. and *Umbilicaria* cf. *proboscidea* (L.) Schrad.) and on black crustose lichens (*Orphniospora atrata* (Sm.) Poelt, *Buellia* cf. *spuria* (Schaer.) Anzi, *Lecidia armeniaca* (DC.) Fr., and *L. fuscocinerea* Nyl.).

The larvae probably take many years to mature. In June when adults are in flight, eggs and larvae of all instars except the first were found. The locations of several egg batches were marked in June; by the end of the summer most larvae had just molted to second instar. The larvae may tend to crawl upwards; abundance of larvae increases moving up a hill with the greatest densities occurring at the hilltop. Egg batches and females, however, were lower down, on the hillsides. The hilltop shown in Fig. 1 had larvae under almost every rock.

Cocoons are spun and attached to the underside of a rock. Larval hair is used in its construction. The pupa lacks excessive body hair found in lymantriid pupae but does have small clusters of hair at verrucae scars as is typical of arctiid pupae (Mosher, 1914). We could not determine whether mature larvae pupate in the fall or in the spring. When we left the Richardson Mountains at the end of the season, mature larvae but no pupae were found. After bringing them into the laboratory in late August several did pupate and adults emerged by mid-September. Larvae were relatively easy to rear on location where fresh lichens could be supplied each day. Rearing was difficult under laboratory conditions, however, because the lichens tended to dry out and if moistened, they would mildew.

Distribution and Abundance

Acsala anomala is known only from unglaciated areas in the northern half of Yukon and Alaska. It is probable that its range remained

restricted following deglaciation because of habitat limitations and poor dispersal ability.

At first it seemed puzzling that a species that is so abundant as larvae should be relatively scarce as an adult. This anomaly can be explained by two factors; first, if the larvae take a number of years to mature, only a fraction of the larvae would pupate each year. Second, parasitism may take a heavy toll. Cocoons of a braconid parasite, *Meteorius* sp., were more common than were those of the moth. A tachinid parasite, *Tryphera* sp., was also present. In addition to these, an ichneumonid hyperparasite, *Gelis obesus* (Ashmead), was reared, this apparently attacking a second, uncollected, braconid parasite.

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GENERAL NOTES

A BILATERAL GYNANDROMORPH OF *ERYNNIS HORATIUS* (HESPERIIDAE)

Eight larvae (2nd and last instars) and 2 pupae of Horace's dusky wing, *Erynnis horatius* Scudder and Burgess, were collected on 13 August 1980 in Baton Rouge, East Baton Rouge Parish, Louisiana. The larvae were found on cherrybark oak, *Quercus falcata* var. *pagodaefolia* Ell. and raised on this in captivity. On 10 September 1980 an adult bilateral gynandromorph emerged.

The right half of the specimen is female in appearance, and the left is male (Fig. 1). The right forewing measures 18.1 mm in length and exhibits characters of a typical phenotype 2 female, i.e., spots 2, 3, 6, 7, 8, 9 and Yd 5 are present (Burns, J. M., 1964, Evolution in skipper butterflies of the genus *Erynnis*, Berkeley, Univ. of Cal.). The left forewing measures 16.4 mm in length and has the male costal fold, spots Yd 5 and 3 are smaller in the left forewing (δ) than in the right forewing (φ), and spot 2 is not present on the left forewing (δ). The median dark brown mottling on the right (φ) forewing is stronger than on the left (δ) forewing and the right hindwing (φ) is also lighter than the left (δ) hindwing. All spots on both forewings are semihyaline. The antennae appear dissimilar and the right (φ) labial palp measures 1.5 mm and left (δ) 1.2 mm.

The external genitalia were dissected and consisted of male structures including an aedeagus. A bursa copulatrix was also present. The valvae of a typical individual (com-



FIG. 1. Bilateral gynandromorph of *Erynnis horatius* Scudder and Burgess.

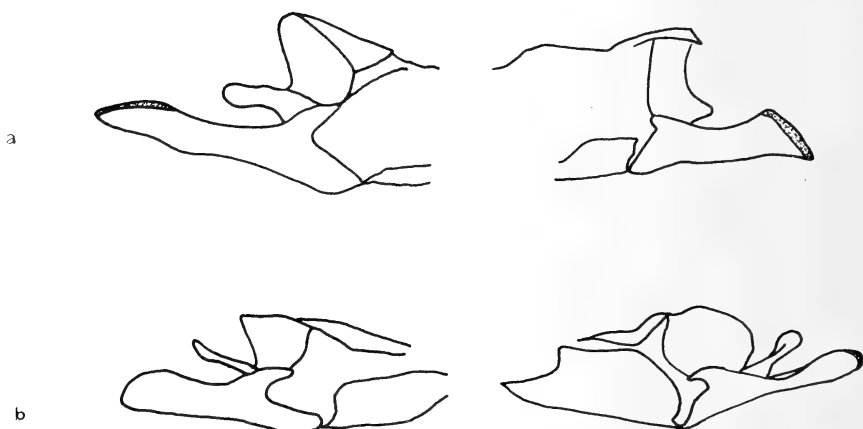


FIG. 2. Left and right valvae of *Erynnis horatius* a) typical individual, b) corresponding gynandromorph.

pared with illustrations from Forbes, W. T. M., 1960, *Lepidoptera of New York and neighboring states, Part IV, Cornell Univ. Agri. Exp. St. Memoir 371* and the corresponding pair of gynandromorph valvae are shown in Fig. 2. The length of the right and left valvae of the typical individual (collected 23 August 1976, Baton Rouge, LA) measures 1.15 mm and 1.30 mm respectively, while the gynandromorph valvae measure 0.95 mm and 1.05 mm. The gynandromorph has ampullae on both valvae, while the typical individual displays the usual asymmetrical dimorphism. The number of marginal spines on the valvae of the typical specimen is 11 (right) and 11 (left) in contrast to that of the gynandromorph which is 13 (right) and 9 (left).

The specimen and pupal case have been deposited in the Louisiana State University, Department of Entomology Collection (LSUC). We thank Drs. H. B. Boudreaux and J. B. Chapin for reviewing the manuscript.

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THE CASE OF *PERRHYBRIS LYPERA* (PIERIDAE) AND THE
LAURACEAE: HOST-PLANT RECORD OR ASSUMPTION?

The study on *Perrhybris lypera* (Pieridae) in Costa Rica by Young (1980, J. Lepid. Soc. 34:36-47) reveals some interesting differences from my own observations on that species and raises some points I would like to clarify concerning host-plant records. While engaged in studies on the butterflies of the La Selva field station, Heredia Province, Costa Rica, I was able to study *P. lypera* intermittently for a period of six months (July through December 1979). Both study sites used by Dr. Young (La Selva and "La Tigra") are part of the same tract of forest and have adjoining boundaries. Although "La Tigra" is under extensive cultivation, the remnant patches of forest there have a considerable number of both butterfly and plant species in common with La Selva.

While it is of great interest that Dr. Young has found *P. lypera* in association with *Ocotea* sp. (Lauraceae), because it represents a divergence from host-plant relationships known in the Pieridae, my own experiences with *P. lypera* at La Selva differ considerably, and I feel that he is in error concerning his host-plant record. I have in eleven instances while at La Selva reared *P. lypera* to adulthood and all were on *Capparis pittieri* (Capparidaceae). This is in accord with my other host-plant records for other *Perrhybris* species in Costa Rica and Peru as well as records of other workers (L. Gilbert, M. Singer & J. Smiley, pers. comm.). These rearings are also in accord with my host-plant records for other closely related genera (*Itaballia* and *Pieriballia*) in Costa Rica, which likewise feed on Capparidaceae as larvae. While Dr. Young has observed an oviposition record by *P. lypera* on the host-plant (which I believe is *Capparis*) and obtained first instar larvae, he has not reared them to adulthood. This does not constitute a host-plant record for the butterfly; reared butterflies are from larvae that feed on and develop to adulthood on a certain plant. In figure 2 (Young, op. cit.) several photographs are shown with eggs on the upper side of a leaf along with a photograph of the first instar larvae. All of the photographs show "pronounced stellate pubescence," which appears to me to be highly characteristic of many Capparidaceae in Costa Rica, yet I know of no Lauraceae occurring at La Selva (*Ocotea* in particular) which show this character. It is my suspicion that Dr. Young has confused the identity of the larval host-plant with that of the leaf he originally found the pupae of *P. lypera* upon. I therefore question his speculations on the aposematic nature of *P. lypera*, because they are based on suspect host-plant data, not because of features inherent to the natural history of the butterfly.

His assumption that the pupation site constitutes the larval host-plant may be misleading. In Dr. Young's paper the assumption is made that the genus *Pereute* (Pieridae) uses *Ocotea*, and this was perhaps influential in his recording *P. lypera* as the second record of a member of the Pieridae to feed on the Lauraceae; both are very interesting records. This assumption is based on Jorgenson (1916, Ann. Museo Nacional, Buenos Aires 28:427-520), which says that groups of larvae and pupae of *Pereute* were found on the trunk of an *Ocotea* tree. However, my own field work in Costa Rica indicates that the genus *Pereute* does not feed on the Lauraceae as has been assumed. *Pereute* and other closely related genera in Costa Rica feed on the Loranthaceae (DeVries, ms. in prep.), which are common epiphytic parasites of many tropical forest trees, including *Ocotea*. Larvae feeding on these epiphytes crawl down the tree and pupate on the tree trunk. They do not feed on the leaves of the plant where pupation takes place. While the use of the Loranthaceae by New World Pieridae is still somewhat novel (i.e., unstudied), the allied genus *Delias* in the Old World uses Loranthaceae extensively, and their pupation behaviors are similar to those of *Pereute*; both genera follow the theoretical lines of coevolution of butterflies and plants of taxonomic relatedness. Thus the genera *Pereute* and *Perrhybris* both appear to be erroneous records on Lauraceae and have little in common regarding their respective host-plants.

As tempting as it may be, unless larvae actually feed upon and develop into adults

on a particular plant, I do not feel one can draw lines of host-plant relationships by casual observation. With this in mind I would urge future workers to be suspicious of host-plant records that are far afield from what we know of coevolutionary relationships (Ehrlich & Raven, 1965, *Evolution* 18:586-618), to double check the identity of host-plant material that is **taken from the plant on which larvae are feeding**, and to record oviposition observations as such. By following such criteria, perhaps future misconceptions and errors can be minimized.

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PERRHYBRIS LYPERA (PIERIDAE) FEEDING ON LAURACEAE:
A RESPONSE TO DEVRIES

In an earlier paper in the pages of this journal (Young, 1980, *J. Lepid. Soc.* 34:36-47) I reported both oviposition and first instar larval feeding on the young leaves of a tropical rain forest understory tree identified, albeit from vegetative parts alone, by reputable authorities as a species of *Ocotea* in the Lauraceae. I had originally discovered the gregarious pupae of this butterfly on a mature leaf of a tree from Finca La Selva in 1969 and tentatively identified at that time by Dr. William Hathway of the University of Washington as either *Ocotea* or *Nectandra* (both Lauraceae). The subsequent observations, several years later, of oviposition and larval feeding at Finca La Tigra, approximately ten km from the La Selva site but at a slightly higher elevation, also revealed an association with Lauraceae (Young, op. cit.).

Mostly by accident and indirect communication, I learned of the note by Mr. DeVries already submitted to this journal (DeVries, 1982, *J. Lepid. Soc.* 36:229-230), in which he suggested an error in the identification of the oviposition and larval host for *P. lypera* which I reported (Young, op. cit.). At my request, Mr. DeVries very graciously sent me a copy of his note. At the time I was preparing to leave for Costa Rica, and therefore, had the timely opportunity to once again check in the wild the food plant questioned.

I retrieved additional samples of the leaves and stems of the exact same tree, a feat made simple because that tree had been marked for further studies of *P. lypera* behavior and natural history at this locality. This fresh material was taken to San Jose where Dr. Gary Hartshorn, the well-known authority on tropical trees who identified Mr. DeVries's La Selva food plant of *P. lypera*, made an identification of my material. Thus, the opportunity offered a control of sorts, since *P. lypera* food plant materials from two different sources (DeVries and Young) would have been identified by the same authority, something indeed worth doing if an error had been made by other authorities in earlier identifications. Dr. Hartshorn kindly examined my fresh material and gave me his very assured identification of the tree as *Nectandra gentlei* (Lauraceae). He also indicated to me that, while the tree was very clearly lauraceous, the



FIG. 1. Mature leaves of *Nectandra gentlei* (Lauraceae) from "Finca La Tigra" in northeastern Costa Rica possess a thick coating of pubescence. *N. gentlei* is a larval food plant of the pierid *Perrhybris lypera* at this locality (see also Young, 1980, J. Lepid. Soc. 34:36-47).

genera *Ocotea* and *Nectandra* are extremely closely related, and eventually, the former will probably be combined with the latter in a systematic revision. I explained the *P. lypera* debate to Dr. Hartshorn, who then commented to the effect that it is easy to distinguish between Capparidaceae and Lauraceae. Dr. Hartshorn thus confirmed my original identifications of this food plant as being Lauraceae, and I, therefore, conclude that an error in identification in Young (op. cit.) had not been made. Dr. Hartshorn agreed to deposit my pressed material of this tree in the herbarium collections of the National Museum of Costa Rica.

DeVries (op. cit.) offers as proof of an error in identification the stellate pubescence characteristic of the young leaves fed upon by *P. lypera* in my study (my figure 2 in Young, op. cit.). He claims that Lauraceae do not have such a characteristic. Yet, it is common knowledge, particularly in dealing with tropical evergreen floras, that morphological characteristics of young leaves of a tree can be quite different from older leaves on the same tree. Mr. DeVries's claim that the Lauraceae, including the food plant genus reported in my paper, do not possess such pubescence is not substantiated by available data. Fig. 1 shows the pubescence from a mature leaf of the larval food plant from La Tigra. This pubescence, while not as pronounced as in the young leaves of *N. gentlei*, is generally characteristic of older leaves of this plant. One might argue, in the absence of data, that the very pronounced pubescence of the younger leaves of *N. gentlei*, as shown in figure 2 in Young (op. cit.), is an adaptation to deter insect folivores such as larval *P. lypera*. DeVries is incorrect in his use of such a labile characteristic, in this case, for disclaiming the identification of the food plant.

DeVries is certainly to be applauded for making the well-founded assertion that one needs accurate field data on larval food plants, and that the best data, of course, come from complete rearing studies. The incomplete rearing of the larvae in this case, as I

thought was explained in Young (op. cit.), was due to running out of food plant when the material was brought to Milwaukee, and therefore, the larvae died from starvation and not from feeding on the wrong plant. But two events, oviposition, and actual feeding on *N. gentlei* over several days without losses in vigor, together satisfy the criteria for an accurate food plant record (Ehrlich & Raven, 1965, *Evolution* 18:586-608). At the very same time, a food plant record, substantiated by recognized authorities in the field as exemplified by the association of *P. lypera* with *N. gentlei* in northeastern Costa Rica, that does not necessarily fit man-made dogma on the coevolutionary interactions between plants and insects (lest we believe in a T.C.M., "Tropical Coevolutionary Messiah") should not be rejected as an error. Yet I too agree that there is the need to weed out suspect food plant records from the butterfly literature (Ehrlich & Raven, op. cit.), something which, based on the data again presented here, DeVries has failed to demonstrate for the butterfly in question.

I do not question that *P. lypera* is perhaps polyphagous and indeed feeds on Capparidaceae as do some other pierids. DeVries apparently has reared *P. lypera* on this family at La Selva. Dr. Hartshorn and I discussing this possibility very briefly tentatively developed the idea that the greater abundance and density of *Nectandra gentlei* in the premontane tropical rain forest zone encompassing the La Tigra site promotes this tree as a frequent food plant of *P. lypera* at this site, while the interaction may shift toward other groups (i.e., Capparidaceae) in lower elevational areas (La Selva), where *N. gentlei* is far less abundant (Dr. G. S. Hartshorn, pers. comm., 24 February 1981). When a preferred larval food plant becomes very scarce locally and the butterfly has the physiological capacity to exploit another family of plants, the carrying capacity of the environment can be realized, at least in part, by the expression of polyphagous feeding locally in which both families of plants are incorporated into the diet. Depending upon the relative abundance of the two or more plant families exploited by the folivore, the biologist studying such a system may encounter one type of interaction (food plant association) more frequently than another, particularly when repeated samples, as done by DeVries (op. cit.), are taken from the same locality. Current dogma may induce one to assume most Neotropical pierids are strictly monophagous, but there may very well be cases such as *Perrhybris* in which ecological factors promote polyphagy.

I thank the editor of this journal for allowing me the opportunity to make this response. I thank Dr. Gary S. Hartshorn, Tropical Science Center, San Jose, Costa Rica, for identifying the food plant and for the fruitful discussion.

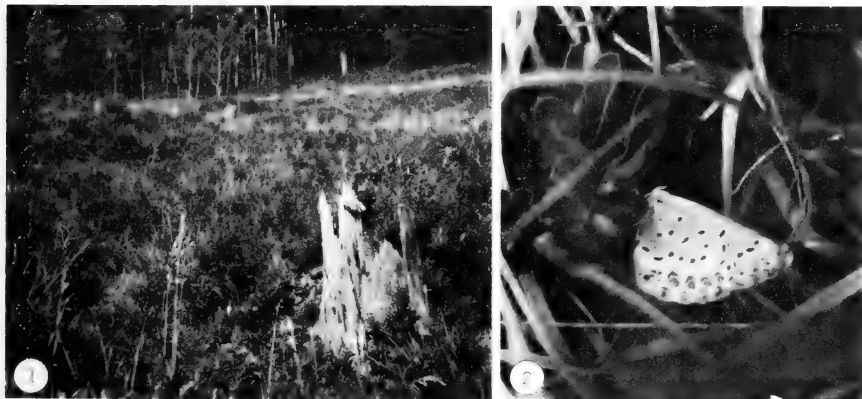
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OBSERVATIONS OF *LYCAEIDES ARGYROGNOMON NABOKOVI* IN
THE GREAT LAKES REGION (LYCAENIDAE)

The presence of the northern blue, *Lycaeides argyrognomon* Bergtraesser, in the Great Lakes Region was first cited by the late Louis Greiswich (1953, Lepid. News 7: 54), based on a long series of specimens collected in Oconto and Marinette counties, 1-15 July 1952, in northern Wisconsin. The Greiswich specimens were examined by Professor V. Nabokov and found to be an undescribed subspecies of *L. argyrognomon*. It wasn't until 1972 that this population was recognized as a new subspecies, *nabokovi* Masters (1972, J. Lepid. Soc. 26: 150-154), occurring in Minnesota and Wisconsin. Masters (op. cit.) indicated that the new subspecies may also occur in northern Michigan. In 1979 James Parkinson (pers. comm.) reported the first capture of *L. argyrognomon nabokovi* on 15 July, from Dickinson County, Michigan, thus establishing its range in the western portion of Michigan's Upper Peninsula. Parkinson (pers. comm.) again collected specimens of the northern blue on 2-4 July 1980, near Iron Mountain in Dickinson County.

The foodplant of *nabokovi* was unknown to the authors until 1980, when Les Ferge, 'Mo' Nielsen, and Jim Parkinson discovered females ovipositing on the stems of dwarf bilberry, *Vaccinium caespitosum* Michx., on 4 July, in Florence County, Wisconsin. Several females were observed at close range ovipositing on the dwarf bilberry in a trailside opening in a wooded area of aspen, oak and jack pine. Oviposition took place in the late afternoon between 1500-1730 CDT. The immediate habitat consisted of miscellaneous low plants, including grasses and sedges (*Carex* spp.), creeping blackberry (*Rubus* sp.), bracken fern (*Pteridium aquilinum* L.) with large patches of *V. caespitosum* on a sandy soil (see Fig. 1). The males were more commonly found flying along the adjacent trail and 'puddling' at moist spots in the trail. Females were collected in close proximity to dwarf bilberry, where they were ovipositing or resting on various low plants (see Fig. 2). Farther south along the same trail in Marinette County, several northern blues of both sexes were also collected nectaring on Alsike clover (*Trifolium hybridum* L.). On 14 July 1979 at mid-day, females were found nectaring on dogbane (*Apocynum androsaemifolium* L.) and yarrow (*Achillea millefolium* L.) in Florence County.

Ova collected in the field and obtained from a captive female in 1980 remained dormant the rest of the summer, indicating that *nabokovi* eggs overwinter. An egg was also found unhatched in the wild on 1 September 1980 by the junior author.



FIGS. 1-2. 1, habitat of *Lycaeides argyrognomon nabokovi* Masters, Florence Co., Wisconsin; 2, *Lycaeides argyrognomon nabokovi* female ovipositing on *Vaccinium caespitosum*.

The authors have since learned from Robert Dana (pers. comm.) that he also observed females of *L. argyrognomon nabokovi* ovipositing on *V. caespitosum* in St. Louis County, Minnesota. His observations occurred on 5 July 1976 when several females were ovipositing on dwarf bilberry, or on debris immediately beneath; a few additional ova were found by searching the foodplant. Dana also noted that males seemed to concentrate their 'patrolling' over patches or mats of dwarf bilberry.

The northern blue, *L. argyrognomon scudderi* (Edwards) has been reported from Ontario, Canada (1979, Toronto Entomol. Assoc. Occ. Pub. 11:48), with a flight period and habitat similar to that of *nabokovi*. Dr. Nick Escott (1979, *ibid.*) reported *scudderi* also ovipositing on *V. caespitosum* on 17 July 1977 in northern Ontario. Is it possible that the Ontario population may be synonymous with *nabokovi*? Until a long series of each population can be thoroughly examined, we cannot be certain that the two subspecies are actually the same.

ACKNOWLEDGMENTS

The authors wish to thank Robert Dana and James Parkinson for furnishing us with notes of their field observations, and to Parkinson for guiding us in 1980. We also thank Dr. John W. Thompson, University of Wisconsin, Botany Department, for verifying the identity of *V. caespitosum*.

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OUTBREAK OF *ASTEROCAMPA CLYTON* (NYMPHALIDAE) IN LOUISIANA

In the area adjacent to and including East Baton Rouge Parish, Louisiana, the tawny emperor butterfly, *Asterocampa clyton* (Boisduval & Le Conte), has at least 3 broods a year, occurring in early June, mid-July to early August and early September. Adult specimens have been taken from April through November. This species is usually extremely local but can be common in colonies in bottomland forests. In mid-July 1980, an unexpected population outbreak occurred in an area observed to extend as far north as Hamburg in Avoyelles Parish and as far west as Port Barre in St. Landry Parish. Tens to hundreds of butterflies (females were more conspicuous) could be seen daily within the city limits of Baton Rouge, where none or few had been previously recorded. Large numbers were observed flying across highways and many were killed by automobiles. The species was noticed in West Feliciana, West Baton Rouge, Avoyelles, Point Coupee, St. Landry and Iberville Parishes surrounding Baton Rouge. It was found to be especially common in areas where its food plant, hackberry (*Celtis laeviga* Willd.) occurred.

Two 10-minute counts were taken on 14 July 1980. The first count was made around a Mexican ash, *Fraxinus berlandieriana* A. DC. at 1700 hrs. CST; 105 female and 64 male *A. clyton* were counted feeding on sap, which was exuding from wounds caused by borers. This count included 3 mating pairs of *A. clyton*. Four *A. celtis* (Boisduval & Le Conte) and 1 *Polygonia interrogationis* (F.) individuals were also present. The second count at 1900 hrs. CST under and on a fig tree, *Ficus carica* L., and particularly on fallen fruit, revealed 101 female and 60 male *A. clyton* individuals including 4 pairs in copula. One *Papilio troilus* L., 2 individuals of *Euptychia hermes sosybia* (F.), 2 of *P. interrogationis* and 2 of *Limenitis arthemis astyanax* (F.) were also attracted to the fermenting fruit. In both counts many other individuals of *A. clyton* were flying in the near vicinity.

Egg masses were first noticed on 20 July. The number of eggs in 13 masses ranged from 27–135 with a mean of 59. An egg parasite, *Telenomus* sp. (Scelionidae), probably *T. rileyi* Howard, was identified from several of the eggs. The vespid wasp, *Polistes exclamans* (Vier.), and the spined soldier bug, *Podisus maculiventris* (Say), were observed preying on larvae on 12 August. The first adults emerged in late August and emergence continued into mid-September. They created a second outbreak which was not as large as in mid-July. One worn female was captured as late as 22 October.

A possible clue as to what upset the normal equilibrium of controlling factors for this species can be found in the climatic conditions in the Baton Rouge area in June, July and August 1980. Excessively high temperatures in June with an average daily temperature of 82°F, (1.7°F above normal), July 83.7°F, (1.7°F above normal) and August 82.2°F, (0.6°F above normal) were experienced. The areas surrounding Baton Rouge endured severe drought beginning in late May and lasting through August. Total precipitation in Baton Rouge, however, was above normal in June and July, due to heavy rains on 19–20 of June and 18 and 21 of July. These conditions have not been duplicated in Baton Rouge climatological history (recorded since 1890). Only 1921 parallels 1980 in high average temperatures for June and July and precipitation in the summer months. Average temperatures in 1921 were even higher than those in 1980, 83.1°F in July and 86°F in August. There is no recorded outbreak of *A. clyton* in 1921, which may be due to the extremely high temperatures or failure to report the phenomenon. It appears that very high temperatures in connection with rainfall in June 1980 created conditions which directly or indirectly fostered the population explosion in mid-July 1980. The continued above-normal high temperatures through August and the increased egg crop from the mid-July outbreak account for the second smaller population peak in late August to mid-September.

Specimens collected have been deposited in the Louisiana State University, Department of Entomology Collection (LSUC). I thank Lubomir Masner, Biosystematics Research Institute, Ottawa, Ontario for the identification of the scelionid, and Drs. H. B. Boudreaux, J. B. Chapin and L. D. Newsom for their help and suggestions with this manuscript.

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NOTES ON SOME SPECIES OF *ASTRAPTES*
HÜBNER, 1819 (HESPERIIDAE)

Astraptes fulgerator (Walch) 1775

Synonymy: *mercatus* Fabricius, 1793; *fulminator* Sepp, 1848; *misitra* Ploetz 1881; *albifasciatus* Rober, 1925; *catemacoensis* Freeman, 1967, NEW SYNONYMY.

Type locality: (?)

Distribution: U.S.A. (Texas), through Mexico, Central America to Argentina in South America.

Remarks: Apparently there are two subspecies involved here, *A. fulgerator fulgerator* (Walsh) and *A. fulgerator azul* (Reakirt). Typical *fulgerator* occurs from southern Mexico (Oaxaca and Chiapas) to Argentina. *A. fulgerator* has the following characteristics: wing bases greenish-blue; the hind termen convex; the upper and lower surfaces dark brown; the central band on the primaries dislocated at vein 3, and spot 2 not conjoined to the cell spot; usually 3 apical spots in the males, 4 in the females; cilia in space 1b white; the white basal streak on the lower surface of the secondaries short and broad, with a black streak at the extreme base present; and one of the most important characteristics is the broad, distinct, white suffusion in space 1b on the lower surface of the primaries. *A. fulgerator azul* (Reakirt), 1866 is the subspecies that occurs in Texas and most of Mexico, extending into South America. *A. f. azul* has the following characteristics: the wing bases are blue or violet-blue; the hind termen straight or convex; the upper and lower surfaces dark to pale brown; the central band on the primaries usually compact, with the spot in space 3 present or absent; usually 4 apical spots but may be 3 or 5; cilia in space 1b brown or white; the white basal streak on the lower surface of the secondaries may be short and broad or long and narrow, with the black streak at the extreme base of the costa present or absent; and there is usually no white suffusion in space 1b on the lower surface of the primaries; however, in the blend zone of *fulgerator* and *azul* in Oaxaca and Chiapas, Mexico and in Central America, this suffusion will be present but never as broad and distinct as is found in typical *fulgerator*. Most of the specimens of *azul* that I have examined from South America have this white suffusion fairly well developed.

When I described *A. catemacoensis* from specimens collected at Catemaco, Veracruz, Mexico (Freeman, 1967, J. Lepid. Soc. 21:115-119), the description was based on individuals that were generally larger and darker than normal *fulgerator azul* from other Mexican localities and also by their having the termen of the secondaries straight. At the time I had not examined as many hundred specimens of *azul* from Mexico as I have since and can readily detect that *azul* is extremely variable and *catemacoensis* should have never been named. With this information I place *A. catemacoensis* as a synonym of *A. fulgerator azul*.

Astraptes crana Evans, 1952

Synonymy: *escalantei* Freeman, 1967, NEW SYNONYMY.

Type locality: San Geronimo, Guatemala.

Distribution: Southern Mexico to Panama.

Remarks: There are apparently five species or subspecies involved in the *creteus* (Cramer) complex; however, I have not actually examined some of them and am basing my information on data stated by Evans (1952, A Catalogue of the American Hesperidae, Part II, Pyrginae, Sec 1, London, 170 pp.). They may actually all turn out to be subspecies of *creteus*, but for the present I am going to consider them to be separate species. The five are *creteus* (Cramer), 1780; *siges* (Mabille), 1903; *crana* Evans, 1952; *crilla* Evans, 1952; and *cyprus* Evans, 1952. In describing *escalantei* I was misled by Evans' discussion of *crana*, in which he states that on the under-surface of the primaries of that species the extreme base of the costa is brown, followed by white to mid-wing. This applies to the two females that I have from Rio Santa Domingo, Chiapas, and Presidio, Veracruz, Mexico; however, it did not apply to the two males used in the description of *escalantei* from Ocozingo, Chiapas, Mexico, as the costa on the under-

surface of the primaries was brown throughout with no white present. There was no trace of green iridescence at the base that Evans indicated might be present in *siges*; thus, indicating it was not that species. The genitalia are somewhat similar to Evans' figure of *creteus*. Since describing *escalantei* I have acquired another male specimen from E. C. Welling, collected at Musté, Chiapas, Mexico, 31 July 1968, which has the same characteristics as the two males from Ocozingo used in the original description. S. R. Steinhauser (1975, Bull. Allyn Mus. No. 29:1-34) indicated in his article "An Annotated List of the Hesperidae of El Salvador," that the females that he had collected were definitely *crana*, but the males were somewhat similar to *escalantei*. With the available information it appears as if the females of Evans' *crana* have the characteristics that he indicated, but the males of that species lack the white on the costa of the lower surface of the primaries. With the available information present, I place *escalantei* as a synonym of *crana*.

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36(3), 1982, 237

PROLONGED PUPAL DIAPAUSE OF *ALYPPIA OCTOMACULATA* (AGARISTIDAE)

A recent note by C. Brook Worth (1979, J. Lepid. Soc. 33(3):166) concerning pupae of *Citheronia regalis* Fabricius, which overwintered twice, prompts this additional note on pupal longevity. During the twenty years I have been rearing various species of moths I have found that a small percentage of the pupae of some species will diapause for two years. I have experienced this phenomenon in some broods, though not in every brood, of *Hemileuca maia* Drury, *Ceratomia amyntor* Hübner, *Eupackardia calleta* West., *Callosamia promethea* Drury, *C. angulifera* Walker, hybrids of *promethea* × *angulifera*, and even three and four year diapause in *Saturnia pyri* Denis & Schiffmuller (Bryant, 1980, Maryland Entomologist 1(4):8-9). *Alypia octomaculata* Fabricius represents the first instance of an agaristid with a protracted diapause.

On 30 April 1977, while on a collecting trip to the Green Ridge Mountain area of western Maryland with the Maryland Entomological Society, I caught a female *Octomaculata* ovipositing on *Vitis* sp. Upon returning home, the moth was placed in a plastic bag containing leaves of *Parthenocissus quinquefolia* (L.), where it deposited approximately eighty ova. The larvae were reared to maturity on *P. quinquefolia* and fifty pupae were obtained (Bryant, *in litt.*). Since the Baltimore population is double brooded, I had expected the moths to begin emerging in July. Apparently, however, the western Maryland population is univoltine, as no moths issued from the pupae that summer nor have any emerged during the mid-season flight period in the ensuing years.

The pupae were left, in plastic shoe boxes at ambient temperatures, throughout the summer, fall, and winter of 1977 and on 20 May 1978 moths began emerging. Only nine adults were obtained in 1978. The pupae remained in the plastic boxes for the rest of 1978 and on 2 May 1979 activity was noticed in the boxes. Twenty-five adults emerged in 1979. On the chance that there might still be a few viable pupae among the remaining sixteen unhatched individuals, they were left undisturbed for a third year. Moths were again noticed flying in the boxes on 23 May 1980. Four adults were obtained during the spring flight period in 1980. Convinced that I had seen the last live moths from those old pupae, I decided to clean out the boxes but luckily never followed through. To my astonishment, a single living female was discovered in one of the boxes on 18 May 1981. The boxes will now be observed regularly until a season passes with no new emergences, at which point any remaining pupae will be dug out of their pupal chambers and examined.

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FALSE HEAD BUTTERFLIES: THE CASE OF *OXYLIDES FAUNAS* DRURY (LYCAENIDAE)

I was most pleased to read the recent paper by R. K. Robbins (J. Lepid. Soc. 34:194-208) on the false heads of the underside patterns in certain species of the Lycaenidae. The bibliography of his paper is also useful. Interesting as that author's research undoubtedly is, I found it even more interesting that there is such a dearth of real research into such a promising and fascinating issue. I had always assumed that false heads were clear-cut and well documented.

The paper evoked memories of my own experiences in the late 1960's in Nigeria with a species called *Oxylides faunas* Drury, a butterfly whose behavior, quite literally, adds a further twist to the story.

Oxylides faunas is common in the darker habitats of the tropical zone, such as dense primary forest and especially dense secondary forest. Neither sex ever ventures out in open sunshine. They normally fly where there is dense undergrowth and usually stay at a height of about one meter. The flight is weak and bumpy, most uncharacteristic of a member of the Theclinae. The underside displays a splendid example of a finely adorned false head. The species almost invariably settles on large, flat green leaves; so, the question of whether it settles head-up or head-down is immaterial.

The special twist is that when *Oxylides faunas* lands it flicks itself around 180° a fraction of a second before landing, so that the false head now faces in the direction of flight, fluttering convincingly in even the mildest breeze.

As luck would have it I received Robbins' paper a few days before leaving for Nigeria on a business trip, and I hoped to substantiate my recollections of more than 10 years ago. Although limited time was on hand, I managed to observe a total of 61 landings made by 1 male at Akure, Ondo State, 1 male at Benin, Bendel State and 5 males and



FIG. 1. A specimen of *Oxylides faunas* seated on a leaf in secondary forest (Agege, Lagos, 14 xii 1980).

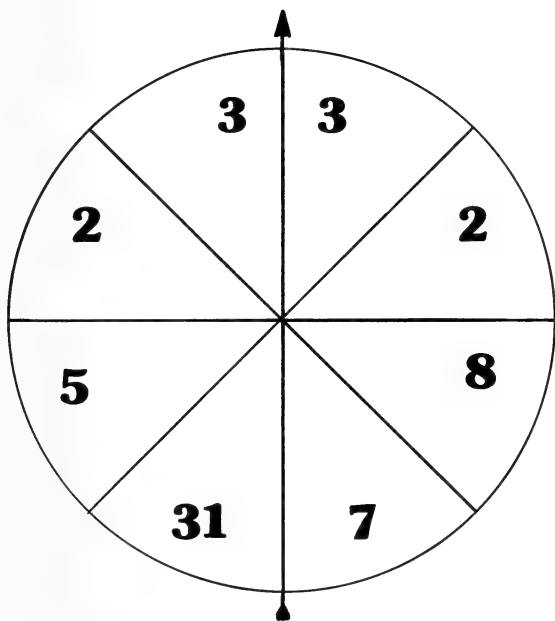


FIG. 2. Position of head in relation to direction of flight in 61 observed landings of 14 specimens of *Oxylides faunas* in Nigeria.

7 females at 4 mi. NW of Agege, Lagos State (Nov.-Dec. 1980). The results of these observations are shown in Fig. 2.

Even the relatively short series of observations clearly shows a statistically significant tendency towards making a complete turn. Fifty-one landings (83%) involved a twist of more than 90 degrees, most of which were close to 180 degrees (62%). Compared to a random distribution the first of these figures is significant at the 0.001 level (Chi-square = 27.85, one degree of freedom). In some of the cases where no turn was made the reason almost certainly was that the specimen had been disturbed by me to the point when normal landing behavior was abandoned. There is a curious leftward bias in the turning behavior, with 62% turning left and only 38% right. This is statistically significant at the 0.01 level (Chi-square = 7.23, one degree of freedom). The species observed by Robbins turned only after landing and did not do so as frequently as *Oxylides faunas*, but there was also a clear leftward bias.

I recalled that specimens often walked backwards after landing and had supposed that this was a further reinforcement of the false head effect. My current series did not support this view. About half the landings were followed by walking, but it was usually forwards, and the purpose appeared to be to get the butterfly a better launch position. There would usually be a pause of three or four seconds between alighting and the start of any walk.

Given the places where *Oxylides faunas* lands, I would expect the main predators to be praying mantises and hunting spiders, against both of which a false head should offer good protection.

BOOK REVIEW

BUTTERFLIES OF THE AFRO-TROPICAL REGION (Volume 2 of *Butterflies of the World*), by Bernard D'Abrera. 1980. E. W. Classey Ltd. Price approximately \$150.

There are others who will review this book from the viewpoint of a professional entomologist; this review is the opinion of an experienced amateur. While I think this book is well worth the long wait and the relatively high price, I find myself somewhat disappointed. The publishers have led us to believe that "it will virtually replace . . . Seitz" (my quotes from a recent Classey flyer), but I cannot agree with this description. There is much that is missing from this volume and it appears as though considerations of cost have cut out much of what could have made it a true "replacement" for Seitz. This is unfortunate, as the volume is the first attempt in over fifty years to cover all the African taxa and as such could have commanded almost any price.

The main problem with the book is its incompleteness. It purports to include Carcasson's new catalogue, but the list that appears is implicit, is not synonymic, and does not have a complete bibliography. A comparison of Peters' checklist (1952) and D'Abrera indicates that many changes have been made in classification over the past 30 years and that a number of species that are described in Seitz and supported in Peters are missing from the present volume. One has only an occasional clue as to where they have been placed, and the D'Abrera index does not list subspecies, making the task even more difficult. Although the author claims that there are only a few species which are shown, the book has far too many instances of "I have not seen . . ." For the book to be complete such statements should be followed with "but the description is as follows . . ." this is unfortunately not the case. The author declines to include keys "as they would be largely redundant," but in many cases the differences are not obvious nor are the illustrations good enough to warrant this type of omission. A small point—the volume covers the "Ethiopian region" of Seitz but adds to it the area now known as Yemen in Southern Arabia. This complicates the problem of the checklist by adding a number of species (particularly in the *Pieridae*).

The illustrations, while impressive, could be better. In the first place the registration and the color balance are both slightly off. Compare the illustration of *Lampides boeticus* in this volume with that in volume I (Australian Region) or with that in Pennington. While this is perhaps an extreme case it points up a technical problem that I hope the publishers will correct in future volumes in the series. The author needs to improve the technique of photographing reflectant wings, the glare on many *Acraeids* is distracting. In addition I wonder if page folds across wings were not avoidable.

The central point of my comments is that this volume is not a complete reference work in itself. One still needs Seitz, Peters, Stempffer, Pennington and several other references to do a proper job. Collectors in East and Southern Africa have many excellent works readily available; those whose collections are concentrated in West Africa are still forced to guess. I find I cannot use the book to make a positive identification of a specimen even when I know the identity from other sources. A companion volume to D'Abrera, containing the Carcasson synonymic catalogue, keys where necessary, and original descriptions of species not figured in D'Abrera would solve most of the problem and in my opinion is urgently needed.

I realize that the preceding comments are somewhat negative. However, it should be stressed that in spite of these problems it is still a magnificent volume. The photographs of the incomparable collection of the BMNH are worth many times the price of the book and the shots of collecting locales are positively "mouth-watering." I highly recommend this book to all lepidopterists, professional and amateur. Mr. D'Abrera deserves highest praise for his efforts to bring us up to date on the highly complex taxa of a rapidly changing continent.

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Cover illustration: Mature Larva of *Eumorphia fasciata* Sulzer (Sphingidae) feeding on *Ludwigia* sp. (Jussiaea) in southern Florida, where this hawk moth is generally found throughout the year. Original drawing by Mr. John V. Calhoun, 382 Tradewind Ct., Westerville, Ohio 43081, USA.

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HABITAT, DIVERSITY AND IMMIGRATION IN A TROPICAL ISLAND FAUNA: THE BUTTERFLIES OF LIGNUMVITAE KEY, FLORIDA¹

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ABSTRACT. An annotated account is presented of the 22 resident and 15 casual butterfly species reported from Lignumvitae Key, a small, protected and relatively unspoiled island in the Florida Keys. The fauna, largely Neotropical, is a segment of that found on the Florida mainland and is analyzed in relation to that area and also to Cuba and Andros. The majority of species occur in open habitats, the forest being impoverished. The overall faunal reduction as compared with the mainland is probably an area effect. Among the species on the Key, *Eunica tatila*, *Hemiargus thomasi* and *Phyciodes frisia* are noted as being in decline elsewhere in South Florida.

Two facets of island faunas are of major interest: their biogeographical affinities and their diversity. Additionally, there is the frequent exhibition of colonization patterns and faunal change (Simberloff, 1978). Since published information on the Florida Lepidoptera covers one hundred years, we have found these insects to be of great value in studying the above related topics. The present work considers the butterfly fauna of Lignumvitae Key. In the chain of small islands situated in Florida Bay known as the Keys, Lignumvitae is the least disturbed by the pressures of man and nature and so is of outstanding biological importance (Wilson & Eisner, 1968). The species compo-

¹ Florida Agricultural Experiment Station Journal Series No. 4462.

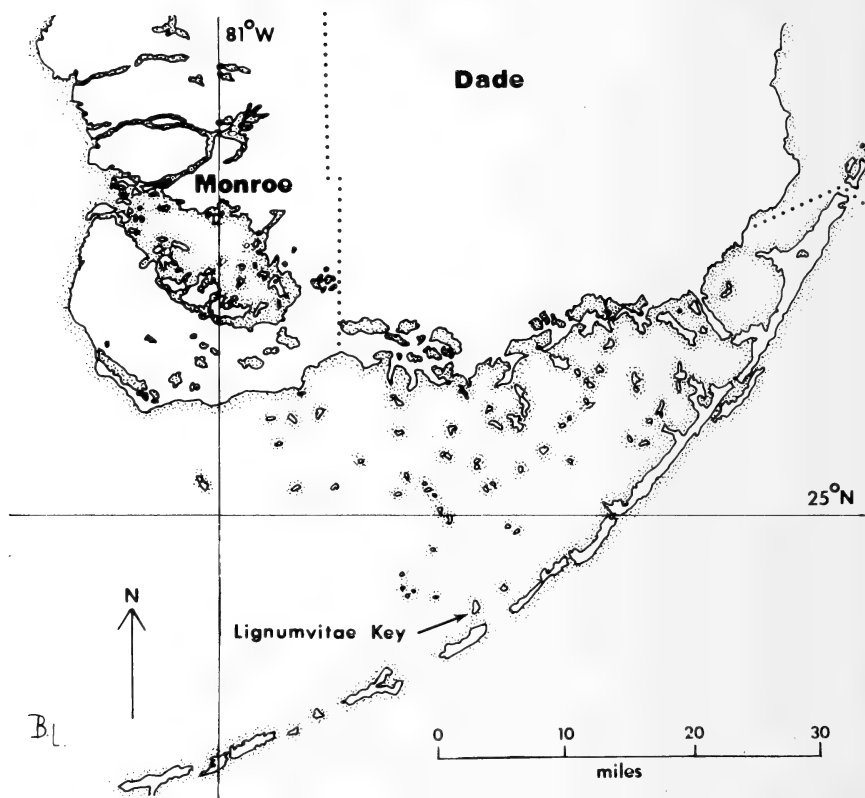


FIG. 1. Map of the southern tip of the Florida peninsula, including the Florida Keys. Lignumvitae Key is indicated (arrow).

sition of this island takes on even greater significance when viewed in the context of a more extensive study of the faunal changes of southern Florida, the Keys and the Bahamas currently in progress (Lenczewski, 1980; Leston et al., in preparation).

Lignumvitae Key covers about 270 acres and is situated about half a mile north of the eastern tip of Lower Matecumbe Key in the middle Keys, Monroe County (Fig. 1). The Florida mainland is approximately 20 miles to the north, the coast of Cuba is 125 miles to the south and the island of Andros in the Bahamas is 140 miles east. The geological composition of the Key is Key Largo limestone, a fossilized coral rock; and Lignumvitae is the highest of the Florida Keys, reaching 16 feet above mean sea level.

There are no meteorological data available for Lignumvitae Key, but, although situated at $24^{\circ}55'$ north and therefore outside the geophysical tropics, its climate in the Köppen system is of tropical rain forest.

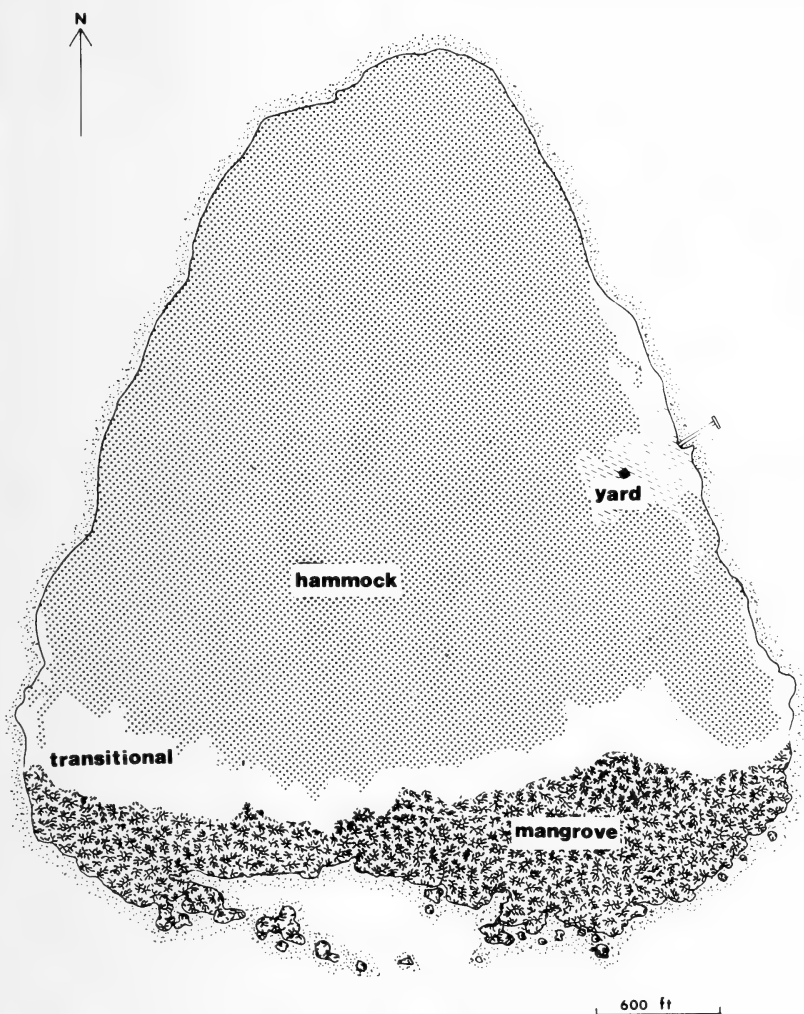


FIG. 2. Map of the vegetation zones of Lignumvitae Key. Note the pier and adjacent yard on the eastern shore. Numerous paths of indeterminate age extend from the yard area through the hammock; these have not been surveyed and are not included here.

There is a dry period extending from November through April, the rest of the year being wet. The absence of adequate figures, especially of mean hours of bright sunshine per day, does not permit greater precision in the defining of seasons (Leston & Gibbs, 1971).

The Key has a long history of human occupation, dating back to pre-Columbian times, but more recent farming has left little mark save for some surviving sisal and a few overgrown coconut palms. The

Matheson house, dating from 1919, is the only substantial building on the Key except for outhouses and a caretaker's dwelling: these all lie within a somewhat barren mown yard with a few ornamental plants and nearby refuse dumps. A short pier extends from the yard. The Key became the property of the State of Florida when it was established as a Botanical Preserve in 1971.

The greater part of the vegetation is forest (Fig. 2), locally known as 'hammock,' comprising about 60 species of trees and larger shrubs, almost entirely of West Indian origin. Popenoe and Avery (1972) suggested that "the Key is covered by one of the finest tropical forests in an essentially virgin condition to be found anywhere in Florida."

METHODS

Butterflies were netted and, except for hesperiids required for identification, were usually released after capture. A voucher collection has been deposited with the Department of Natural Resources on Lignumvitae Key.

One or more of the authors visited the Key, singly or in various combinations and sometimes accompanied by a colleague, on ten mornings between 8 March 1979 and 10 July 1980. A record of person-hours collecting was kept (Fig. 3), and a regular route was followed to maximize the area covered. No particular attention was paid to larvae but any seen were recorded. A few records of adults seen or collected by Ranger Jeanne Parks are included in the checklist and so identified (J.P.).

After completion of our fieldwork, our attention was drawn to two earlier, unpublished studies, the results of which have been incorporated. R. E. Silberglied (pers. comm.) scored butterflies during several visits between 1967 and 1971 and recorded 18 species. The absence of precise dates has limited us to listing only the four species not found in our own collecting. C. V. Covell (pers. comm.) visited the Key on 14 May 1973 and 15 May 1974, and all his records are cited below. One of the present authors (D.S.S.) was a member of Dr. Covell's party on the former visit.

For comparison, data are included for mainland Dade and Monroe Counties and the rest of the Florida Keys, based upon the findings of Leston et al. (in preparation), for Cuba (Bates, 1935; Riley, 1975) and for Andros, Bahamas (Clench, 1977).

RESULTS

Terminology

We use **migrate** in its basic meaning: to pass from one place to another. This excludes "flitting," the short-range movement associ-

ated with the search for food. A **regular migrant** is a species whose movements show a consistent seasonal pattern, as opposed to **casual migrants** (=transients).

Checklist of Species

Satyridae

1. *Euptychia areolata* Smith

Present before 1972 (R.E.S.). Clearly a rare casual on Lignumvitae Key, the species occurs around freshwater marshes and grassland habitats on the mainland and the larger Keys. It is absent from Cuba and Andros.

Danaiidae

2. *Danaus plexippus* Linnaeus

Hammock edge and yard (30.III.79) also 28.X.76 (J.P.). An uncommon but regular non-breeding seasonal migrant. Probably absent between May and early October. Occurs in mainland Dade and Monroe Counties, throughout the Keys, in Cuba and, sporadically, in Andros. The sparsity of *Asclepias* species host plants on the Key perhaps limits the opportunity for breeding, which may take place on the adjacent mainland in the dry period.

3. *Danaus gilippus* Cramer

Northwest shore, 17.V.79—when disturbed, the butterflies flew back out over Florida Bay; transition zone, 8.VI.79, numerous; yard and east shore, 10.VII.80, three or four only. Probably a non-breeding seasonal migrant, surprisingly absent August through April. Occurs in mainland Dade and Monroe Counties, throughout the Keys, in Cuba and in Andros, where it was first noted in 1977. When compared with *plexippus* this is scarcely to be considered a migratory species, but there is some evidence for movement (Harris, 1972). Brower (1962) showed that *gilippus* and *plexippus* can compete for larval food, and the apparent non-overlap of the two on Lignumvitae Key may reflect this. *Asclepias* is scarce on the Key; however, other Asclepiadaceae such as *Cynanchum scoparium* and *Sarcotremma clausa* are indigenous and may perhaps be utilized.

Heliconiidae

4. *Heliconius charitonius* Linnaeus

Hammock, 8.III., 16.III., 30.III., 20.IV., 17.V., 8.VI., 18.VII., 13.XI.1979, 18.I., 10.VII.1980. Also 15.V.74 (C.V.C.). Visits the yard in search of flowers, as on 30.III.79 at flowers of *Carissa macrocarpa* and on 18.VII.79 far more frequent at the yard edge than in the hammock. In all, the butterflies were present in the yard on five of ten visits. New broods occur at least in March and June, and observations on a 'dormitory' of this species in Miami (T. Smith & D. S. Smith, unpublished) suggest that at least five generations may be completed in a year.

A resident, the zebra is found in the nearby mainland counties, throughout the Keys, and as different subspecies in Cuba and Andros. The larval foodplants are *Passiflora* species (Passifloraceae), one or two of which occur on the Key.

5. *Dryas iulia* Fabricius

Yard, 8.III., 16.III., 30.III., 20.IV., 17.V., 8.VI., 18.VII. 1979, 18.I., 10.VII.1980. Also 15.V.1974 (C.V.C.). On 16.III.1979, individuals were at the northwest shore on flowers of *Suriana maritima*; on 30.III.79 some were feeding upon flowers of *Carissa macrocarpa* in the yard. A new brood was present in June.

A resident, the Lignumvitae Key subspecies is the same as on the adjacent mainland and throughout the Keys. Other subspecies occur on Cuba and Andros (Clench, 1975). The larvae feed upon *Passiflora* species.

6. *Agraulis vanillae* Linnaeus

Yard, 8.III., 16.III., 30.III., 20.IV., 17.V., 8.VI., 18.VII., 13.IX.1979; 18.I., 10.VII.1980; also 28.X.1976 (J.P.). Only found in the yard, where it visits flowers including *Carissa macrocarpa* and *Nerium oleander*. Most abundant in May through July, with new broods occurring at least in early May and late July.

A resident, the larval foodplants being *Passiflora* species. This insect is found in mainland Dade and Monroe Counties and throughout the Keys, a distinct subspecies occurring in Cuba and Andros.

Nymphalidae

7. *Marpesia petreus* Cramer

Hammock, 10.VII.1980, also sight records 11.VI.1979, 3.VII.1980 (J.P.). The single sighting in 1979 suggested a casual immigrant, but the numbers seen within the hammock in 1980, when up to four were visible at a time, indicate that this is a resident. The butterflies were commonly seen around *Ficus aurea* (Moraceae), a native fig and known larval foodplant.

M. petreus occurs in mainland Dade and Monroe Counties and throughout the Keys but is absent from Andros and Cuba.

8. *Eunica tatila* Herrich-Schaeffer

Hammock, 8.III., 16.III., 30.III., 20.IV., 17.V., 8.VI., 18.VII., 13.IX.1979, 18.I., 10.VII.1980, also 27.X.1976 (J. P.) and 14.V.1973, 15.V.1974—"more common than in 1973" (C.V.C.). This butterfly never leaves the hammock nor, apparently, does it fly above the canopy. It was abundant in March but scarce in May and June, with a new brood in July (1979, 1980) producing a smaller population than the February brood. Numbers are relatively low through the Fall.

The larval foodplants, all of which are trees, probably include *Gymnanthes lucida* (Euphorbiaceae). Currently, this butterfly occurs in the Upper Keys between Elliot Key and north Key Largo, and there are recent reports from Upper Matecumbe and Plantation Keys. However, the Lignumvitae Key population is undoubtedly the largest concentration. Although a single fresh specimen was found in a Miami garden in 1979 (D.S.S.), no populations have been found by us in a search of the larger surviving Dade and Monroe mainland hammocks, and the last Everglades National Park example dates from 1973 (Lenczewski, 1980). *E. tatila* is present in Cuba but probably absent from Andros—see discussion by Clench (1977).

9. *Junonia evarete* Cramer

Yard, 16.III., 30.III., 20.IV., 18.VII.1979; also in transition zone, 20.IV., 18.VII., 13.XI.1979 and in the hammock, 30.III.1979. A resident, but absent or scarce in May through July. The larval foodplants include *Lippia nodiflora* and *Stachytarpheta jamaicensis* (Verbenaceae).

This butterfly occurs on Andros and, perhaps, as a separate subspecies in Cuba (cf. Riley, 1975). It is widespread in the Keys but confined to coastal areas on the Florida mainland: migrations complicate the distribution pattern.

10. *Anartia jatrophae* Johansson

Seaward edge of the yard, 10.VII.1980. Three specimens were seen within five minutes, but absence of this distinctive species from previous samplings or inspections and absence of the larval foodplant, *Bacopa monnieri* (Scrophulariaceae) indicate that this is a non-established casual immigrant. It occurs in mainland Dade and Monroe Counties, the Keys, Cuba and Andros.

11. *Siproeta stelenes* Linnaeus

Yard, 30.III.1979, one, at flowers of *Carissa macrocarpa*; also one seen 18.VI.1979 (J.P.). A non-established casual immigrant known from Cuba and, for the past 15 or so

years, established in the Keys and mainland south Florida but apparently absent from Andros. The larval foodplants are *Blechnum* species and perhaps other Acanthaceae.

12. *Phyciodes frisia* Poey

Yard, 8.III., 16.III., 30.III., 20.IV., 18.VII., 13.XI.1979, 18.I., 10.VII.1980; also hammock, 30.III.1979. Also 14.V.1973 (C.V.C.). Numbers were high in March, reduced in April and again up (the result of a new brood) in June. Through the rest of the year, the biology of the Cuban crescent was unclear. Adults visited flowers of *Carissa* in the yard in late March and flowers of *Pluchea purpurescens* in the transition zone in July 1980. A resident, the larval foodplants include *Dicliptera assurgens* (Acanthaceae), which is common on the Key. The species is found in Andros, Cuba and throughout the Keys but on the mainland of Florida is now confined to the Flamingo area in the Everglades National Park (Lenczewski, 1980).

13. *Phyciodes phaon* Edwards

Yard, 30.III., 20.IV., 19.VII., 13.XI.1979, 18.I., 10.VII.1980. Absent in May and June and scarce in July, this butterfly was most frequent in November and January. It is a breeding resident, the larval foodplant being *Lippia nodiflora* (Verbenaceae). Unlike *frisia* this species never strays from the yard.

Phyciodes phaon is widespread in southern Florida and the Keys, rare in Cuba and absent from Andros.

Lycaenidae

14. *Strymon melinus* Hübner

Yard, 8.III., 16.III., 30.III., 17.V., 8.VI.1979. This species is a breeding resident with two, perhaps three, broods per year. It is highly polyphagous and its larval foodplant has not been detected on the Key, but this plant is undoubtedly one of the common yard forbs. The butterfly is common in the Keys and on the mainland, absent from Andros and Cuba.

15. *Strymon columella* Fabricius

Transition zone, 13.XI.1979, 10.VII.1980. On the latter date the butterfly was visiting flowers of *Pluchea purpurescens*. Also 14.V.1973 (C.V.C.). The larval foodplant is probably one of the Malvaceae, of which several occur as yard forbs on the Key. The species occurs on the mainland and through the Keys, also in Andros and Cuba, but there is some uncertainty concerning the identity of the involved subspecies (Clench, 1963). On Lignumvitae Key, the paucity of records suggests that *columella* is a casual immigrant, though the presence of potential foodplants indicates that breeding populations may be sporadically established.

16. *Strymon martialis* Herrich-Schaeffer

Yard, 30.III. and 13.XI.1979. Probably a casual migrant, although the foodplant *Trema micrantha* (Ulmaceae) is said to occur on the Key. Widespread, but never abundant in mainland Dade and Monroe Counties and in the Keys; it is also present in Cuba and Andros.

17. *Brephidium pseudofea* Morrison

Transition zone, 16.III., 30.III., 20.IV., 17.VI., 8.VI., 18.VII., 13.XI.1979, 18.I., 10.VII.1980; also on shore of the yard throughout. Other records: 14.V.1973, 15.V.1974 (C.V.C.). The butterfly was abundant in June and July, common at other times. It is a resident breeding species, the larvae feeding on *Salicornia* species (Chenopodiaceae). Adults seldom move more than a few yards from the larval foodplant, and those noted at flowers of *Pluchea purpurescens* (10.VII.1980) were no exception.

Brephidium pseudofea is present in saltmarshes along the coast of Dade and Monroe Counties and in the Keys, but is absent from Cuba and Andros.

18. *Leptotes cassius* Cramer

Yard, 8.III., 16.III., 30.III., 18.VII., 13.XI., 1979, 18.I., 10.VII.1980; also in transition zone 13.XI.1979, and 14.V.1973 (C.V.C.). This butterfly is seemingly absent April through June. It is a resident species, the larvae feeding on flowers of a range of herbs, all papilionaceous. It is common in mainland Dade and Monroe Counties, throughout the Keys, on Andros and in Cuba.

19. *Hemiargus thomasi* Clench

Yard, 8.III.1979; transition zone and yard, 16.III.1979; hammock, transition zone and yard, common 30.III.1979 and in the same areas 20.IV. and 17.V.1979; transition zone and yard, 8.VI. and 18.VII.1979; transition zone, 13.XI.1979; yard, 18.I.1980; hammock and transition zone, 10.VII.1980.

A resident species, the larvae feed upon the green seeds within the inflated calyx of *Cardiospermum halicacabum* (Sapindaceae); this is the same foodplant previously noted by us on Key Largo (Lenczewski, 1980). On Lignumvitae Key, *thomasi* is essentially a species of the hammock canopy and the transition zone edge of the hammock, at times flying further afield in search of flowers.

The Miami blue is now probably extinct in mainland Dade and Monroe Counties, but it occurs throughout the Keys from Key Biscayne and Elliot Key southwards and on Andros but is apparently absent from Cuba (but see discussion in Riley, 1975).

20. *Hemiargus ceraunus* Fabricius

Yard, 30.III., 13.XI.1979. The paucity of records suggest that this is a casual immigrant, but as the larval foodplants include a range of weedy Caesalpinaceae and Papilionaceae (*Abrus*, *Cassia*, *Crotalaria* and *Phaseolus* species), establishment is possible. The species is common on the mainland and occurs throughout the Keys, also on Andros and Cuba (but compare the views of Riley, 1975 and Clench, 1977 as to the identity of this species and *H. hanno* Stoll).

Papilionidae

21. *Papilio cresphontes* Cramer

Yard, 16.III., 30.III.1979, some at flowers of *Carissa macrocarpa*; hammock, 17.V., 8.VI.1979; yard and hammock, 13.XI.1979. Also 22.X.1976 (J.P.); 14.V.1973, 15.V.1974 (C.V.C.). Larvae have been found on *Zanthoxylum fagara* and *Amyris elemifera* (Rutaceae). The captures suggest that there are three broods of this resident. The species occurs throughout the Florida mainland and in the Keys but is absent from Andros and rare in Cuba.

Pieridae

22. *Phoebis sennae* Linnaeus

Transition zone and yard, 8.III., 30.III., 8.VI.1979; yard only, 16.III.1979. A regular migrant, perhaps temporarily established. The larval foodplants are usually weedy herbaceous Papilionaceae or Caesalpinaceae. The butterfly is common in mainland Dade and Monroe Counties and throughout the Keys, in Cuba and Andros.

23. *Phoebis agarithe* Boisduval

Yard, 8.III.1979; transition zone and yard, 16.III. and 30.III.1979, some at flowers of *Carissa macrocarpa*; 20.IV., 17.V., 8.VI., 13.XI.1979, 18.I., 10.VII.1980. Also 14.V.1973, 15.V.1974 (C.V.C.). Numbers remain fairly constant throughout the year except for a dip in July. It is a resident butterfly, the larvae feeding upon *Pithecellobium* (Mimosaceae), of which two species occur on Lignumvitae Key. Common in mainland south Florida and the Keys, the insect is present also in Cuba and Andros.

24. *Aphrissa statira* Cramer

Present before 1972 (R.E.S.) and regarded by us as a rare casual, the 'migrant sulfur' (Riley, 1975) is recorded from the Keys, the Florida mainland and Cuba but not from

Andros. It is very restricted in southern Florida but certainly breeds locally, its numbers possibly augmented by immigration. We follow Riley's generic placement.

25. *Eurema lisa* Boisduval and Leconte

Yard, 13.XI.1979, 10.VII.1980. Only one specimen was found in November; the insect was apparently absent in January and yet numerous in July 1980. We consider this species to have been a casual originally, but now established. The larval foodplants comprise a range of Papilionaceae and Caesalpinaceae. Common throughout southern Florida and found through the Keys, the butterfly occurs also in Cuba and Andros, but there is some confusion concerning the range of the various subspecies.

26. *Eurema दौरа* Godart

Yard, 16.III., 30.III., 20.IV., 17.V., 18.VII., 13.XI.1979, 18.I., 10.VII.1980, also 28.X.1976 (J.P.). The species was most common in each July. A resident and never found away from the weed-riddled grass areas of the yard, the larvae feed on a range of low herbaceous Papilionaceae. *E. दौरа* is common throughout mainland Florida, the Keys, Cuba and Andros. Elsewhere (Smith et al., 1982), we have re-examined the problem of seasonal and sexual variation in this butterfly, and have included Lignumvitae Key material in the analysis. As in Dade County populations surveyed, *palmira*-like individuals occur on Lignumvitae Key.

27. *Nathalis iole* Boisduval

Before 1972 (R.E.S.); 15.V.1974 (C.V.C.). This species was sought for in our visits without result. We regard it, therefore, as a casual species on Lignumvitae Key, perhaps becoming temporarily established. It is widespread and often abundant on the mainland and in other Keys, Cuba and Andros.

28. *Ascia monuste* Linnaeus

Yard and transition zone, 8.III., 16.III., 30.III., 20.IV., 17.V., 8.VI., 18.VII., 13.XI.1979, 18.I., 10.VII.1980, including individuals visiting flowers of *Pluchea purpurascens*. The grey form was present in the June sample. The species is apparently most numerous in January through March. While a resident, the numbers may well be enhanced by regular immigration. Larval foodplants include a range of herbaceous Capparidaceae and Cruciferae. The species is common in south Florida, the Florida Keys, Cuba and Andros.

29. *Appias drusilla* Cramer

Hammock, 20.IV., 17.V., 18.VII., 13.XI.1979, 10.VII.1980; also at the hammock-yard edge, 17.V. and 18.VII.1979. Also 15.V.1974 (C.V.C.). The butterflies were noticeably absent in January and March, most numerous in June and July, with a new brood present in June. A resident, the larval foodplants include *Drypetes* (Euphorbiaceae) and *Capparis* (Capparidaceae) species. This pierid is present in the hammocks of mainland Dade and Monroe Counties and in suitable habitats throughout the Keys, in Cuba and, rarely, in Andros.

Hesperiidae

30. *Panoquina panoquinoides* Skinner

Shore edge of yard, 18.VII., 13.XI.1979, at flowers of *Conocarpus erecta*; 18.I.1980. Resident, but numbers always low and confined to the narrow coastal edge of the yard. The larval foodplant is *Sporobolus virginicus* (Graminae). In addition to buttonwood, the adults utilize the flowers of *Sesuvium portulacastrum*. The species is found in similar habitats on the mainland, throughout the Keys, on Andros but not currently occurring in Cuba, according to Riley (1975).

31. *Asbolis capucinus* Lucas

Yard, 8.III., 30.III., 20.IV., 17.V., 18.VII.1979. A resident, the larvae feed upon the introduced *Cocos nucifera* (Palmae). Originally Cuban, *capucinus* has been estab-

lished on the Florida mainland and through the Keys since about 1950. It is not recorded to date from Andros.

32. *Erynnis zarucco* Lucas

Before 1972 (R.E.S.). This skipper is widespread in the lower Keys and present on the mainland and in Cuba, but not Andros. Clearly a casual on Lignumvitae: foodplants include a few Papilionaceae.

33. *Urbanus proteus* Linnaeus

Yard and hammock, 16.III.1979; yard and transition zone, 13.XI.1979, 18.I.1980, also 7.XI. and 12.XI.1976 (J.P.). A regular immigrant, temporarily established and breeding in the dry period, November through April. The larval foodplants include a wide range of herbaceous Papilionaceae. This species is common in mainland Dade and Monroe Counties, throughout the Keys, and is represented by a distinct subspecies in Cuba and Andros.

34. *Urbanus dorantes* Stoll

15.V.1974 (C.V.C.). Another casual species, recorded only once from Lignumvitae, this skipper occurs in Cuba and Andros and, in the past decade or so, has become a common butterfly on the Florida mainland and in the larger Keys. It is markedly seasonal, and its foodplants include many weedy Papilionaceae.

35. *Polygonus leo* Gmelin

Yard, 16.III., 30.III.1979, at flowers of *Gliricidia* and *Carissa*; 20.IV., 17.V.1979, 18.I., 10.VII.1980; in hammock, 30.III., 20.IV., 13.XI.1979, 18.I.1980; also in transition zone, 13.XI.1979. Also taken 15.V.1974 (C.V.C.). This hesperiid, a resident, is most common November through March. The larvae feed upon *Piscidia piscipula* (Papilionaceae). The distribution includes mainland Dade and Monroe Counties, the Keys, Cuba, but apparently not Andros.

36. *Epargyreus zestos* Geyer

Hammock, 10.VII.1980, a single worn individual; also 15.V.1974 (C.V.C.). A casual immigrant, now probably extinct on mainland Florida but unpredictably present through the island chain from Key Largo to Key West; found on Andros but absent from Cuba. The larval foodplants are probably legumes (Riley, 1975).

37. *Phocides pigmalion* Cramer

Yard, 8.III., 16.III.1979, at flowers of *Gliricidia*. 30.III.1979 numerous, some at flowers of *Carissa*, 20.IV., 18.VII. (new brood), 13.XI.1979, 18.I., 10.VII.1980; also in transition zone, 20.IV.1979 and 28.X.1976 (J.P.). A resident, the larvae feed on the leaves of *Rhizophora mangle* (Rhizophoraceae). This skipper is widespread in the belt of red mangrove of Dade and Monroe Counties, in the Florida Keys and, as distinct subspecies in Andros and Cuba.

DISCUSSION AND ANALYSIS

The butterfly species found on Lignumvitae Key may be divided according to their status as follows:

Immigrant, casual, non-breeding	11
Immigrant, regular, breeding	1
Immigrant, regular, non-breeding	3
Immigrant, total	15
Resident, breeding, total	22
Species total	<u>37</u>

The species, immigrant and resident, also segregated by habitat:

	Immigrant	Resident	Total
Forest: hammock	1	6	7
mangrove	0	1	1
total			<u>8</u>
Open: yard/scrub	9	13	22
shore/saltmarsh	0	2	2
total			<u>24</u>
Total (all habitats)			<u>32</u>

Species noted by previous observers (*E. areolata*, *A. statira*, *N. iole*, *E. zarucco* and *U. dorantes*) for which locality data is not available are not included in the above analysis. Although not statistically significant, it is noteworthy that all but one of the hammock species are resident. There is a marked preponderance of species of open habitats, though these comprise less than 20% of the Key's area: the 50% probability test indicates a significant departure from a random distribution hypothesis— $0.05 > P > 0.01$. Based on mainland observations of habitat preference, none of the five species mentioned above is a forest dweller, suggesting that the significance of non-random distribution based on our survey is underestimated.

The Lignumvitae Key species, resident or immigrant, occur in neighboring areas in the following numbers:

	Lignumvitae	Florida Keys	Mainland So. Florida	Cuba	Andros
Numbers	37	37	34	30	25
Percent	100	100	91.9	81.1	67.6

The butterfly fauna of Lignumvitae Key contains no unique species, all being found elsewhere in the Florida Keys, but beyond this island chain, there is a reduction with distance of species held in common. The difference from the nearby Florida mainland (Dade and Monroe Counties) is the result solely of the recent extinctions in the Miami/Homestead area: *E. tatila*, *H. thomasi* and *E. zestos* have been lost within the past ten to twenty years (Lenczewski, 1980; Leston et al., in prep.). *Phyciodes frisia* too, once widespread in Dade and Monroe Counties, is now confined to the area around Flamingo, Everglades National Park and is another species of diminishing range.

It is assumed that Lignumvitae Key depends for its faunal diversity upon the pool of species provided by the adjacent Florida mainland and the chain of islands of which it is a part. Leston et al. (in prep.) give a checklist of the present day butterflies of Dade and Monroe Counties, which forms the basis of the following comparison; the higher groupings, for convenience follow Klots (1951). Where a species on the mainland comprises both breeding residents and migrants (e.g. *Danaus plexippus* and *Ascia monuste*) it is scored in the former category.

Family	Dade and Monroe Counties			Lignumvitae Key		
	Resident	Migrant	Total	Resident	Migrant	Total
Satyridae	2	0	2	0	1	1
Danaidae	3	1	4	0	2	2
Heliconiidae	3	0	3	3	0	3
Nymphalidae	12	13	25	5	2	7
Libytheidae	0	1	1	0	0	0
Riodinidae	1	0	1	0	0	0
Lycaenidae	16	0	16	4	3	7
Papilionidae	6	6	12	1	0	1
Pieridae	13	7	20	5	3	8
Hesperiidae	36	7	43	4	4	8
Totals	92	35	127	22	15	37

Spearman's rank correlation test shows there is a significant positive correlation between families of the mainland plus Keys fauna, on the one hand, and that of Lignumvitae on the other: $\Sigma d^2 + t = 20.5$, $n = 10$, $P < 0.01$. The assumption made above is therefore confirmed.

The proportion of migratory to resident species is higher in the Lignumvitae list than in the species pool:

	Resident	Migratory	Total
Dade and Monroe	92 (72.4%)	35 (27.6%)	127
Lignumvitae Key	22 (59.5%)	15 (40.4%)	37
L.K. fauna as percent of pool	23.9%	49.9%	29.1%

Overall, the butterflies of Lignumvitae Key represent a little over a quarter (29.1%) of the species pool in Dade and Monroe Counties.

The butterfly fauna of the Key has 31 species whose affinities are Neotropical, with only 6 (*S. melinus*, *P. cresphontes*, *E. areolata*, *E. lisa*, *N. iole*, *E. zarucco*) with Nearctic affinities.

The relationship of collecting hours to the cumulative number of species noted is shown in Fig. 3. It suggests that additional species, probably non-resident, remain to be recorded for Lignumvitae Key.

DISCUSSION

The butterflies of Lignumvitae Key are overwhelmingly of Neotropical origin, but the absence of Cuban or Bahamian species not found on the Florida mainland suggests that the island has probably been colonized, not directly from Cuba and/or the Bahamas, but from the neighboring Florida Keys and peninsular Dade and Monroe Counties. This is scarcely surprising in view of the relative distance involved and applies whether we consider resident or immigrant species separately or in combination.

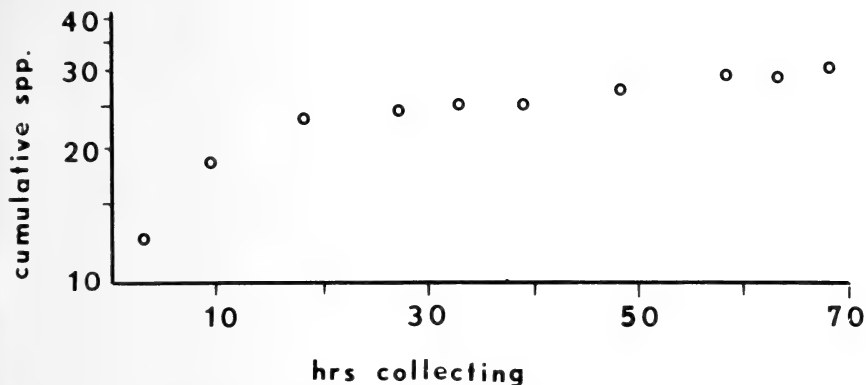


FIG. 3. Illustrating the relationship between person/hours collecting and cumulative number of species recorded (logarithmic).

We meet a phenomenon on the Key of species occurring as transients (casual immigrants) which, in the much larger area of the south Florida mainland and even on some of the larger Keys, are breeding residents: examples include *Danaus gilippus*, *Anartia jatrophae* and *Siproeta stelenes*. MacArthur and Wilson (1967) hypothesized that this might happen, though with little factual data in support. However, whether the absence of species common elsewhere in the vicinity or whether some species are transient instead of permanent can be construed as the result of direct area effect is not at first evident from our data. Simberloff (1978) avers: "... area affects species number independently of habitat diversity." The absence from Lignumvitae Key of such important components of the nearby land areas as pinelands, oak hammocks, Everglades prairies, freshwater marshes and agricultural plots, each of which supports a characteristic butterfly fauna, may directly limit species diversity, though the addition of only one or two of these biotypes can be envisioned in an area as small as 270 acres.

If we ignore exact species composition and work at a higher taxonomic level, as expressed by the list of families and their relative numbers of included species, the significant positive correlation noted indicates that the Lignumvitae Key butterfly fauna may be viewed as a reduced but undistorted simulacrum of the pool community. In other words, direct area effects rather than habitat simplification, may suffice to explain the differences between the faunas of the pool and of the Key.

Both from a study of succession (Southwood et al., 1979) and from a direct comparison of the phytophagous insect fauna of tropical forest

with that of non-forest (Leston, 1980), the wooded climactic areas of Lignumvitae Key would be expected to support more species than the open places. In fact, the reverse is the case: we find the forest of this Key, like the hammocks of mainland south Florida, to carry an impoverished butterfly fauna.

The introduction of *Papilio aristodemus ponceanus* (Schaus' swallowtail) to the Key has been contemplated (Covell, 1976). The principal hostplant of this species *Amyris elemifera* (torchwood) is present on this Key, though sparsely, but the butterfly has not been reliably reported from Lignumvitae or, since May 1945, from nearby Lower Matecumbe Key (Henderson, 1946). *P. a. ponceanus* is established in a threatened area on north Key Largo and is under effective protection on Elliot Key and other islands in the Biscayne National Monument. Covell (1976) has stressed the fluctuation in abundance of this species from year to year: we cannot predict its long-term future in the area, but should a further protected habitat be needed to aid its conservation, Lignumvitae Key remains the obvious choice. In addition, it should be noted that Lignumvitae Key possesses one of the best surviving U.S. colonies of *Eunica tatila*, a species that declines as destruction of hardwood forest progresses. Other species well established on the Key, but with diminishing range elsewhere in the area and notably on the south Florida mainland, include *Phyciodes frisia* and *Hemiargus thomasi*.

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We are sad to record that Dr. Dennis Leston, who initiated the survey described in this report, died in October 1981. An appreciation of his work has been provided by T. R. E. Southwood, 1982. *Antenna* 6:173-174.

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FIELD OBSERVATIONS OF FOODPLANT OVERLAP AMONG SYMPATRIC *CATOCALA* FEEDING ON JUGLANDACEAE

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ABSTRACT. Field collections or observations of eggs, larvae and ovipositing females confirm that *Catocala epione* Drury, *habilis* Grote, *judith* Strecker, *obscura* Strecker, *residua* Grote, *retracta* Grote, and *palaeogama* Guenée feed on shagbark hickory, *Carya* (section Eucarya) *ovata* in Connecticut. *C. obscura* and probably *C. residua* prefer this species over other Eucarya while *C. palaeogama* seems to oviposit randomly on species of this section. No species of *Catocala* appears to prefer a species of Eucarya other than *C. (E.) ovata*. None of the Eucarya feeders were encountered on section Apocarya or *Juglans*. Since *C. ovata* accounts for well over half of all Juglandaceae in Connecticut, it would be the *de facto* primary foodplant of any *Catocala* species that oviposits randomly on Eucarya. The hypothesis that *Catocala* are extensively partitioning the available Eucarya by species is untenable. Individual trees are frequently used by several *Catocala* species, and there is little evidence of partitioning at that level except that *C. epione* appears to feed largely on small plants.

Catocala subnata Grote oviposits on *Carya* (section Apocarya) *cordiformis* and *Juglans cinerea*. *Catocala neogama* (J. E. Smith) and *C. piatrix* Grote probably feed largely or entirely on *Juglans* in Connecticut. Few comparable assemblages of oligophagous or monophagous congeneric Lepidoptera utilizing a single foodplant occur in the North Temperate Zone.

The moth genus *Catocala* is well known for its extreme sympatric diversity (see Sargent, 1976). In southern New England, three well sampled locations have produced from 35 to 40 species¹ each (Sargent, 1976), and I have taken 39 species in seven years within a kilometer of my home in Hamden, Connecticut, almost entirely at sugar bait. Most of the species are taken every year, and many are taken in large numbers. I estimate that 52 species of *Catocala* have been taken in Connecticut since about 1890. Forty-six of those are present now on a regular basis. At least one that is now common (*C. judith* Strecker) is absent from old area collections, while *C. robinsonii* Grote was established between about 1898 and 1964, but no longer occurs. *C. pretiosa* Lintner has also disappeared.

In addition to sympatry, *Catocala* have been suspected of extensive foodplant overlap. For example, fourteen species of current Connecticut *Catocala* are well known to use Juglandaceae as larval foodplants. Four additional Juglandaceae feeders have been taken in the state. However, the foodplant compilations of Sargent (1976) are based largely on rearings *ex ovis*, and it is not possible to determine precise natural foodplants. The situation with older references is much worse as specific plant names were almost never given. Thus, with two

¹C. "*amica*" includes two species at all three localities.

species of *Juglans* and five of *Carya* [four Section Eucarya, one Apocarya (Fernald, 1950)] present widely in Connecticut, it seemed possible that fourteen *Catocala* species indeed might be partitioning the Juglandaceae by species to some extent. However, one species of hickory, *Carya ovata*, greatly outnumbers all other combined Juglandaceae in most portions of the state (see localities, below).

With the data presented below, I intend to document the *Catocala* fauna of *Carya ovata* and to provide some indication of the range of foodplant choices of these moths.

METHODS

A variety of methods have been used to document foodplant usage in the field. During the winter of 1978–1979 bark samples of five to ten shags were taken from seven mature *Carya ovata* and two mature *C. glabra* at Roxbury, Litchfield Co., Connecticut, as well as from two to five mature *C. ovata* each from four localities in New Haven County, for a total of 18 *C. ovata* samples, each containing visible *Catocala* eggs.

Bark samples were sleeved on *C. ovata* in April 1979, and larvae were changed to new sleeves as needed in June. A limited supply of sleeveable branches necessitated pooling of some samples. A more serious complication was the excessive number of larvae produced. The two most rapidly growing species, *C. palaeogama* and *C. residua* severely depleted food supplies, and this may well have led to high mortality of other species. Table 1 gives the results of this method.

A second method was searching for larvae. On 30 June 1979 I

TABLE 1. *Catocala* reared from eggs collected during the winter of 1978–1979 in Litchfield (Roxbury) and New Haven (all others) Cos., Connecticut. Identifications were mostly from adults, but some were from larvae which were subsequently preserved. All eggs were sleeved on *Carya ovata*.

Locality and tree	<i>Catocala</i> produced			
	<i>palaeogama</i>	<i>residua</i>	<i>retecta</i>	<i>obscura</i>
<i>Carya ovata</i>				
Roxbury, tree B	6	3	1	0
C	21	13	0	0
D	?	2	0	0
E	13	6	0	0
Roxbury, trees A, F, G	35	14	4	2
Lake Gaillard, 2 trees	20	0	0	0
New Haven-Hamden, 9 trees	7	0	2	0
<i>Carya glabra</i>				
Roxbury, 2 trees	6	0	0	0

TABLE 2. Collections of *Catocala* larvae in Connecticut and southern New Jersey. Designations under N refer to number of trees, except letters specify an individual tree. A range of dates indicates two or more checks of that tree. Larvae were reared until large enough to identify.

Tree species	N	Approx. diameter	Locality	Date	Catocala
<i>J. nigra</i>	>15	8-20 cm	Batsto, N.J.	10 July '73	<i>maestosa</i> (≥ 1), <i>neogama</i> (≥ 2)
<i>J. nigra</i>	2	8 cm	Batsto, N.J.	1 June '80	<i>neogama</i> (1, mature)
<i>J. nigra</i>	3	10-15 cm	New Haven, Ct.	1-15 June '78	<i>neogama</i> (>10)
<i>J. nigra</i>	3	10-15 cm	New Haven, Ct.	1-8 June '79	<i>neogama</i> (5-10), <i>piatrix</i> (1)
<i>J. nigra</i>	3	10-15 cm	New Haven, Ct.	May-June '80	<i>neogama</i> (21)
<i>J. cinerea</i>	2	20 cm	New Haven, Ct.	1-15 June '78	<i>neogama</i> (>5)
<i>J. cinerea</i>	2	20 cm	New Haven, Ct.	1-8 June '79	<i>neogama</i> (5)
<i>J. cinerea</i>	1	20 cm	New Haven, Ct.	May-June '80	<i>neogama</i> (3)
<i>J. cinerea</i>	4	10-20 cm	N. Ashford, Ct.	9 June '79	<i>neogama</i> (1)
<i>J. cinerea</i>	4	10-20 cm	N. Ashford, Ct.	30 June '79	<i>neogama</i> (1)
<i>C. pallida</i>	3	8 cm	Greenbank, N.J.	1 June '80	<i>vidua</i> (3)
<i>C. tomentosa</i>	5	<6 cm	Elmer, N.J.	20 May '79	<i>epione</i> (3)
<i>C. ovalis</i>	3	10 cm	West Rock, Ct.	20-30* May '80	<i>palaeogama</i> (1)
<i>C. glabra</i>	1	8 cm	West Rock, Ct.	20-30* May '80	none
<i>C. ovata</i>	A	8 cm	West Rock, Ct.	25 May '80	<i>palaeogama</i> (2), <i>epione</i> (1), <i>retecta</i> (2)
	B	8 cm	West Rock, Ct.	30 May '80	<i>palaeogama</i> (2)
	C	10 cm	West Rock, Ct.	26 May '80	<i>palaeogama</i> (9), <i>epione</i> (5), <i>retecta</i> (1)
	D	8 cm	West Rock, Ct.	26 May '80	<i>palaeogama</i> (1), <i>residua</i> (2)
	E	15 cm	West Rock, Ct.	26 May '80	none
<i>C. ovata</i>	F	8 cm	West Rock, Ct.	20-30* May '80	none
<i>C. ovata</i>	>15	>25 cm	N. Ashford, Ct.	30 June '79	<i>habilis</i> (6), <i>residua</i> (1)
<i>C. ovata</i>	1	8 cm	New Haven, Ct.	1-10 June* '80	<i>habilis</i> (3)

* Checked two or more times during this time period.

TABLE 3. Summary of *Catocala* ovipositions and number of trees (*Carya*, *Juglans*) checked in New Haven County, Connecticut (during 1979 and 1980). Numbers in parentheses refer to same night repeats of previously checked trees (see text).

Tree species	N obser- vations	<i>Catocala</i> species						
		<i>neogama</i>	<i>subnata</i>	<i>palaeo- gama</i>	<i>residua</i>	<i>obscura</i>	<i>judith</i>	<i>retecta</i>
<i>C. ovata</i>	179 (12)	0	0	42	15	22	1	3
<i>C. glabra</i>	35 (3)	0	0	4	1	0	0	0
<i>C. ovalis</i>	5	0	0	1	0	0	0	0
<i>C. tomentosa</i>	13	0	0	3	0	0	0	0
<i>C. cordiformis</i>	36 (19)	0	5	0	0	0	0	0
<i>J. cinerea</i>	19 (10)	1	1	0	0	0	0	0

searched for larvae under shags of mature *C. ovata* near North Ashford, Connecticut. No other *Carya* species was encountered, but four *Juglans cinerea* were checked. By this date most larvae had probably pupated. During May 1980 young larvae were collected from foliage and branches of small hickories on West Rock, New Haven, Connecticut. Branches were beaten after being inspected visually. Most larvae were found by inspection. Larvae were also taken on *Juglans* in various years on the trunk, at the base of large limbs, or in debris at the base of the trees. None were found on small branches or leaves. Numbers of trees searched and larvae found are given in Table 2.

A third method was searching for ovipositing females at night when they are easily found on tree trunks. Initial attempts at this method in 1979 were somewhat haphazard, but systematic searches were implemented that year and in 1980 with exact numbers of trees searched being recorded (Table 3).

Tree trunks were searched after dark with lights, and when possible, moths were captured. Only females seen probing bark crevices with the tips of their abdomens were recorded as ovipositing. Interestingly, startled females sometimes returned to such activity almost immediately. Very few females were encountered that were not clearly ovipositing. The most effective procedure was to have one person, armed with a net and cyanide jar, search using a headlamp, while a second person would operate a more powerful hand-held lantern and record data.

Some trees were checked more than once as indicated in Table 3. Such checks were always more than forty-five minutes apart, and moths were removed each time; therefore, I treat these as independent observations. All Juglandaceae over about 5 cm in diameter that were encountered were checked.

Localities

All localities at which searches for ovipositing females were conducted are in New Haven County, Connecticut. The majority of observations were on Nelson Rd., Southbury, or on West Rock Ridge, New Haven. Other observations were from Brooksvale Park, Hamden and various areas in Cheshire and Wallingford. Except on West Rock, all trees were mature, almost always with trunk diameters of 25 cm or more. Some were greater than 70 cm in diameter. Most of the trees were at the edges of extensive mixed mesic forests.

West Rock Ridge is a hotter and drier habitat than the others with thin acid soils overlying trap rock. The hickories there are stunted, though numerous. Very few have diameters of 20 cm or greater. The canopy is more open than at the other forested sites. This is the only one of the localities where *C. ovata* accounted for less than half of all Juglandaceae searched, and the only one where *Carya ovalis* was seen.

At Brooksvale Park, Hamden the area checked contained 13 *C. ovata*, 1 *C. glabra*, 2 *C. tomentosa* and 1 *J. cinerea*. The Southbury area contained 36 *C. ovata*, 9 *C. glabra*, 6 *C. cordiformis* and 3 *J. cinerea*. At West Rock 22 *C. ovata*, 16 *C. glabra*, 5 *C. ovalis*, 6 *C. tomentosa* and 1 *J. cinerea* were checked. The Wallingford area contained 10 *C. ovata*, 1 *C. glabra*, 1 *C. tomentosa*, 4 *J. cinerea*, and the Cheshire locality had 8 *C. ovata* and 1 *J. cinerea*. Most of these areas were checked on more than one occasion, and some trees were sometimes overlooked.

The few larval data from New Jersey are from the vicinity of villages in the Pine Barrens region, ca. 200 kilometers southwest of the Connecticut sample areas.

RESULTS

Egg and larval samples. These data (Tables 1 and 2) permit several conclusions: 1) at least *Catocala epione*, *habilis*, *obscura*, *residua*, *resecta* and *palaeogama* utilize *Carya ovata* as an important foodplant in Connecticut; 2) *C. neogama* is restricted, or nearly so, to *Juglans* in this region; 3) those species regularly utilizing *Carya* were not encountered on *Juglans*; 4) little can be deduced regarding utilization of other *Carya* spp., but *C. palaeogama* at least uses species other than *C. ovata* in Connecticut and *C. epione* does so in New Jersey.

It was not uncommon for several species to occur together on individual trees. *C. epione* seems to utilize primarily small plants (based on observations herein, and those of H. D. Baggett, L. F. Gall, T. D. Sargent, all pers. comm.), but the other *Carya* feeders must often all occur together.

One unsolved enigma is the absence of *C. habilis*, a common species, from oviposition observations (below) and bark samples. L. F. Gall (pers. comm.) has also failed to record it. Perhaps it oviposits very late at night or high in the trees. Larvae are common on *Carya ovata* (Table 2; L. F. Gall, pers. comm.).

Analysis of oviposition data. The data in Tables 2 and 3 convincingly demonstrate that *C. palaeogama*, *C. residua*, *C. obscura* and *C. resecta* regularly utilize *Carya ovata* for oviposition. *C. judith* is also added to the list of *C. ovata* feeders.

Chi-square goodness of fit tests were performed with oviposition data for those *Catocala* species for which ten or more observations are available. These analyses show that oviposition is non-random among all Juglandaceae for *C. palaeogama* ($P < .001$), *residua* ($P < .01$), and *C. obscura* ($P < .001$). *C. palaeogama* apparently oviposits randomly on any Eucarya ($P > .20$), while *C. obscura* prefers *C. ovata* over the other (pooled) Eucarya ($P < .05$). I suspect that *C. residua* also prefers *C. ovata* over other Eucarya in this region, but current data do not demonstrate such a preference ($P > .10$), probably due to the small sample size. The preferences of *C. palaeogama* ($P < .001$) and *C. obscura* ($P < .05$) for Eucarya over Apocarya and *Juglans* combined are significant.

Data for *C. subnata* are not adequate for analysis, but it is presumably limited to Apocarya and possibly *Juglans*. *Juglans cinerea* is the only previously reported host (Sargent, 1976). In 1981 L. F. Gall and I attempted to rear the progeny of three different female *C. subnata*. Hatchlings accepted *Carya* (Apocarya) *cordiformis*, and adults were obtained using this plant. *C. (A.) illinoiensis* was also readily accepted, but the plants available were too small to allow for an attempt at rearing larvae on this species. In no-choice situations, some larvae would accept both species of *Juglans*, but no larvae matured in sleeves on these. When cuttings were used, no larvae completed the first instar. My larvae would not accept any species of Eucarya. In 1981 I observed two more *C. subnata* ovipositing on *C. cordiformis* and L. F. Gall also observed several. Aside from *C. subnata*, no species of Connecticut *Catocala* seems to prefer a species of *Carya* other than *C. ovata*.

DISCUSSION

The above observations document that not less than seven species of *Catocala* utilize *Carya ovata* in Connecticut. These are *C. epione*, *C. habilis*, *C. judith*, *C. obscura*, *C. residua*, *C. resecta* and *C. palaeogama*. I have also reared adults of all of these *ex ovis* on *C. ovata*. *Catocala serena* Edwards adults rest on this tree in Connecticut and

have been observed ovipositing on it in Michigan (Nielsen, 1978). Sargent (1976) and myself have reared *C. dejecta* Strecker on *Carya ovata*, and in some of the moth's localities other hickories are nearly absent. *Juglans cinerea* is also an acceptable foodplant for at least the first three instars (pers. obs.). *C. dejecta* is very rare in New Haven County where oviposition observations were made. Two other *Carya* feeders, *C. vidua* (J. E. Smith) and *C. flebilis* Grote, occur in Connecticut at present. Their local foodplants are unknown. Thus, it is quite possible that 11 species of *Catocala* use *Carya ovata* in Connecticut and, as discussed previously, some of these species prefer this plant. However, even random oviposition on any *Eucarya* individual would result in *C. ovata* being *de facto* the principal foodplant in most of the state (see localities above). Thus, the hypothesis that these *Catocala* extensively partition the *Eucarya* by species is untenable.

There is at present no evidence that they are extensively partitioning *C. ovata* by individual trees, except for *C. epione*, although more data are desirable. The four trees on which multiple (>2) ovipositions were observed always had more than one species present. At Southbury on 2 September 1980 one tree had three *C. palaeogama*, one *C. judith* and one *C. obscura* ovipositing on it, while an adjacent tree had two *C. palaeogama*, two *C. obscura* and one *C. resecta*. Observations of *C. residua* and *C. palaeogama* ovipositing together have been frequent, and at least three species have been obtained from some larval collections and bark samples (Tables 1, 2). Doubtless, had observations of individual trees been carried out over the entire *Catocala* season at Southbury (the early *C. judith* was largely missed), many trees would have had recorded ovipositions by five or more species.

Although the observations reported here show that several species of *Catocala* larvae frequently occur together on *Carya ovata*, there are insufficient data to determine whether other forms of niche splitting are used. With seven or more species potentially occurring on the same tree and with all of these feeding exclusively on foliage and most having similar egg hatching dates (manuscript in prep.), such niche splitting would have to be rather fine. Sargent (1976) has pointed out that some similar species grow at different rates as larvae, and I have similar data (unpublished). *Eucarya* foliage appears rather synchronously in early spring, and additional foliation after early May is rare. Therefore, late maturing species (e.g. *C. habilis*, *obscura*) might compete with the early species if food became limiting. Effective avoidance of competition for food, if such occurs, would probably have to involve utilization of different portions of the tree. As I note

elsewhere (Schweitzer, 1982) there is some evidence for differences in resting behaviors (see also Sargent, 1976).

Casual observation suggests that *Catocala* larvae are held at relatively low numbers (relative to leaf availability) by some as yet unknown factor, probably predators and/or parasitoids. One can consult most ecology texts (e.g. Ricklefs, 1973, pp. 510, 522–523) and find that the “principle of competitive exclusion” applies only with regard to limiting resources. Sargent (1976, 1977) suggests foodplant availability may not be an important factor in *Catocala* evolution. The data in this paper support that contention at least to the extent that competition has not forced the Eucarya feeders to specialize on different species or to avoid frequent co-occurrence on individual trees.

Nevertheless, I am not aware of any well documented comparable sympatric assemblages of congeneric (or even of closely allied genera), largely synchronic, monophagous or oligophagous macro-Lepidoptera on a single foodplant species in the North Temperate Zone. However, at least eight species of *Zale* (Noctuidae: Catocalinae) are sharing two species of pines in much of southern New Jersey. There may well be a comparable assemblage of *Catocala* on Apocarya in the southeastern United States. Comparable assemblages of polyphagous congeners may well occur on some trees. *Lithophane* would be a likely candidate genus, with *Quercus* spp. and *Betula* spp. being likely hosts.

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THE BUTTERFLIES OF KENT ISLAND, GRAND MANAN, NEW BRUNSWICK

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ABSTRACT. A list of 23 species of butterflies found to be on Kent Island, New Brunswick has been compiled.

Kent Island, New Brunswick (44°35'N, 66°45'W) is the southernmost island in the Grand Manan archipelago in the Bay of Fundy. Kent Island is approximately 7.2 kilometers from Grand Manan and 9.3 kilometers from Maine, which is the nearest point of mainland (Fig. 1).

Thirty-four of Kent Island's 75.15 hectares are characteristically Canadian Zone forest, dominated by white spruce (*Picea glauca*) and balsam fir (*Abies balsamea*). The rest of the island is open grassy fields. McCain et al. (1973) and McCain (1975) have described the vegetation in some detail. Kent Island's weather is dominated by cool wet maritime air with frequent and dense summer fog. The Bowdoin College Scientific Station maintains a weather recording station on the island and data from this station for several meteorological variables are presented in Table 1.

Twenty-three species of butterflies have been found on Kent Island. Over 95 species have been recorded in nearby Maine (Brower & Payne, 1956) and, though it has not been systematically studied, Grand Manan hosts many lepidopteran species not found on Kent Island (Cannell & Maddox, personal observations). The number of species occurring on Kent Island is probably limited by its remote location, small size, and climatic conditions. Gobiell's (1965) preliminary study of Kent Island butterflies included one species, *Limenitis archippus* Cramer, not found during our study, but each of the twenty-three species listed here is also found in Maine (Brower & Payne, 1956) and Nova Scotia (Ferguson, 1954).

Many of the species in the following list are known migrants (*P. interrogationis*, *V. atalanta*, *V. virginiensis*, *N. antiopa*, *N. j-album*,

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and *D. plexippus*) and would be expected to reach such an island even if they could not breed there. Since there is no *Salix* or *Populus* on Kent Island *L. archippus* must be a non-breeding migrant. This is surprising since it is usually considered a fairly sedentary species.

The following list is based on observations conducted between June and early September 1979 and between June and mid-October 1980. Daily abundances for 1980 were derived from daily estimates of population sizes (counts of flying adults) and are presented in Fig. 2. Larvae were not systematically hunted; so, for most species, definite statements about breeding status cannot be made. Nomenclature follows Howe (1975). Voucher specimens are held at the Bowdoin College Scientific Station, Kent Island.

SYSTEMATIC LIST

Danaus plexippus L. Seen regularly in summer and abundant in fall.

No *Asclepias* species are found.

Cercyonis pegala Fabricius. Infrequent and uncommon in both years.

Limenitis arthemis Drury. One seen in each year. The principal larval food plants (Howe, 1975) are not found. However, *Alnus* and *Sorbus*, secondary hosts, are common.

Limenitis archippus Cramer. Seen rarely in 1960 (Thomas Skaling, communication to C. Huntington) and once in 1964 (Gobiel, 1965).

There is no *Salix* on Kent Island and therefore *L. archippus* must be a migrant.

Chlosyne harrisii Scudder. Seen only once, on 8 July 1980. The larval food plant, *Aster unbellatus*, is uncommon.

Polygonia interrogationis Fabricius. Common for a brief period in July of both years. Adults were always seen near an *Alnus* bog but never near the reported larval food plant, *Urtica dioica*, which is common.

Vanessa atalanta L. Very common in both years. Adults often seen visiting flowers. The larval food plant, *Urtica dioica*, is common.

Vanessa virginiensis Drury. Frequently seen in 1979, but less common in 1980. Usually found in open field of *Achillea millefolium*. Potential larval food plants are abundant, especially *Artemisia*, *Gnaphalium*, and *Anaphalis*.

Nymphalis antiopa L. Frequently seen in August of both years. Larval food plants are not present.

Nymphalis j-album Boisduval. Seen only once, in late August 1980. Larval food plants are not present.

Nymphalis milberti Godart. Uncommon during July of both years. *U. dioica*, the larval food plant, is common.

- Speyeria cybele* Fabricius. Very common from early July until mid-August. Larval food plants, *Viola cucullata* and *V. pallens*, are common.
- Speyeria aphrodite* Fabricius. Seen once but not collected on 28 June 1980.
- Speyeria atlantis* Edwards. Rare in both years.
- Lycaena phleaus americana* Harris. The first butterfly seen each summer. This species was common in June and July of both years. A second brood seemed to appear in late August (Fig. 2). The principal larval food plant, *Rumex*, is abundant.
- Lycaena epixanthe* Boisduval & Le Conte. In each year ten to twenty individuals appeared over a two day period in July. These were restricted to a small acid bog. The only reported larval food plant, *Vaccinium macrocarpum*, is not found, but *V. oxycoccus* is locally abundant.
- Glaucopsyche lygdamus* Doubleday. This species was seen only once, in mid-July 1980. Some of the food plants, *Lathyrus* and *Vicia*, are found.
- Pieris rapae* L. Very common in late summer of both years. Crucifers are not numerous, but *Cakile edentula* and *Capsella bursa-pastoris* are present. August females were seen ovipositing on the latter species.
- Colias eurytheme* Boisduval. Not seen in 1979 and uncommon in 1980. Several *Trifolium* species are common. *C. eurytheme* is an annual immigrant to this region but is probably unable to overwinter. It is surprising that *C. philodice*, a much commoner insect in New Brunswick and Nova Scotia, did not occur on Kent Island.
- Colias interior* Scudder. Fairly common in August 1980. Several *Vaccinium* species are uncommon.
- Papilio glaucus* L. Seen once in 1979 and once in 1980. One of the larval food plants, *Sorbus*, is common.
- Papilio polyxenes* Fabricius. Seen twice in late August 1980.
- Polites coras* Cramer. The only skipper seen in the two years, on 21 July 1980. The food plant in nature is unknown.

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TABLE 1. Meteorological variables for Kent Island in 1979 and 1980.

	1979			1980		
	June	July	Aug	June	July	Aug
Mean daily maximum (°C)	—	16.9	17.3	14.3	17.4	18.2
Mean daily minimum (°C)	—	10.2	10.8	7.3	9.9	11.4
Mean daytime (°C)	—	14.6	14.7	12.4	14.5	16.6
Precipitation (cm)	—	12.0	12.9	9.7	18.9	7.3
Days with dense fog	—	17	7	5	11	7
Maximum temperature (°C)	—	23	22	20	22	24
Minimum temperature (°C)	—	8	10	3	8	10

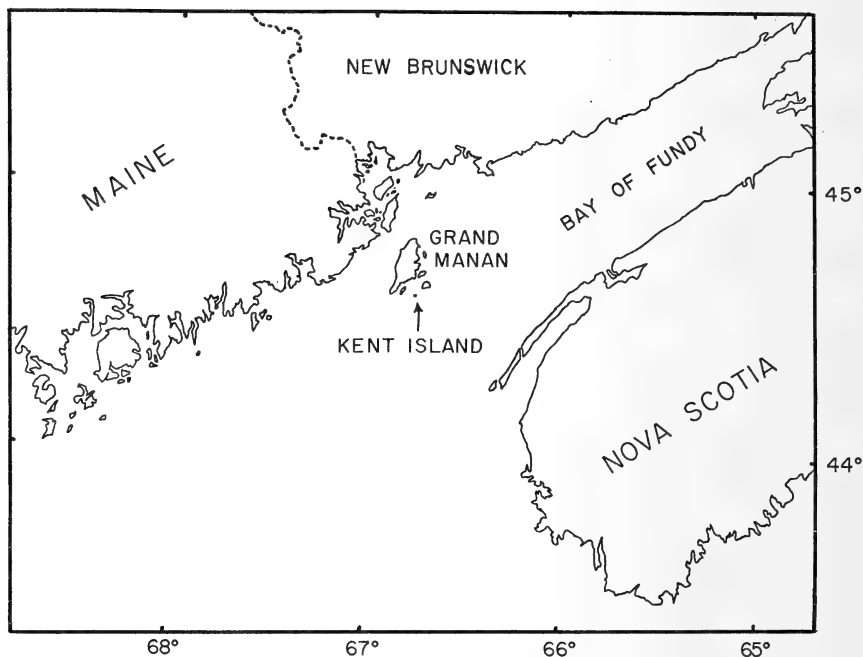


FIG. 1. Map of the Bay of Fundy indicating the position of Grand Manan and Kent Island.

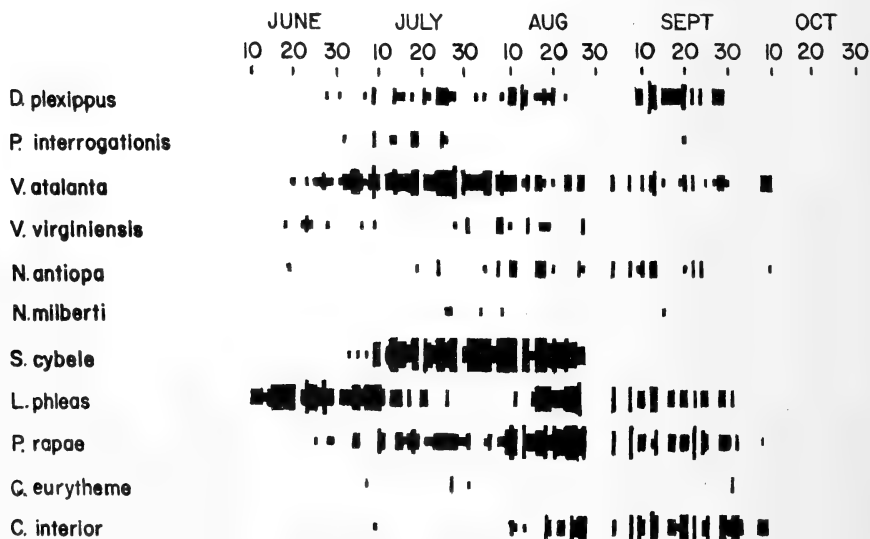


FIG. 2. Abundance and phenology for 1980 of the eleven species seen at least four times in 1980.

FLIGHT PATTERNS AND FEEDING BEHAVIOR OF ADULT *MILIONIA ISODOXA* PROUT AT BULOLO, PAPUA NEW GUINEA (GEOMETRIDAE)

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ABSTRACT. At Bulolo, daily flight activity of adult *Milionia isodoxa* commenced between 0600-0630 h when the moths began moving from hoop pine (*Araucaria cunninghamii* Ait. ex D. Don) plantations to adjacent feeding areas (the females to blossoms and the males usually to sites along streams and roads). The numbers of males at the feeding sites reached a peak between 0800-0915 h and by 1030 h most had returned to the plantations; females usually returned towards 1200 h. Field observations suggested that atmospheric conditions influenced flight behavior of the moths but no direct relationship was found.

Adults feed on floral nectar and the males presumably supplement their diet with solutes contained in wet sand, mud, animal dung and carrion. Males preferred to feed at the decomposing bodies of the toad, *Bufo marinus* Linnaeus, and at fresh cattle dung. A few males fed at dried toad bodies and at dry dung by moistening the surface with a droplet of anal liquid which they then imbibed. Observations suggested that odor was important in aggregating males at feeding sites, although some visual stimuli may be involved.

Studies in Papua New Guinea on the taxonomy, distribution and biology of *Milionia isodoxa* Prout, an endemic defoliator of hoop pine (*Araucaria cunninghamii*), were reported by Wylie (1974a, b, 1982). Only brief references were made there to studies of adult populations of this insect. The majority of adult Geometridae are nocturnal, but the adults of *M. isodoxa* are day flying (Wylie, 1974b) and are rarely attracted to light at night. They are seldom found far from where their larval host plant, *A. cunninghamii*, occurs and no long distance migratory patterns have been observed. Females feed almost exclusively on floral nectar, a habit common in Lepidoptera (Norris, 1936). The males, on the other hand, appear to feed primarily on solutes contained in wet sand, mud, animal dung and carrion, and are frequently seen in large groups at such sites. At Bulolo, the feeding sites for each sex were usually widely separated (several hundred meters or more) and the normal sex ratio of 1:1 was approached only in collections made within the plantation canopy (Wylie, 1974b). Studies of the daily movement of adults to and from their feeding areas and the feeding behavior of the males, carried out at Bulolo during the period April 1968 to April 1970, are reported below.

MATERIALS AND METHODS

Five sites regularly frequented by adult *M. isodoxa* within and adjacent to hoop pine plantations were chosen as observation stations.



FIG. 1. Feeding site (station 2) at Bulolo. Plates of "attractants" used in the food preference study are shown. Margin of hoop pine plantation is visible on the left and natural forest on the right.

Stations 1, 2 and 4, each approximately 50 m² in area, were situated at nearly 1 km intervals along an unsealed road, 1 and 2 being at shallow creek crossings (Fig. 1) and 4 at a cattle grid. These three stations were in the open and received direct sunlight during most of the day. Station 3 (area 300 m²) extended nearly 50 m along both banks of a shallow stream, the margins of which were, in parts, closely bounded by secondary vegetation and received patchy sunlight. Station 5 (area 50 m²) was located beneath the plantation canopy (tree age eight years at commencement of study) almost equidistant (50 m) from stations 2 and 3 and received only diffuse sunlight. Adults gathered on mud, decaying organic matter, wet sand and rocks at stations 1, 2 and 3, on cattle dung and mud at station 4 and on hoop pine foliage at station 5.

In April 1968, the number of adults found at stations 1-4 were counted at 15 minute intervals during daylight hours (0530-1800 h approximately) for seven consecutive days. Similar seven-day counts, conducted at three monthly intervals from July 1968 to April 1970,

were restricted to the period 0700–1100 h, when nearly all adult activity at the stations occurred. Additional counts were made simultaneously at stations 3 and 5 for three days in March 1969 to determine flight patterns between the open areas and the adjacent forest.

In March 1970, a simple experiment was conducted at stations 1, 2 and 4 to determine the relative attractiveness to *M. isodoxa* adults of five substances: fresh cattle dung, decomposing toad carrion, urine, honey-water (1:2 mixture) and water. Five white porcelain dining plates (19 cm diameter), each containing one of these substances, and two empty plates as controls were positioned at each station with a distance of 2 m or more between adjoining plates. The surface area of "attractant" on each plate was approximately 200 cm²; the urine, honey-water and water were soaked onto pieces of cotton wool to provide a footing for the adults. These "attractants" were replenished daily and their relative positions at the stations rotated to ensure uniformity. Where possible, extraneous attractive material such as carrion and dung was removed from the vicinity of the stations at this time. Counts were made of the numbers of adults present at each plate at 15 minute intervals from 0700 h to 1100 h daily for seven consecutive days.

During the studies, bulb thermometers (0–100°C), Lambrect thermohygrographs® type 252 and solar radiation recorders® model R401 were used to measure temperature, relative humidity and solar radiation at the stations. Records of the number of sunshine hours each day were obtained from the meteorological station at the Bulolo Forestry College, approximately 3 km from the study area. Other details recorded included subjective assessments of cloud cover and rainfall intensity and observations on the feeding behavior of the males.

RESULTS

Flight Patterns

At the open sites (stations 1–4) the adults were predominantly males, and they displayed a similar daily flight behavior with little variation. They first appeared at the stations at approximately 0700 h, numbers reaching a peak between 0800–0915 h and declining rapidly thereafter so that by 1030 h few remained at the stations (Fig. 2). Within the plantations, adults resting overnight on hoop pine foliage became active between 0600–0630 h and began moving to the feeding areas. Few adults were seen within the plantations between 0800–0900 h each day. Counts at stations 3 and 5 showed that, as the number of adults along the stream decreased after 0900 h, numbers within the plantations increased, reaching a peak at approximately the same time

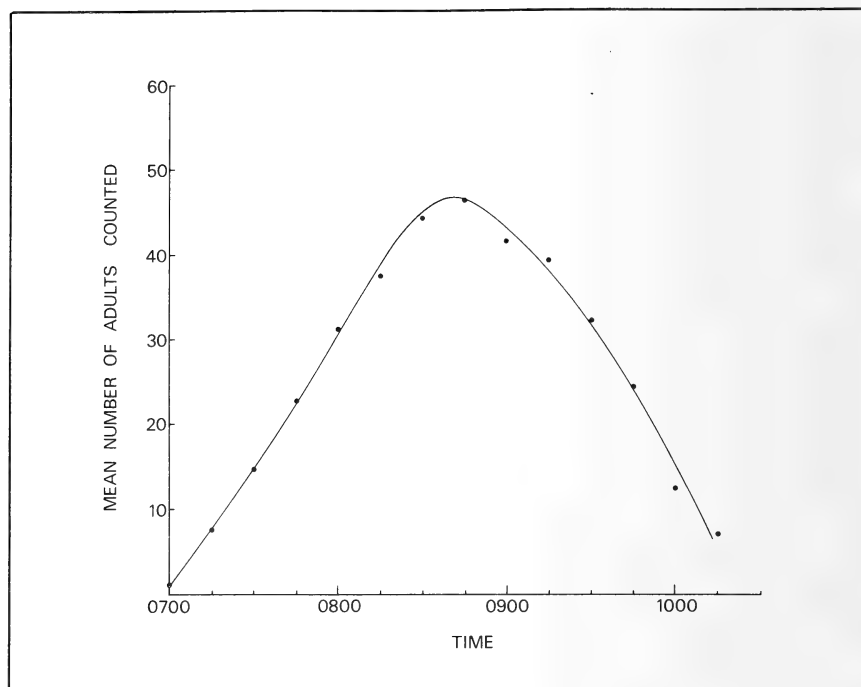


FIG. 2. Typical daily flight pattern of male *M. isodoxa* at feeding sites in the open at Bulolo. Means for station 1 are shown for 58 days of observation.

that the last adults left the stream (Fig. 3). Females observed at blossoms adjacent to the study area continued to feed for some time after the last males had been recorded at the stations and returned to the plantations towards 1200 h. Both sexes tended to congregate for a time on foliage of hoop pine trees along the margins before dispersing deeper into the plantation.

Field observations suggested that adult activity at the stations was greater on warm, sunny days, and population peaks occurred earlier in the morning than on cool, overcast days. For example, during counts at station 2 on 29 March 1969 in cool, overcast conditions (22.2–24.8°C), numbers of moths reached a peak of 66 at 0915 h. During counts at the same station four days later in warmer, sunny weather (22.7–27.8°C), numbers reached a peak of 160 at 0745 h. However, there were some cool, overcast days when large numbers of moths and early population peaks were recorded and some hot, sunny days when low numbers and late peaks occurred.

At all stations most population peaks (163 or 72% of a total of 225

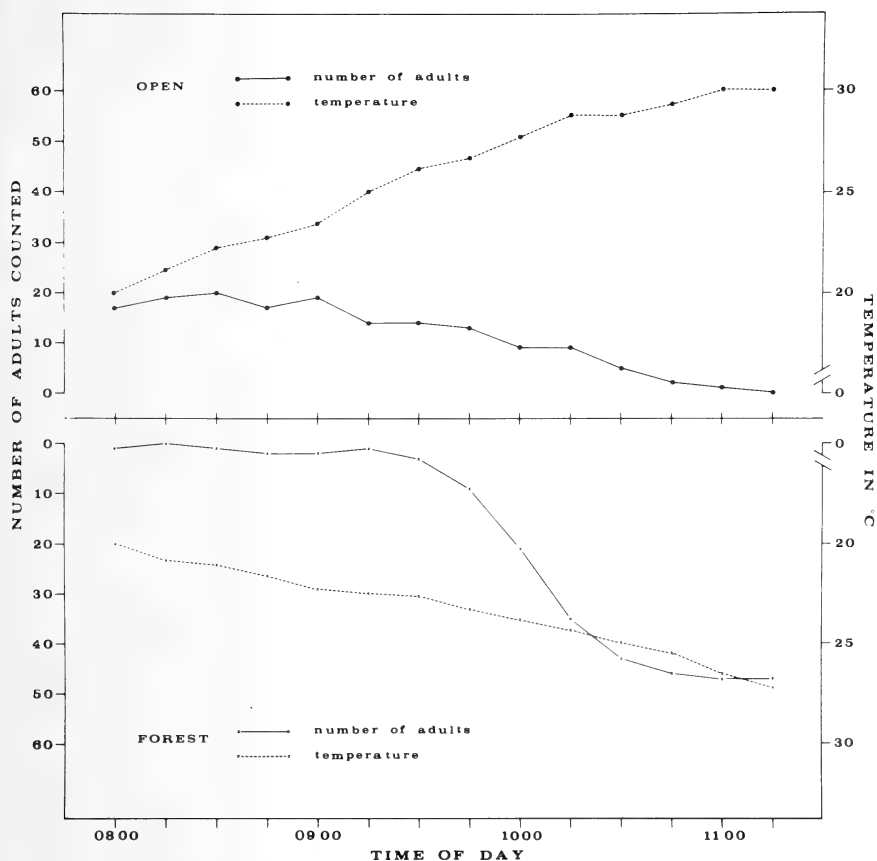


FIG. 3. Number of adults counted at station 3 (*open*) and station 5 (*forest*) between 0800–1115 h on 5 March 1969.

observations of peak time) occurred between 0800 and 0915 h each day. The earliest peak time recorded was 0730 h and the latest 1015 h. Of a total of 41 peaks recorded after 0915 h, 21 occurred at station 3 while, of the remainder, the numbers recorded at stations 1, 2 and 4 were six, five, and nine respectively. This again suggested that atmospheric conditions influenced flight activity of the moths, since station 3 received more shade during the morning than did the other three stations. However, peak time of activity at station 3 was not consistently later than, and in a few instances preceded peak times at the other stations.

When the data was subjected to stepwise multiple regression analysis, no direct relationship was found between adult flight behavior

and climatic conditions. The total number of adults (for any particular day) and peak time of activity (time during any particular day at which numbers reached their peak) varied at random. No definite seasonal effect was observed in the numbers of adults counted during the seven-day study periods in January, April, July and October each year.

Food Preferences

The total numbers of adults counted at all stations during the study period on dead toad, dung, urine, honey-water, water and controls were 1237, 633, 203, 52, 37 and 14 respectively. Analysis of variance showed a significant difference at the 1% level between the numbers of adults counted at the different "attractants." There was no significant difference at the 5% level between station replications. Numbers counted on toad and dung differed significantly from each other and from the remaining "attractants" (LSD = 135.7). Although some adults fed on wet sand and mud away from the plates, their numbers were much fewer than those recorded at toad and dung.

Feeding Behavior of Males

Males greatly outnumbered females in collections made on wet sand, mud, animal dung and carrion at Bulolo (Wylie, 1974b). Many of these moths appeared to be recently emerged; their wing and body scales were intact and there was no sign of the wear usually apparent on older insects. They probed and fed (with the proboscis extended) at moist sand and mud along stream and puddle margins, and occasionally at moss on rocks and at stream debris, not at the free water itself. On very wet ground the moths perched on the edge of dry pebbles and probed at the mud below. Several fed at patches of ground moistened by human urine and some were attracted to human sweat on both clothes and body. Males also fed on floral nectar and, in the laboratory, on a honey-water solution. When feeding, the males were remarkably docile and were easily captured by hand.

Large numbers of males fed commonly at cattle dung and toad (*Bufo marinus*) carrion. Fresh dung was preferred to dry, but toads dead for at least a day and beginning to decompose appeared more attractive than recently killed or dry material. A number of moths observed at dry dung and dry toad carcasses exuded a drop of liquid from the anus and imbibed from the moistened surface. This behavior among Lepidoptera has previously been regarded as a habit confined to the Hesperiiidae (Norris, 1936).

It is interesting to note that while male *M. isodoxa* feed at the dead bodies of *B. marinus*, they are themselves prey to the toad, as evidenced in the laboratory when a supposedly dead toad revived among

captive moths, and in the field, when males attracted to a dead toad in a culvert were eaten by other toads sheltering in the culvert.

DISCUSSION

There are few references in the literature to adult behavior of *Milionia* species. De Mesa (1934, 1938) records daily flight patterns similar to those of *M. isodoxa* for adults of the pine-needle measuring worm *Milionia coronifera* Swinhoe at Baguio in the Philippines. He notes that adult *M. coronifera* migrate to the flowering plants between 0600–0900 h, returning to the pine forests (*Pinus kesiya*) between 0900–1000 h each day. A second migration to blossoms occurs at 1700 h, and the moths rest at night in the crowns of the pine trees. At Bulolo there was no conspicuous late afternoon migration of *M. isodoxa*, although occasional moths were seen in flight along the roads at this time. In Sumatra, Mangundikoro and Depari (1958) mention only that moths of *Milionia basalis* Walker, a defoliator of *Pinus merkusii*, were frequently observed in flight during the day along the fringes of the plantations.

Eight species of *Milionia*, in addition to *M. isodoxa*, have been recorded from the Bulolo/Wau area. Two of these species, *M. dohertyi* Rothschild and *M. mediofasciata* Rothschild, are predominantly night-flying and regularly appear in collections at light. No daylight flight has been observed for moths of *M. dohertyi* (J. J. H. Szent-Ivany, pers. comm.) but a single *M. mediofasciata* male was recorded at station 1 at 0745 h during counts in January 1970. Both *M. callima* Rothschild & Jordan and *M. grandis* adults were observed in morning flight near the plantations, and *M. grandis* was also collected at light. The remaining four species, *M. ? aglaia* Rothschild & Jordan, *M. aroensis* Rothschild, *M. diva* Rothschild & Jordan and *M. paradesia* Jordan, were captured in flight during the day along mountain streams (1700 m) near Wau (P. Shanahan, pers. comm.).

Although the daily flight patterns of adult *M. isodoxa* at Bulolo, involving a movement from the plantations to obtain food and a subsequent return to mate and egg-lay, are established, the factors influencing the timing of these flights to and from the feeding areas remain unknown. Initial observations suggested that either temperature or solar radiation may be important in determining when numbers peak and when the moths begin to leave the stations. These factors could act directly by heating the body of the insect, or indirectly by drying out the food and rendering it less attractive. However, this does not explain the sometimes early disappearance of moths from shaded areas along creeks or roads or the rapid decline in numbers at the stations on some cool, overcast days. Similarly, relative humidity or saturation

deficiency must be of minor importance when considering a stream environment even on the hottest days.

Rainfall may deter or delay the flight of moths to the stations on certain days. It may also affect the numbers of moths recorded at the stations on subsequent fine days by (i) increasing the number of alternative feeding sites and thus decreasing totals at the stations or (ii) increasing the attractiveness of the stations as feeding sites and thus increasing total numbers recorded. However, it would be unlikely to affect flight times on these fine days.

Many records in the literature indicate that atmospheric conditions are important in influencing flight patterns of puddle-frequenting species (see Norris, 1936). However, because of anomalies such as those described above for *M. isodoxa*, a simple relationship appears unlikely.

Norris (1936), in an extensive review of the feeding habits of Lepidoptera, lists many species which feed at puddle margins, dung and carrion, including some Geometridae. Nearly all records show a great preponderance of males at sites similar to that found for *M. isodoxa* at Bulolo. She notes that, as with *M. isodoxa*, many species drank at puddle and riverside sites contaminated by animal excreta even when cleaner water was abundantly available and observes that practically all water-drinking may be primarily due to the attraction of such contaminants. Downes (1973) concurs, regarding puddles as areas of concentration of organic debris and solutes and further suggests that puddles, dung and carrion represent successively higher levels of the same stimuli. Observations of *M. isodoxa* at Bulolo support this view, toad carrion and dung in that order being preferred to wet sand and mud.

With respect to carrion and dung and perhaps other foods, there appear to be different degrees or stages of attractiveness. For example, Payne and King (1969) list 21 species of Lepidoptera attracted to pig carrion at Clemson, South Carolina, 17 of which (including three geometrids) preferred the carrion in a state of advanced decay. At Bulolo, *M. isodoxa* preferred toads which were actively decomposing to freshly killed or dried material, and more were attracted to fresh dung than to dry.

The nutritional requirement for insects that is satisfied by probing at puddles, dung and carrion is little known (Downes, 1973; Norris, 1936). In Diptera, protein is required by some species for reproductive development in females. For example, the females of the sheep blowfly, *Lucilia cuprina* (Wiedemann), require protein to mature each cycle of oocytes (Williams et al., 1977), and in many species of mosquitoes the number of oocytes that reach maturity is related to the

amount and type of blood that the females ingest (Shelton, 1972). In Lepidoptera, males of most species are seen puddling much more often than females. Puddling behavior probably permits them to take in nutrients above those provided by larval nutrition or available from nectar, and both organic and inorganic solutes may be sought (Downes, 1973; Arms et al., 1974).

The tendency for many puddle-frequenting Lepidoptera to gather in closely packed groups at the feeding sites is often mentioned in the literature (Norris, 1936). Collenette and Talbot (1928) show how feeding aggregations of *Catopsilia* (Pieridae) are built up by visual recognition of the already established individuals. Downes (1973) however, suggests that odor may be more important than visual stimuli for some species, although visual responses may also occur. In the case of *M. isodoxa* at Bulolo, odor seems to be of major importance in the formation of feeding groups. The most striking aggregations of moths are seen on carrion and dung, while they tend to feed more individually at lightly contaminated and less odorous areas such as stream margins. However, several males, on arriving at the stations, flew directly to join groups feeding on toad and dung, a behavior which suggests some visual response.

The described flight behavior of *M. isodoxa* adults may influence the distribution of larval populations of the insect in hoop pine areas. At Bulolo, Wylie (1982) showed that *M. isodoxa* larvae were more abundant on host trees in areas adjacent to a stream or soak than on trees in drier areas of the plantations. This was attributed, in part, to a presumed higher frequency of egg-laying where adults congregate on trees close to the feeding sites.

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REDISCOVERY OF THE TYPE OF *PAPILIO PHINEUS*
CRAMER AND ITS BEARING ON THE GENERA
PHEMIADES HÜBNER AND *PROPERTIUS*
EVANS (HESPERIIDAE)

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ABSTRACT. The type of *Papilio phineus* Cramer has been rediscovered. It is shown that Hübner's inclusion of the species in his genus *Phemiades* and Scudder's designation of it as type-species of *Phemiades* are based on misidentifications. Evans misidentified a yet undescribed species as *Papilio phineus* Cramer and erected the genus *Propertius* with type-species *Hesperia propertius* Fabricius, which is congeneric with the true *Papilio phineus* Cramer. The resulting nomenclatorial mess can be solved by designation of the yet undescribed *Phemiades* species as type-species of *Phemiades*. This species is named *Phemiades pseudophineus* here. The inclusion of *Papilio phineus* Cramer in *Propertius* results in the sinking of *Phemiades albistriga* Tessimann into synonymy with *Phemiades phineus* (Cramer) on subjective grounds.

In a recent paper in this journal, Clench and Miller (1980:107) expressed the hope that more of Cramer's species could be determined soon. At least for one species their hope seems to have become a reality. Previously, the uncertainty as to the identity of the species was due to Cramer's poor descriptions and the unreliability of his data and figures. The confusion around the species being dealt with here has been caused by mistakes of subsequent authors, to put it kindly. The name *Papilio phineus* seems to have cast a spell on people somehow, as almost every subsequent author added some new confusion. Now we face a number of nomenclatorial problems that would have been quite unnecessary if only these authors had better perused the literature and better corrected their proof prints. It may be pardonable to some extent if the mainly English speaking authors who dealt with the species had problems in understanding relevant Dutch, French and German texts, but it is inexcusable that they apparently never had them properly translated. In the following I will indicate the pertinent errors in the literature and suggest some corrections, hoping that the name *Papilio phineus* will not bewitch me as well.

I am grateful to Mr. R. I. Vane-Wright of the British Museum (Natural History), London, for the opportunity of studying and describing relevant material.

Original Description and Type of *Papilio phineus* Cramer

The original (Dutch) description of *Papilio phineus* by Cramer (1777: 123; in the index on page 150, spelled "*phyneus*") reads as follows:



1



2



3



4



5



6

FIGS. 1-6. 1, *Papilio phineus* Cramer, after the original figure; 2, *Papilio phineus* Cramer, type, upper surface; 3-4, *Propertius propertius* (Fabricius), upper (3) and under surface (4); 5-6, *Phemiades pseudophineus* sp. n., holotype, upper (5) and under surface (6).

“Fig. E. *Phineus*. De geele tekening op de onderzyde der vleugelen is niet zo schoon van kleur dan van boven, doch voor ’t overige niet onderscheiden. Zy word nevens de twee volgende in Surinamen gevonden.” **Translation:** Fig. E. *Phineus*. The yellow markings on the underside of the wings do not have the beautiful color of the upper-side, but for the rest are similar. It is found in Surinam, as are the next two species.

Together with the figure of the upperside (pl. 176, fig. E) (repro-

duced in Fig. 1), the description is clear enough. In the present context it is especially important to note the similarity of the markings on the upper and underside of the wings as stated by Cramer.

According to Cramer the specimen from which the illustration of *Papilio phineus* was made, was in the collection of E. F. Alberti, a Reverend of the Lutheran Community in Amsterdam. Reverend Alberti died in 1788, and his collection was apparently sold, possibly auctioned in parts as was usual in those days. One collector who was active in buying parts of other collections was J. Calkoen, who lived in Amsterdam and died in 1813 or 1814. His extensive collection of insects was in turn auctioned in parts in 1814. Most of it was bought by Reinwardt, Director of "'s Lands Kabinet van Natuurlijke Historie" in Amsterdam. At the founding of the Rijksmuseum van Natuurlijke Historie, Leiden, in 1820 by fusion of the "Kabinet" and the very large private collection of Temminck, the Calkoen collection constituted the basis for the insect collection. This is how some of Cramer's type material came to be housed in the Rijksmuseum.

A badly worn male from the Calkoen collection (Fig. 2) corresponds well with Cramer's figure of *Papilio phineus* except that the head is missing. I have little doubt as to its being the actual type. The yellow markings of the upper side are repeated on the underside, those of the forewings being a little more extensive and a little paler than on the upper side, while the yellow band of the upper side of the hindwing has a pale, almost white color on the underside. There is another whitish band on the underside of the hindwing from the base to the end of vein 8. The presence of this band, although not mentioned by Cramer who often omitted details of markings, does not contradict the original description of *Papilio phineus*.

It must be stressed here that the rediscovery of the supposed type of Cramer is not essential for the following lines. Cramer's description alone is sufficient to point out the incorrect statements prevalent in the literature.

Original Description of *Phemiades* Hübner, 1819, and Selection of a Type-Species

In his well-known "Verzeichnis" Hübner (1819:112) erected the genus *Phemiades*, which he characterized as having "*Alle Flügel oben bandartig angelegt, unten nur zerstreut schwarz bezeichnet*" (all wings marked with bands on the upperside, underside only sparsely marked with black). The following species were listed by Hübner (with the references given by him):

1208. *Phemiades Ephesus*.

1209. *P. Edippus* Cram. 366. E.

1210. *P. Epictetus* Fabr. Ent. Hesp. 252. Hüb. Urb. vigil. Mys.

1211. *P. Phineus* Cram. 63. G.

1212. *P. Augias* Linn. Syst. Pap. 257.

Although the description of the genus is short, its meaning is clear. I like to draw special attention to the underside of the hindwing described as sparsely marked with black. If one still doubts the meaning, a glance on the underside of the species listed¹ makes it clear that Hübner meant a plain yellow or tawny underside with some black shading on the fore- and hindwing or the latter with scattered black dots. The only species that does not at all comply with the description is "*P. Phineus* Cramer," because the underside of the hindwing is quite different. There is one more peculiar aspect to the listing of this species by Hübner: the reference to the figure by Cramer does not match up. On plate 63G, Cramer (1775) does not depict *Papilio phineus*, but shows another South American skipper, *Papilio midas* Cramer. This species, currently placed in the genus *Bungalotis* Watson, does not fit the description of the genus *Phemiades* either. In the male (figured by Cramer) the upper side of the wings does not have band-like markings (the underside comes closer to *Phemiades*).

Whatever Hübner had before him when placing *Papilio phineus* Cramer in *Phemiades*, it was certainly not Cramer's *Papilio phineus*. This would have been unimportant if Scudder (1875) had not selected this same species as the type-species of *Phemiades*, apparently without checking Hübner's reference and without understanding Cramer's description. As a consequence, the type designation is based on a misidentification, and in accordance with Article 70 of the International Code of Zoological Nomenclature, the case must be referred to the Commission. The Commission can make a choice from one of three possibilities: designate as the type-species the nominal species actually involved, which was wrongly named in the type-designation (does not apply here as the identity of that species is doubtful); designate as the type-species the species named by the designator, regardless of the misidentification (does not seem to be a good choice either because of the discrepancy between Hübner's description of *Phemiades* and the true *Papilio phineus* Cramer and this choice would necessitate more changes of names than the third pos-

¹ The species are currently known as follows: *P. Ephesus* (Hübner described this species only in 1823) = *Ampittia dioscorides* (Fabricius) (Oriental Region); *P. Edippus* Cramer = *Pardaleodes edipus* (Stoll) (Afrotropical Region), *P. Epictetus* Fabricius = *Anthophus epictetus* (Fabricius) (Neotropical Region), and *P. Augias* Linnaeus = *Telicota augias* (Linnaeus) (Oriental Region), see Evans (1937, 1949, 1955). For *P. Phineus* Cramer, see the main text.

sibility); or designate as the type-species a species chosen in conformity with the usage of the generic name prevailing at the moment.

The Genus *Phemiades* Hübner in the Literature

All authors who have mentioned a type-species uncritically accepted Scudder's designation (Watson, 1893; Godman & Salvin, 1900; Hayward, 1950; Evans, 1955; Hemming, 1967). The following is a sequential history of the genus *Phemiades*.

1. Plötz (1883:233) synonymized *Phemiades* Hübner and *Hesperia* Auct. (which he made a kind of collective genus).

2. Apart from *Papilio phineus* Cramer, Watson (1893:104) placed *Hesperia Utha* Hewitson, 1868, in the genus. The latter is currently considered a junior synonym of *Pyrrhocalles antiqua* Herrich-Schäffer. From Watson's description of the genus it appears that he had only *P. antiqua* at his disposal, as the description does not fit *P. phineus*.

3. Godman and Salvin (1900) placed *Hesperia propertius* Fabricius, 1793, with *P. phineus* in the same genus, *Phemiades*, and they even remarked that both may be the same species.

4. Schaus (1902) described *Phemiades jamaicensis*, without indication why he placed it in the genus *Phemiades*. Currently, this name is considered to belong to a subspecies of *Pyrrhocalles antiqua* (Evans, 1955) or to a closely related but separate species (Riley, 1975). Apparently, Schaus' allocation was based on Watson's concept of the genus (see above).

5. Mabille (1904:149) followed Watson (1893) in placing *Papilio phineus* Cramer and *Hesperia utha* Hewitson in this genus. He added *Hesperia propertius* Fabricius and listed *Hesperia memuca* Hewitson as a junior synonym of the latter (this will be dealt with later). Maybe, due to a practice of overlooking things, Mabille ignored the type-species designation by Scudder (again mentioned by Watson) and remarked in a footnote that *phineus* probably belonged to another genus.

6. Draudt (1923) did not mention the type-species. He listed the following species: *propertius* Fabricius (= *memuca* Hewitson), *jamaicensis* Schaus, *phineus* Cramer, *simulius* Druce, and *procax* sp. nov. The last two species were placed in a new genus, *Lindra*, by Evans (1955); for *jamaicensis*, see 4 above.

7. Tessimann (1928) described *Phemiades albistriga*, which he compared with *propertius* and considered closely related to this species and *phineus*.

8. Hayward (1950) mentioned *propertius* and *phineus* as belonging to *Phemiades*.

9. Evans (1955) listed in addition to *phineus* as type-species, *Augiades pohli* Bell, 1932, *Trioedusa milvius* Mabille, 1904, and *Phe-miades vergens* sp. nov. as the species of the genus *Phe-miades*. For *Hesperia propertius* Fabricius, mentioned repeatedly above, and *Phe-miades albistriga* Tessmann, Evans erected the genus *Propertius*.

Summarizing, it can be stated that, since Godman and Salvin (1900), there has been agreement that *Papilio phineus* Cramer and *Hesperia propertius* Fabricius are congeneric, except for Evans (1955). It is uncertain and seems unlikely that any of these authors ever checked and understood the original description by Cramer, but as will be shown in the next paragraph, the two species are really closely related.

Propertius Evans, 1955 Versus *Phe-miades* Hübner, 1819

The genus *Propertius* was erected by Evans (1955:303) for the species *Hesperia propertius* Fabricius, 1793 (type-species) and *Phe-miades albistriga* Tessmann, 1928. According to Evans' description the genera *Propertius* and *Phe-miades* differ in the following respects:

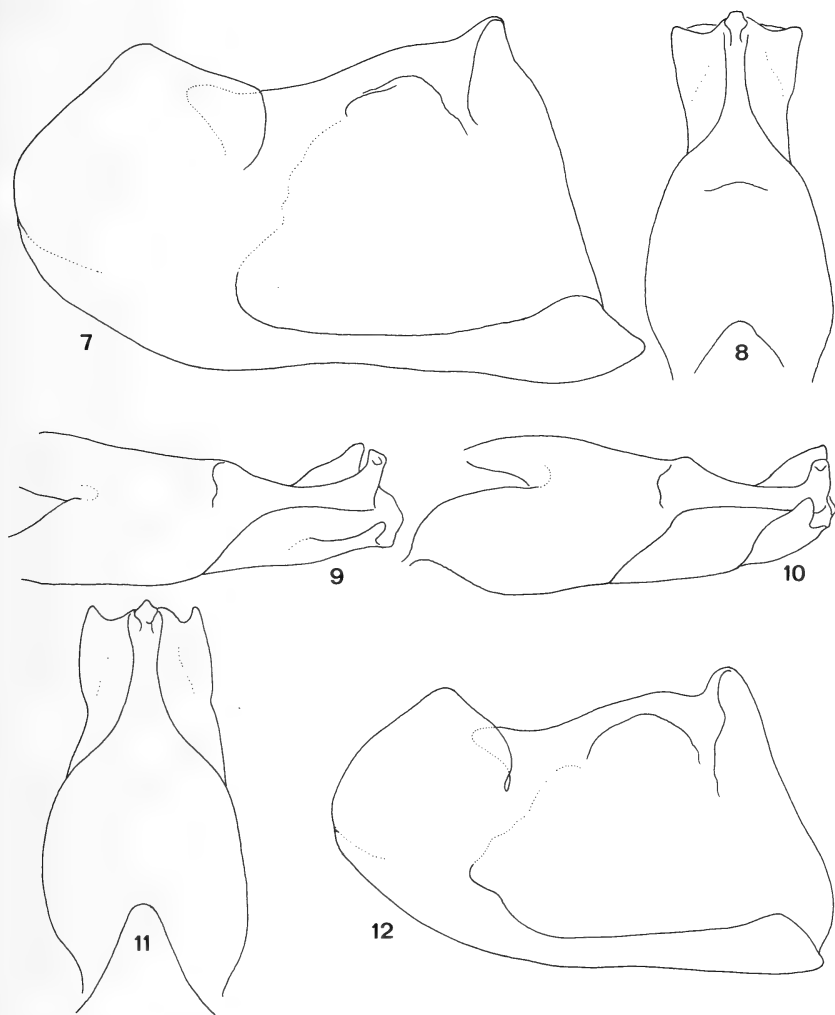
Propertius—"Antennal club long, slender = $\frac{1}{3}$ shaft. Unh with alternating dark red and pale yellow or white bands. Nudum $\frac{7}{8}$. F 17 mm."

Phe-miades—"Antennal club short, stout = $\frac{1}{4}$ shaft. Unh ochreous with faint yellow spots. Nudum $\frac{8}{9}$. F 17 mm."

In an additional description on p. 378, however, the antennal club of *Propertius* is said to be $\frac{1}{4}$ of the shaft (it is very difficult to tell where the shaft ends and the club begins). Further, in *Propertius* the male is stated to have an inconspicuous narrow, broken stigma, while in *Phe-miades* there are separated brands or a broad grey stigma flanked by a black patch on either side. I can add an obvious difference in the male genitalia: in *Propertius* the uncus (Figs. 8, 11) ends broadly with an upturned apex flanked by two similarly upturned, pointed, lateral processes (apparently a formation of the gnathos), while in *Phe-miades* (*sensu* Evans) the uncus tapers and ends simply with a small incision (Fig. 14). I entirely agree with Evans that the species placed by him in *Propertius* are generically distinct from those allocated by him to *Phe-miades*.

The true *Papilio phineus* Cramer agrees with the description of *Propertius*. It is not only very similar to the type-species, but it seems to be identical with the other species placed in the same genus by Evans, viz. *albistriga*. As I cannot find a difference between *albi-striga* and *phineus*, the former is sunk as a junior subjective synonym of the latter (syn. nov.).

Externally (Figs. 1-4), the difference between *propertius* and *phi-*



FIGS. 7-12. Male genitalia of *Propertius* species. 7-9, *P. phineus* (Cramer), type. 7, inside of left valve; 8, dorsal view of uncus and tegumen; 9, left lateral view of uncus and tegumen. 10-12, *P. propertius* (Fabricius). 10, left lateral view of uncus and tegumen; 11, dorsal view of uncus and tegumen; 12, inside of left valve.

neus, apart from the color of palpi and head (cf. Evans, 1955:379), is mainly the color of the pale bands on the underside of the hindwing, being yellow in *propertius* and white in *phineus*. The male genitalia (Figs. 7-12) differ in the following respects: although the two species are of equal size, and tegumen and uncus are also equally large, the valve of *phineus* is $1\frac{1}{4}$ times as long as that of *propertius*, and the

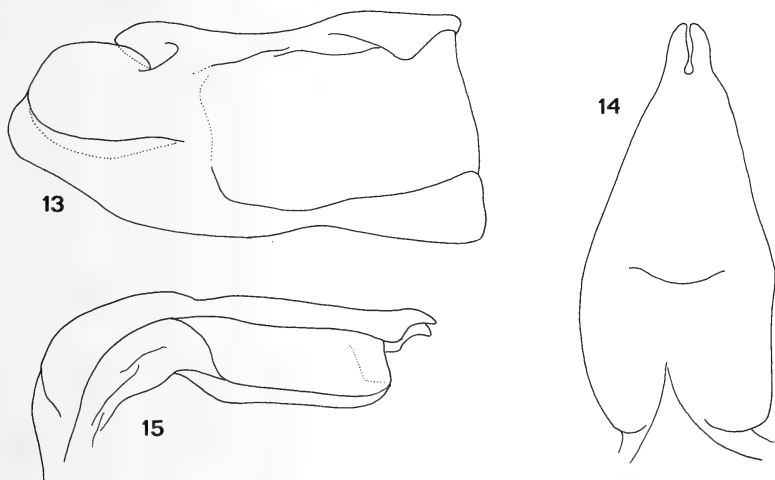
dorsal part of the cucullus of the former is more expanded, covering a larger part of the costa. For the rest the genitalia are very similar.

So, the differences between the two species are slight. Both taxa are largely allopatric and for that reason could possibly be subspecies of a single species, but as both have been recorded from Venezuela and E. Peru (Evans, 1955) and the exact distribution areas are poorly known, it seems advisable to consider them separate species for the moment.

As said above, designation of the true *Papilio phineus* Cramer as type-species of the genus *Pheimiades* would result in a genus concept that is widely different from what was meant by Hübner. Moreover, *Propertius* would become a junior synonym of *Pheimiades* as *phineus* and *propertius* are certainly congeneric, and *Pheimiades* (*sensu* Evans) would be in need of a new name. Such an action would create more instability than the designation of one of the species of *Pheimiades* (*sensu* Evans) as type-species of *Pheimiades* Hübner. For this choice it must also be kept in mind that Evans' work is far more authoritative than any of the other works mentioned. Finally, Evans' concept of *Pheimiades* is not at variance with Hübner's. The only nomenclatorial change needed is a name for the species that Evans mistook for *Papilio phineus* Cramer, this new name being necessary anyway. I would propose to the Commission to select this new species as type-species of *Pheimiades*. According to Evans it virtually was the type-species, and it does not contradict Hübner's concept of the genus. It can be described as follows.

***Pheimiades pseudophineus*, new species**

External characters (Figs. 5-6). Length of forewing, ♂ 17.4-17.7 mm; ♀ 20.9 mm. **Male.** Upperside dark brown, orange-brown along costa of forewing up to apical spots. Forewing with yellow dash in basal half of space 1a, yellow spots in spaces 1b, 2 and 3, and orange spots in spaces 4, 5 (both very small and inconspicuous), 6-8 and two in cell (small and inconspicuous). Hindwing with a central row of yellow spots in spaces 1c-6, separated by dark brown veins. Fringes forewing dark brown, a shade lighter near tornus, hindwing yellow. On the forewing inconspicuous dark brown brands: a V-shaped brand at the base of space 2, a short brand just below it in space 1b, and a dot over vein 1 at the inner corner of the spot in space 1b. Underside forewing along costa and apical third, and all of hindwing with a peculiar brownish-ochreous color, rest of forewing dark brown; spots on underside as on upper side, less conspicuous because of the paler ground color. **Female.** As male, but on upper side, costa of forewing



FIGS. 13–15. Male genitalia of *Phemiades pseudophineus* sp. n., holotype. **13**, inside of left valve; **14**, dorsal view of uncus and tegumen; **15**, left lateral view of uncus and tegumen.

orange-brown only in basal half, spots in spaces 2, 3, 6, and 7 hyaline, spot in space 1b semihyaline, other spots very faint or absent. Underside yellow where the male is brownish-ochreous, spots on hindwing faint.

Male genitalia (Figs. 13–15). Uncus tapering, bifid at apex. Costa of valve slightly swollen and hollowed at apex where it meets the upper edge of the cucullus. Latter broad, gently curved, hollowed at inside forming a narrow longitudinal ledge.

Identification. The new species can be distinguished at a glance from *Propertius* species by the underside of the hindwing, compare Figs. 4 and 6. From the other *Phemiades* species it can be separated by the brand on the forewing consisting of three parts (in the other species it is single), and by the broad and gently curved cucullus.

Material examined. Holotype, ♂, Chapada (Brazil). Paratypes: 1 ♂, Chapada (Brazil); 1 ♀, Espirito Santo (Brazil). All types in British Museum (Nat. Hist.), London.

According to Evans (1955:380) there should be 2 ♂♂ and 2 ♀♀ in the British Museum (under the name of *phineus* Cramer), but Mr. R. I. Vane-Wright of the said museum doubted if there were ever any more specimens than the ones listed above. Evans himself apparently was not quite sure of the identity of the specimens, as he added a note to one specimen reading, “comes nearer *phineus* Cram. than any other known species.”

Classification, Distribution and Synonymy

The following classification is essentially that given by Evans (1955) with necessary nomenclatorial changes:

Propertius Evans, 1955:303. Type-species by original designation: *Hesperia propertius* Fabricius, 1793.

1. *Propertius propertius* (Fabricius). From Panama and Venezuela through Peru and Bolivia to Paraguay, S. Brazil and Argentine.

Hesperia propertius Fabricius, 1793:325 ("Indiis"); Hewitson (1869:70); Plötz (1882:452).

Pheмиades propertius; Godman and Salvin (1900:529); Mabille (1904:149); Draudt (1923:956); Tessmann (1928:127); Hayward (1950:138).

Propertius propertius; Evans (1955:379).

Hesperia memuca Hewitson, 1868:37 (no locality stated), 1869:70 (synonymized his own species with *propertius*); Plötz (1882:452).

Pamphila theodora Ehrmann, 1907:319 (Venezuela), synonymized by Evans (1955).

2. *Propertius phineus* (Cramer), comb. nov. Guyanas, Venezuela, Peru.

Papilio phineus Cramer, 1777:123 (in index on p. 150 spelled "*phyneus*") (Surinam); Fabricius (1781:132).

Hesperia phineus; Hewitson (1869:70); Hewitson's remark on the underside of the hindwing of Cramer's species is based on Cramer's fig. 176C that however represents *Papilio phyllus* Cramer as clearly stated by Cramer; Plötz (1883:225).

Pheмиades phineus; Watson (1893:104); Godman and Salvin (1900:529); Mabille (1904:149); Draudt (1923:956); Tessmann (1928:127); Hayward (1950:138).

Mention of this combination by Hübner (1819:112), Scudder (1875:247), and Evans (1955:380) does not relate to this species.

Pheмиades albistriga Tessmann, 1928:127 (Montealegre, Pachitea, E. Peru), syn. nov.

Pheмиades Hübner, 1819:112. Designation of *Papilio phineus* Cramer as type-species by Scudder (1875:247) based on misidentification. New designation suggested to Commission: *Pheмиades pseudophineus* sp. n. *Trioedusa* Mabille, 1904:144. Type-species *Trioedusa milvius* Mabille, sole species included. Synonymized by Evans (1955:379).

1. *Pheмиades pseudophineus* sp. n. Chapada, Espirito Santo (Brazil).

Pheмиades phineus; Evans (1955:380).

2. *Pheмиades pohli* (Bell). Ecuador, Brazil, Paraguay, Argentine.

Augiades pohli Bell, 1932:136 (Santa Catharina).

Ochlodes pohli; Hayward (1950:52).

Pheмиades pohli; Evans (1955:380).

Ochlodes köhleri Hayward, 1937:94 (Argentine), synonymized by Hayward (1948:106).

Pheмиades pohli cidra Evans, 1955:380 (Archidona, N.E. Ecuador).

3. *Pheмиades vergens* Evans, 1955:381 (Cosnipata, E. Peru).

4. *Pheмиades milvius* (Mabille). Peru, Br. Guyana, Brazil.

Trioedusa milvius Mabille, 1904:145 (Brazil).

Pheмиades milvius; Evans (1955:381).

Pheмиades milvius milor Evans, 1955:381 (Yahuarmayo, Peru).

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SELECTION OF OVIPOSITION SITES BY THE BALTIMORE CHECKERSPOT, *EUPHYDRYAS PHAETON* (NYMPHALIDAE)

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ABSTRACT. Selection of oviposition sites by the Baltimore checkerspot (*Euphydryas phaeton*) was examined in a natural population. Females chose leaves larger than average. Egg clusters were clumped, with 1% of the available leaves and 3% of the available stalks used. The behavior resulting in this non-random pattern is discussed.

Butterflies choose host plants which promote larval survival and avoid those which do not (Wiklund, 1974, 1975; Chew, 1975, 1977; Rausher, 1980). Ovipositing females may discriminate among conspecific host plants either by avoiding eggs on plants or by depositing their eggs with those of other females (e.g. Ehrlich & Gilbert, 1973; Gilbert, 1975; Benson et al., 1975; Rothschild & Schoonhoven, 1977; Rausher, 1979). Most butterflies deposit their eggs singly (Stamp, 1980), but the Baltimore checkerspots (*Euphydryas phaeton* Drury: Nymphalidae) lay clusters of eggs and tend to deposit egg clusters with clusters already present. The advantages for a female in discriminating among conspecific host plants and depositing eggs with other egg clusters have been linked to avoidance of parasitoids and predators and to aspects of the host plants such as the size of the host plant, the part of the plant used by larvae, and the distribution of the host plant (Benson, 1978; Stamp, 1980).

My objective was to examine selection of oviposition sites by *E. phaeton* by determining searching behavior, characteristics of the oviposition sites, characteristics of the host plants available for oviposition, and distribution of egg clusters.

METHODS

E. phaeton was studied at the Conservation and Research Center of the National Zoological Park at Front Royal, Warren Co., Virginia from 1977 through 1979. This butterfly is univoltine and deposits large clusters (\bar{x} = 274 eggs per cluster; Stamp, 1982c) in June. The early instars make communal webs on their larval host plants and then diapause in webs in August. The caterpillars overwinter on the ground in the plant litter (Bowers, 1978). The larval host plant, turtlehead (*Chelone glabra* L.: Scrophulariaceae), is a clonal perennial growing in dense patches (up to 2.3 m in diameter) in wet meadows. Although

a few isolated plants consist of one stalk, most plants contain numerous stalks.

Plants were searched for egg clusters, and those stalks with clusters were tagged. Host plant and leaf-searching behavior were recorded by following females searching for oviposition sites. By making quick sketches of plants, stalks and leaves and numbering them in order of visitation, I kept track of females searching plants, stalks and leaves they had previously encountered during the observations.

In 1979, 107 female *E. phaeton* were marked using Testor's enamel paint on the wings, thorax and abdomen with no detrimental effects. One area (12 × 55 m) was surveyed for host-searching and ovipositing females from 1000 to 1700 hours on 9 through 23 June. Each survey required about 45 min. Upon finishing a survey, another survey was begun immediately. The position of egg clusters was marked with a spot of permanent black ink on the upper surface of the leaf and the stalk tagged with designation of which female laid the cluster, date, height of the cluster from the ground, and leaf upon which the cluster was deposited. To determine the proportions of ovipositions actually observed, all leaves were examined twice a week for additional egg clusters, and those stalks with clusters were tagged. To determine if any egg clusters were missed, the area was searched every week through the second week of July for untagged stalks with red egg clusters (deposited prior to 24 June) and webs of *E. phaeton* larvae. Based on 267 egg clusters (of which 99% were located prior to hatching), I observed 87% of the ovipositions in this area over the 14-day period using the survey method described above.

To determine the size of stalks available to *E. phaeton*, 15 plants were sampled. A rod was placed through each plant until 20 stalks were partitioned. Those stalks were measured for height and for length of leaf nearest to the midpoint of the stalk. The total number of stalks and the number of stalks in the outer 15 cm of each plant group were counted. The width and perimeter of the plant groups were measured. In one area turtlehead was mapped using a reel tape stretched across a grid (of 3 × 3 m units) and moved at 30 cm intervals along the grid. The perimeter of the plant groups and mean width of the plant groups were calculated using a map meter (which determined distance).

RESULTS

Oviposition Behavior

Females searching for oviposition sites flew from stalk to stalk about 0.6 m above the ground along edges of host plant groups, in contrast to non-searching females which generally flew above the vegetation

TABLE 1. Searching behavior exhibited by female *E. phaeton* (n = 21).

Searching behavior	Mean per female based on total observations	Standard error
Minutes observed	11.4	±1.4
Plant groups visited	1.6	±0.2
Stalks visited	8.1	±0.9
Leaves touched	7.5	±1.0
Leaves examined	2.1	±0.3
Turns on top surface of leaves	4.9	±0.8
Times abdomen placed under leaves	9.2	±1.7
Times returned to top surface of leaves	8.1	±1.6

without landing on turtlehead. Usually a female settled at a host plant after landing on one or two plants and stalks and began oviposition after examining an average of two leaves (Table 1). Frequently, a female returned to a host plant, stalk or leaf which she had already visited during this searching period; 28% of the leaves and 32% of the stalks visited had been examined a few to 35 min earlier. However, oviposition on these re-examined leaves was similar to that on newly-examined leaves (8 ovipositions on 47 leaves and 10 ovipositions on 120 leaves, respectively; χ^2 -test, $P > 0.10$). Oviposition on re-examined stalks was also similar to that on newly-examined stalks (9 ovipositions on 49 stalks and 9 ovipositions on 103 stalks, respectively; χ^2 -test, $P > 0.10$). Thus, females appeared to be sampling available oviposition sites rather than just responding to each potential site, positively or negatively. In addition, females examined and oviposited on damaged leaves, partially eaten by sixth instar larvae of *E. phaeton*.

A female examined a leaf in detail by repeatedly walking over its upper surface, tapping it with her antennae, occasionally making 180 or 360° turns on the leaf and examining the under surface of the leaf with her ovipositor while hanging onto the edge of the leaf with the midlegs (Table 1). Often a female examined the under surface of a leaf by hanging first from one side of the leaf and moving along the edge. Then she returned to the top surface, walked to the other side of the leaf, and examined the under surface of the leaf from that side (Table 1).

Each of the 21 females followed oviposited within 22 min. The majority of these females were initially flying quickly from patch to patch of turtlehead and basking intermittently, rather than having started to search among the host plants. Since some other marked females were observed to search for up to three hours before ovipositing, 22 min is a conservative (short) estimate of average search time.

TABLE 2. Affect of inclement weather on oviposition. Sixteen and 15 females deposited single clusters and 23 and 22 females deposited eggs with others, before and after poor weather, respectively.

Ovipositions	Single clusters	Other clusters present	Total
Day before:			
Observed	16	15	31
Expected	16.1	14.9	
Day after:			
Observed	26	24	50
Expected	25.9	24.1	
	42	39	81

Most females oviposited in early afternoon, although some were observed ovipositing from 1100 to 1700 hours. Recently-emerged females (with bright, unworn wings) and older females deposited clusters in the morning and afternoon at a similar rate (for recently-emerged females, 27 deposited eggs in the morning and 44 in the afternoon; for older females, 16 laid eggs in the morning and 62 in the afternoon; χ^2 -tests, $P > 0.10$). Poor flight conditions (e.g., cool, windy, rainy) inhibited egg depositions (χ^2 -tests, $P < 0.001$; Table 2). However, neither the numbers of egg clusters deposited nor the number of females depositing eggs was significantly different between the day before and the day after inclement weather (χ^2 -tests, $P > 0.10$).

Deposition of an egg cluster took an hour and a half ($n = 24$, $\bar{x} = 88 \text{ min} \pm 37 \text{ S.D.}$). The number of egg clusters laid over a 13-day period (by females marked on the first to eighth day of that period) ranged from 0 to 6 ($n = 98$ females, $\bar{x} = 1.3 \text{ clusters} \pm 14 \text{ S.D.}$). However, the count of egg clusters per female was conservative, because 13% of the ovipositions in this area were not observed, and some females may have oviposited in adjacent areas (about 20 m away). Thus, based on a mean of 274 eggs per cluster, a female may lay up to 1650 eggs during her lifetime of two to three weeks. Of the 153 observed ovipositions by marked females, 13% involved females making two or more depositions in a single day.

Females frequently chose stalks and leaves which already had egg clusters (Fig. 1). At the peak of the oviposition period for an area with plantain (*Plantago lanceolata* L., an alternate host plant; Stamp, 1979) and by the end of the oviposition period in areas with turtlehead, over 23% of the stalks with egg clusters had two or more clusters. However, of those turtlehead stalks with clusters just after the first week of oviposition ($n = 46$), 47% had two or more clusters. Additional clusters were deposited a few days apart ($2.4 \text{ days} \pm 0.3 \text{ S.E.}$, range 0 to

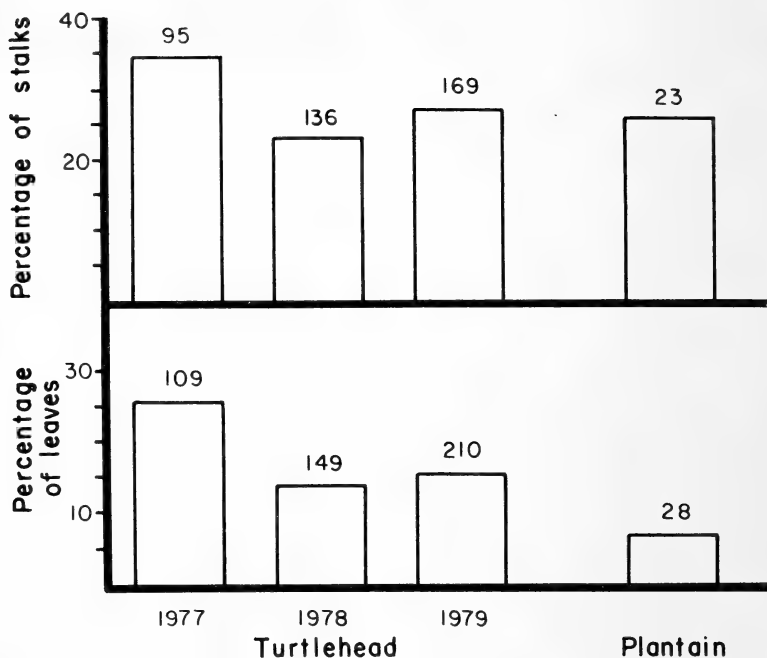


FIG. 1. For those stalks and leaves with egg clusters, the percentages of stalks and leaves with two or more egg clusters are shown. Numbers above the bars indicate total stalks and leaves with egg clusters. Plantain data are from Stamp (1979).

16 days, $n = 82$). Of stalks with two or more clusters ($n = 42$), the mean number of depositions was $3.0 (\pm 0.3 \text{ S.E.})$, with up to a total of 10 clusters per stalk.

Females laid their clusters with those of other females. Of 153 observed ovipositions of marked females, 46 females laid eggs with clusters deposited by other marked females. Only one female laid two clusters on the same stalk. For these 153 females (which used 125 stalks), the binomial probability of two clusters deposited by a female in one place is less than 0.001. Twice I observed a female examining a leaf on which another female was ovipositing. The searching female examined the under surface of the leaf from both sides, crawled across and jostled the ovipositing female, and within a few minutes oviposited next to the other female with their wings touching.

Once oviposition began, females exhibited some degree of site tenacity. I observed 10 ovipositing females which were interrupted by males or my movements and then flew 1.5 m or more from their clusters. Within 2 min, three resumed oviposition on the leaves with their

TABLE 3. Comparison of oviposition sites among years. One standard error is indicated and sample sizes are in parentheses. The first four variables were tested each with one-way ANOVA; χ^2 -test was used for egg clusters in the outer portion of plant groups.

	1977	1978	1979	Statistical significance
Height of stalk in cm	74.9 \pm 1.0 (165)	60.7 \pm 1.1 (168)	60.9 \pm 1.3 (166)	P < 0.01
Height of egg cluster from ground in cm	49.8 \pm 0.9 (165)	43.2 \pm 0.8 (168)	50.8 \pm 0.3 (166)	P < 0.01
Width of plant group in cm	54.4 \pm 3.0 (114)	50.9 \pm 2.5 (129)	66.9 \pm 1.9 (122)	P < 0.01
Leaf length in cm	12.2 \pm 0.2 (165)	11.4 \pm 0.2 (168)	10.7 \pm 0.2 (168)	P < 0.01
Percentage of egg clusters in outer 15 cm of width of plant group	99.3 (165)	91.7 (168)	90.0 (240)	P < 0.01

partially laid clusters. Within 5 min three others resumed oviposition on leaves within 15 cm of the first oviposition sites. The rest of the females left the plant groups and did not return that day.

Oviposition Sites

Considerable among-year variation occurred in the characteristics of oviposition sites: height of stalks chosen by females, height of egg clusters from the ground, width of plant groups, and length of leaves with clusters (Table 3). This may reflect variation among years in the growth of the host plant, probably a consequence of the amount of spring precipitation (Stamp, unpubl. data). Most of the egg clusters occurred in the outer 15 cm of the plant groups. Females chose larger

TABLE 4. Dispersion of egg clusters on host plant stalks, based on an estimate of 6554 available stalks.

Number of clusters per stalk	Number of stalks observed	Percentage of egg clusters
0	6385	—
1	123	47.5
2	28	21.6
3	9	10.4
4	4	6.2
5	0	0
6	2	4.6
7	1	2.7
8	1	3.1
9	0	0
10	1	3.9

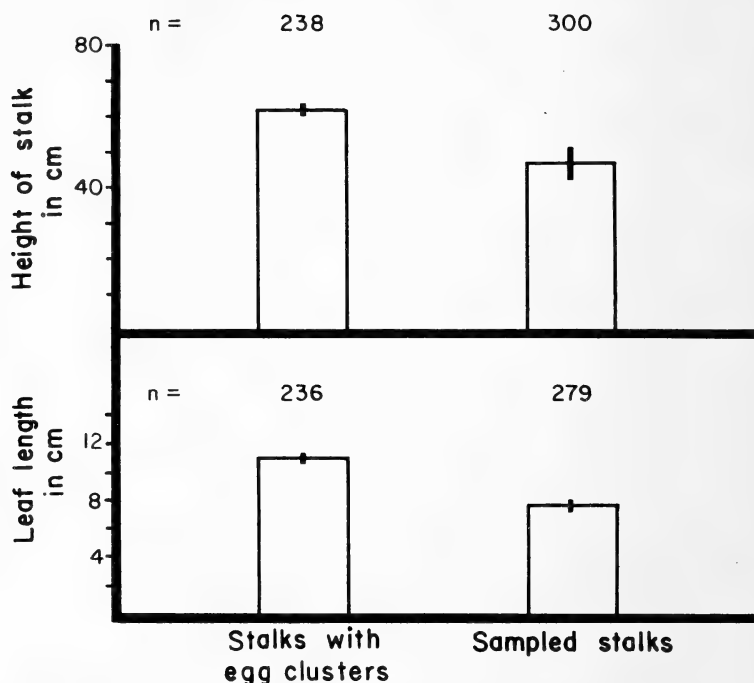


FIG. 2. Comparison of oviposition sites and stalks available for oviposition in 1979, with \pm one standard error. Numbers above bars are sample sizes.

stalks and larger leaves than the mean available (two-sample t tests, $P < 0.01$ for both variables; Fig. 2). Stalks with multiple clusters were compared to stalks with solitary clusters deposited late in the flight period to evaluate the hypothesis that multiple clusters occurred on larger leaves and stalks. However, the height of stalks and length of leaves with eggs were similar for stalks with solitary and multiple clusters ($\bar{x} = 59.6 \text{ cm} \pm 2.6 \text{ S.E.}$ and $\bar{x} = 62.3 \text{ cm} \pm 4.6 \text{ S.E.}$ for stalks, and $\bar{x} = 11.0 \text{ cm} \pm 0.4 \text{ S.E.}$ and $\bar{x} = 11.2 \text{ cm} \pm 0.6 \text{ S.E.}$ for leaves, respectively; $n = 22$ solitary and 25 multiple clusters, two-sample t tests, $P > 0.50$ for both variables). *E. phaeton* used 53 to 59% of the plant groups available to them. Also, plant groups were classified by size: perimeter less than 100 cm, between 100 and 500 cm, and greater than 500 cm. These butterflies were not selecting plant groups by size (4 of 17, 34 of 58 and 7 of 7 of the plant groups had egg clusters for the respective plant group sizes, χ^2 -test, $P > 0.05$). In 1977 and 1979, egg clusters were randomly distributed among the quarters of plant groups (χ^2 -tests, $P > 0.05$). However, in 1978 the southwest quarter

TABLE 5. Dispersion of egg clusters on leaves, based on an estimate of 26,216 available leaves.

Number of clusters per leaf	Number of leaves observed	Percentage of egg clusters
0	26,006	—
1	177	68.3
2	25	19.3
3	3	3.5
4	2	3.1
5	3	5.8

of plant groups had significantly more egg clusters ($P < 0.01$). This was probably a consequence of the availability of edges of host plant groups, with some edges not discovered by butterflies due to the height of adjacent vegetation.

I estimated the number of turtlehead stalks and leaves available to *E. phaeton* for oviposition in one area, based on stalks in the outer 15 cm of the plant groups and large leaves on the upper half of stalks. Although these stalks and leaves are referred to as available, no assumption is made here that they are necessarily suitable to ovipositing females. A mean of one stalk per $3.8 \text{ cm} \pm 0.2 \text{ S.E.}$ of perimeter was calculated. This mean was multiplied by the total perimeter of the mapped plant groups to estimate the number of available oviposition sites. The estimate was 6554 stalks available to *E. phaeton* for oviposition in this area. The estimate of number of leaves available for oviposition was calculated based on four large leaves on the upper half of the stalk for each stalk in the outer 15 cm of the plant groups rather than for all leaves (mean of 18) per stalk. I multiplied four leaves per stalk by 6554 stalks to obtain an estimate of the number of leaves per stalk which were available for oviposition. This estimate was 26,216 leaves.

Only 2.6% of the estimated available stalks and 0.8% of the estimated available leaves were used by *E. phaeton* for oviposition (Tables 4 and 5). These values may be lower if more of the stalks and leaves were available as oviposition sites. Females did occasionally use stalks near the center of the plant groups as well as leaves on the lower half of stalks. The index of dispersion was used to determine if egg clusters were distributed randomly on stalks and leaves (Southwood, 1978). The number of clusters per stalk and per leaf indicated clumped distributions significant at the 0.001 level.

Some stalks may provide more stimulus for oviposition than others and, consequently, *E. phaeton* may respond to these stalks rather than to the egg clusters on them. At four-day intervals from 13 through 25

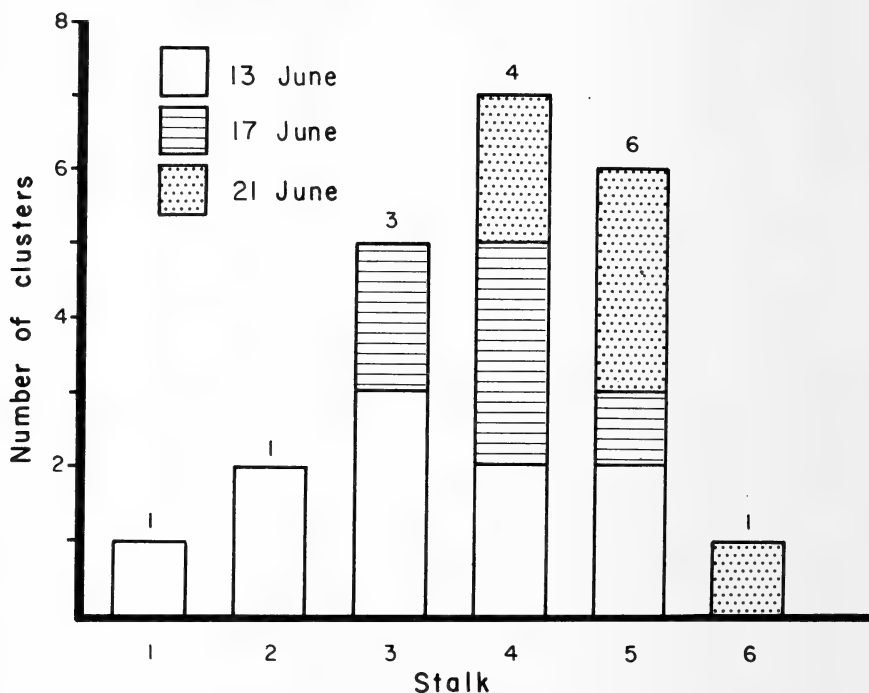


FIG. 3. Repeated use of particular stalks for egg deposition in a moderate-sized plant group. Leaves with egg clusters were removed from these stalks on each date. Total number of leaves with clusters are indicated above bars. No clusters were found on 25 June, at the end of the flight period.

June, the stalks in one plant group were checked for clusters and leaves with clusters were removed. The plant group was 74 cm in diameter with more than 30 stalks in the outer 15 cm of the plant group. Over a period of 12 days, six stalks had clusters (Fig. 3) and the mean number of clusters on those stalks was $3.7 (\pm 2.7 \text{ S.D.})$. Thus, females were repeatedly using particular stalks even though I was removing leaves and the potential stimulus of those stalks either due to those leaves or the egg clusters was reduced.

DISCUSSION

Overall, *E. phaeton* females carefully assessed the suitability of host plant groups and stalks by detailed examination of the leaves upon which they oviposited. *E. editha* are also known to spend considerable time in search of oviposition sites and in depositing egg clusters (Labine, 1968). *E. phaeton* do not appear to be discriminating among plants to avoid parasitoids, predators or competitive larvae.

Egg parasitoids and predators are of more immediate concern than larval enemies, because the eggs are exposed on the leaves three weeks before hatching. However, *E. phaeton* oviposited frequently on leaves and stalks that they examined previously a few seconds to many minutes earlier. This suggests that females were responding to other qualities of the stalks and leaves than the presence of egg parasitoids and predators. The sequence of egg clusters deposited on a leaf did not affect the level of parasitism or number of parasitized eggs per cluster (Stamp, 1981b). Furthermore, loss of eggs to predators was small, with no clear difference between single and multiple clusters on leaves (Stamp, 1981b). Thus, depositing eggs with those of other females did not lower the risk to eggs, as it might by surrounding eggs with others, predator satiation, or causing parasitoids to run out of their own eggs.

E. phaeton chose larger leaves on larger stalks than those generally available and only used a small portion of the available host plant. Furthermore, females oviposited repeatedly on particular stalks, suggesting a paucity of attractive stalks. Perhaps these butterflies were selecting by chemical cues particular stalks of plant groups which promote higher survival of offspring and consequently, yielded a clumped distribution of egg clusters. The fact that more stalks received multiple depositions early in the flight period than later suggests that females later in the flight period may have had to choose between particularly attractive stalks (frequently with several egg clusters) and less attractive stalks. The clonal, perennial turtlehead may benefit by producing a few attractive stalks if that reduces the number of potential flowering stalks which are destroyed by this herbivore. This would be similar to poplar (*Populus angustifolia*) providing a limited amount of optimal resources and thereby, restricting successful colonization by a gall-making aphid (Whitham, 1978).

Frequently *E. phaeton* deposited their eggs with those of other females. Depositing eggs with other clusters has been observed in other populations of *E. phaeton* (Bowers, 1979) and in populations of *E. gillettii* (Williams, 1981) and *E. aurinia* (Keith Porter, pers. comm.). The proposition that *E. phaeton* may deposit eggs with those of others with the result that larvae benefit from large group size (from two or more egg clusters) was examined in detail (Stamp, 1981a, b, 1982a, c). These studies indicated that belonging to a large group over the entire larval period was not essential and was perhaps even detrimental. The group size with highest survivorship to diapause did not exceed the average number of eggs per cluster (Stamp, 1981a).

However, the value of belonging to a large group may fluctuate on a daily and even hourly basis as a consequence of larval and parasitoid

activity (Stamp, 1982a, b, unpubl. data). For example, newly-hatched larvae moved from the oviposition site to the top of the host plant stalk, built a communal web, and then began feeding. Without their webs and the body spines characteristic of the other instars, first instar larvae were particularly vulnerable to parasitoids and predators. One value of belonging to a large group was that such a group quickly reached the top of the stalk. Newly-hatched larvae from all but the first egg cluster deposited on a stalk had a silk trail to follow and a communal web to occupy immediately.

Furthermore, these caterpillars may benefit from membership in large groups due to particular defensive mechanisms (e.g. webs, head-jerking, unpalatability, aposematic coloration). For example, *E. phaeton* reared on turtlehead were unpalatable to blue jays (*Cyanocitta cristata*; Bowers, 1980) and, thus, the effect of the aposematic coloration of these larvae may have been enhanced by large group size. Also, by head-jerking, second and third instar larvae warded off parasitoids effectively (Stamp, 1982a). If caterpillars in contact with each other on the outside of a web were disturbed by a parasitoid, they simultaneously head-jerked for several minutes. However, if these larvae were not touching each other and were disturbed, only a few caterpillars head-jerked and for a shorter period. In the latter case the parasitoid continued to search and make contact with caterpillars.

Since observed survival was highest for moderate-sized groups (that is, equivalent to a single egg cluster), why then were many (30%) of the clusters in groups? Variation in group size of *E. phaeton* may be the result of two opposing and variable selective pressures. Group size of eggs and the ensuing larval aggregations of these checkerspots varied tremendously, with one to 10 egg clusters occurring per stalk and, thus, about 250 to 2500 newly-hatched caterpillars per web (Stamp, 1981a.). By depositing moderate-sized clusters with those of other females, *E. phaeton* may benefit from spreading their eggs, and the offspring may benefit during critical larval periods from membership in large groups. Thus, clumping of egg clusters may enhance reproductive success under some circumstances. However, spreading eggs may also maximize the probability that some of a female's eggs will survive.

In conclusion, *E. phaeton* females were carefully choosing oviposition sites and frequently depositing their eggs with those of other females. These behaviors suggest a scarcity of particularly attractive or high quality stalks. These oviposition behaviors may also indicate the value of group membership for larvae during critical periods, such as the first instar.

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GENERAL NOTES

FIELD OBSERVATIONS OF DIVERGENT RESTING BEHAVIOR AMONG HICKORY FEEDING *CATOCALA* LARVAE (NOCTUIDAE)

Catocala are known for their sympatric diversity, with at least 35 species present at almost any forested locality in southern New England (see Sargent, 1976, Legion of night: The underwing moths, Univ. Massachusetts Press, Amherst, MA; also personal observation). Of these, about one third feed on Juglandaceae (hickories and walnuts). The precise foodplant preferences of these Juglandaceae feeders will be the topic of another paper (Schweitzer, in prep.) and are also being investigated by L. F. Gall.

Sargent (1976, op. cit.; 1977, J. Lepid. Soc. 31:1-16) suggested that food may not be an important limiting factor in *Catocala* evolution. "Competition" for predator avoidance might be more important in *Catocala* ecology. Such competition might be manifest in different larval resting behaviors, which might serve to inhibit effective search image formation by predators, especially birds. Sargent (1976, op. cit.) reports laboratory observations of instar specific resting behaviors in *Catocala dejecta* Strecker and *C. resecta* Grote which were reared in plastic containers on *Carya ovata*. Although similar in appearance the two species grow at very different rates and so avoid having similar size and behavior simultaneously.

Little is known about field resting habits of most *Catocala* species. From my own observations it seems that late instar *C. epione* (Drury) and *C. c. consors* (J. E. Smith) larvae almost invariably rest on branches or small trunks. Late instars of *Catocala habilis* larvae are quite flattened and can be found resting under bark shags. Most sleeved *C. palaeogama* and *C. dejecta* last instar larvae rested exposed on the branches. Most other species typically hid in folds of the cloth or in debris.

The resting habits of larvae collected on 25 and 26 May 1980, West Rock, New Haven, Connecticut, were noted and are presented in Table 1. Data for those larvae observed at rest were analyzed by chi-square tests. *Catocala epione* differs from the other species, all of which appear to have similar resting behavior ($\chi^2 = 10.6$, $P < 0.005$, with Yates correction). Of course, resting habits may diverge in later instars, and a larger sample size might have revealed more differences.

These limited observations are apparently the first demonstration of differences in field resting behavior of the sort described by Sargent and may be the first published documentation of natural foodplants for these species. The data in Table 1 are from larvae collected on four stunted trees at the edge of trap rock outcrops. All trees had trunk diameters of less than 15 cm and had some bark exfoliations on the trunk. All branches were carefully searched and then beaten with a baseball bat. All but two of the 25 larvae were found by the visual search.

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TABLE 1. Resting behavior of *Catocala* larvae collected at West Rock, New Haven, Connecticut on 25 and 26 May 1980 on *Carya ovata*. *C. epione* were in ultimate (1) and penultimate (5) instars. Others were 2-3 cm long and dark colored, and were probably in the third instar.

	Beaten	Numbers observed resting on			Crawling
		Foliage ¹	Twig	Trunk	
<i>C. epione</i>	1	0	5	0	0
<i>C. palaeogama</i>	1	9	1	0	1
<i>C. residua</i>	0	4	0	0	0
<i>C. resecta</i>	0	2	1	0	0

¹ Midrib on underside of leaflets.

A LATE-SEASON EMERGENCE OF *CALLOPHRYS* (*SANDIA*)
MACFARLANDI (LYCAENIDAE)

Callophrys (*Sandia*) *macfarlandi* Ehrlich & Clench is extremely restricted in larval foodplant utilization, although it is widely distributed and often common in much of New Mexico east of the Continental Divide (Holland, 1974, J. Lepid. Soc. 28:38-52). It appears to be an obligatory feeder on *Nolina texana* Wats. (Liliaceae). In the small portion of New Mexico which is south and west of Truth or Consequences, *N. texana* is replaced by *N. microcarpa* Wats., seemingly without intermediate forms. The two species of *Nolina* never occur together in New Mexico, although they come within 30

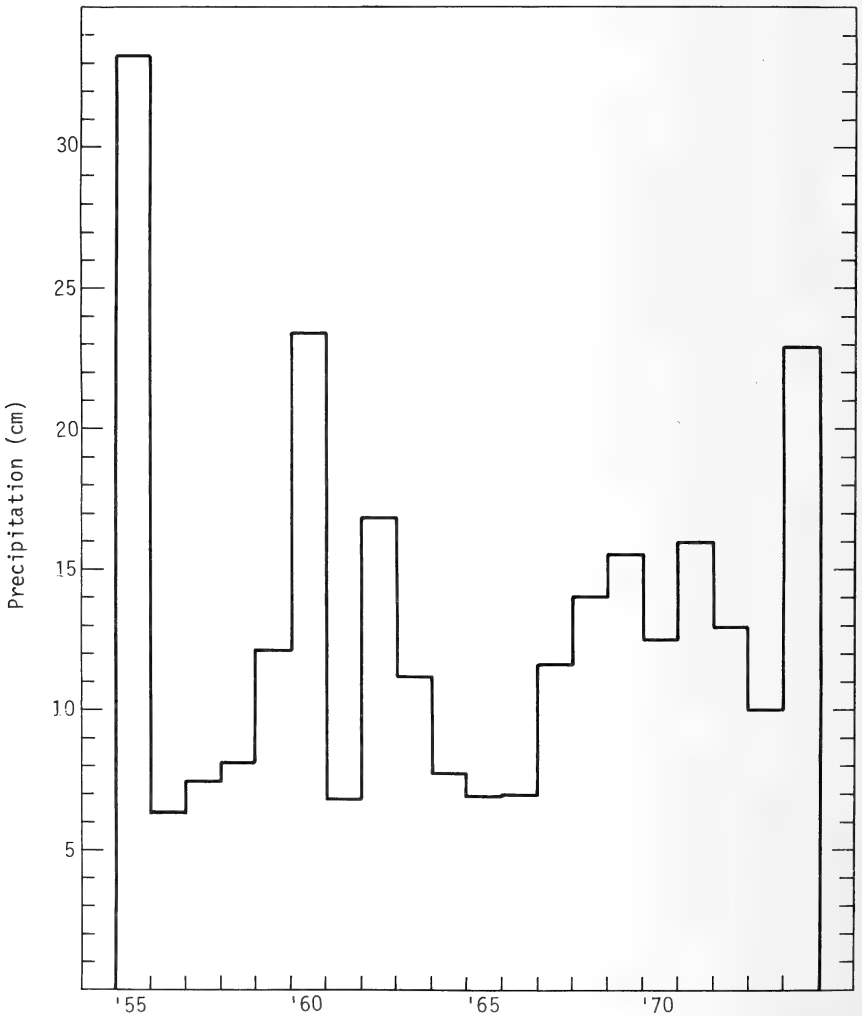


FIG. 1. July rainfall at Sunspot, NM, for 1955-1974.



FIG. 2. ♀ (**upper**) and ♂ (**lower**) *Callophrys (Sandia) macfarlandi*, ventral surfaces, 19·VIII·74, Grapevine Can., Sacramento Mts., Otero Co., NM, 6000' (1640 m).

mi. (50 km) of contact in some places. *Callophrys macfarlandi* has never been observed in association with *N. microcarpa*. On the other hand, whenever one locates a stand of *N. texana*, no matter how isolated from other stands, one can nearly always find *macfarlandi*. It has not yet been determined whether *macfarlandi* will accept *microcarpa* in captivity when no choice is offered. The most obvious distinguishing feature between the two species of *Nolina* is the height of the inflorescence. In *texana*, the inflorescence is about the same height as the leaf, while in *microcarpa* the inflorescence is approximately twice the leaf height. This gives *microcarpa* some resemblance to *Yucca*, a genus closely related to *Nolina*.

Callophrys macfarlandi larval feeding is restricted not only to *N. texana* but, in particular, to the bloom of the plant. *Nolina texana* normally blooms in April or early May, depending on the location. Fresh *macfarlandi* have been captured from 15 February to 29 June, however, with no clear pattern of discrete broods. This seasonal distribution raises some difficult questions. First, it is uncertain how many generations of *macfarlandi* occur in a given year. Blooms stay fresh long enough and the *macfarlandi* larval stage is brief enough that two complete generations may be possible. However, there is definitely no bloom available under any circumstances in June. This seemed to mean the late May and June emergers are either a "suicide brood" or the species is able to pass the fall and winter as ova. One would normally expect natural selection to act very swiftly against genotypes with a "suicide brood" proclivity. This viewpoint would favor the fall-winter, ova-diapause hypothesis. The problem with that

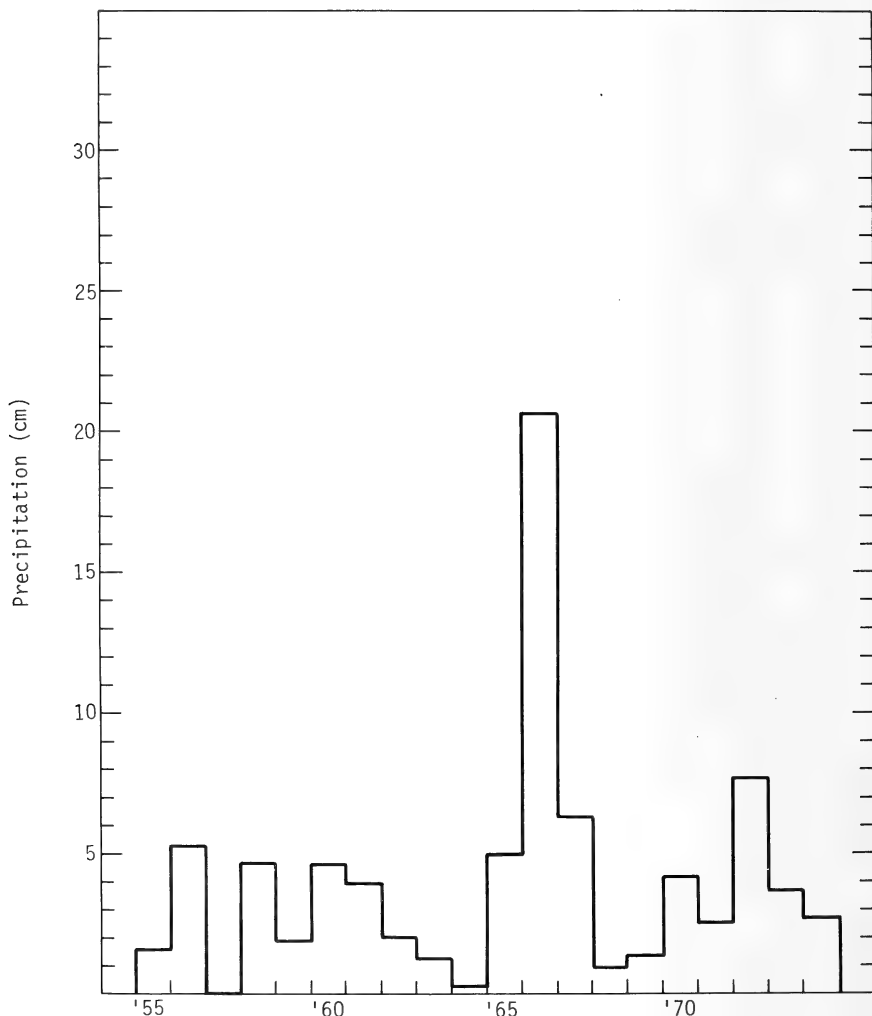


FIG. 3. June rainfall at Sunspot, NM, for 1955-1974.

hypothesis is it is incompatible with the February flight, unless *macfarlandi* can diapause either as ova or pupa.

A purely speculative explanation for these observations may be found in a series of events which took place in 1974. This year was marked by an exceptionally wet July around Alamogordo, Otero Co., NM. Rainfall records were kept for a 20-year period from August 1954, to July 1974, at Sunspot, NM, high in the Sacramento Mts. near Alamogordo (Demastus, 1976, A twenty-year summary of Sacramento peak weather—August 1954 through July 1974, Sacramento Peak Observatory, Air Force Geophysics Laboratory, Hanscom AFB, Massachusetts 01731, AFGL-TR-76-0096, Special Report No. 196). July rainfall at Sunspot is graphed in Fig. 1 for these years. It may be seen

that July 1974 was significantly wetter than any other July between 1964 and 1974. (These eleven seasons include the ones in which I had been active in New Mexico and consequently, for which I have overlapping data both on rainfall and Lepidoptera.)

In August 1974 around the Sunspot-Alamagordo area, the *Nolina* did a very unexpected thing, apparently in response to the extreme wetness of July: Many of the plants bloomed a second time. The August inflorescence was quite dwarfed compared to the normal bloom; its height was perhaps one fourth of the height of the spring inflorescence.

On 19 August 1974, I checked a summit in the Sacramento Mts. foothills about 5 mi. (8 km) SE of Sunspot. This particular summit has often produced interesting hilltopping specimens, although *macfarlandi* does not usually hilltop. In this case however, I was rewarded by the capture of a fresh female and an extremely worn male (Fig. 2). Despite the tattered condition of the male, it seems unlikely this small lycaenid could have been on the wing since June.

If we again refer to Fig. 1, we see that the July 1955 and 1960 precipitation was also great enough at Sunspot to have caused the *Nolina* to bloom again in August, had anyone been there to look. I, thus, suggest that the *macfarlandi* which emerge in June may be favored by virtue of their progeny being able to utilize the August flowering of their foodplant if very heavy July rains intervene. If this strategy is successful three years out of twenty, as our limited data here indicates, the selection pressure against June emergence would, at least, be considerably mitigated. Normally, June is far drier than July in the Alamagordo area; however, highly unusual rains in June 1966, could conceivably have triggered a second blooming of *Nolina* that year also (see Fig. 3). If this indeed occurred, the odds for the June emergence successfully completing a life cycle without diapausing as ova improve to four in twenty.

On the other hand, it is fully possible that the "suicide brood" concept is actually correct. For instance Shapiro (1967, J. Res. Lepid. 6:181-183) has demonstrated that in Pennsylvania *Colias* and *Pieris* are subject to suicide eclosions just before the onset of lethally cold weather. Also, the presence of a female *macfarlandi* exhibiting hilltopping (mate-seeking) behavior implies the number of available males at that time and place must have been very low. Whether by accident or adaptation, however, the unseasonal concurrence of *Nolina* bloom and *macfarlandi* eclosion in August 1974 is a most interesting example of desert survival.

The American Museum of Natural History has *macfarlandi* specimens of both sexes taken by F. H. Rindge at Sitting Bull Falls near Carlsbad, Eddy Co., NM, on 27 and 29 July 1964. I am not personally familiar with that site and feel unqualified to speculate on a relationship between this record and my own observations.

ACKNOWLEDGMENTS

J. McCaffrey formerly of Sunspot, NM, and now at New Mexico State University, Las Cruces, succeeded in tracking down the obscure Air Force precipitation report which made a cohesive presentation of these items possible.

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THE CORRECT PLACEMENT OF *EVERES* 'HERRII'

Since its description in 1901, the taxonomic placement of *herrii* (Grinnell) has been in question. After being variously designated as a subspecies of *Everes comyntas* (Gardner) and *Everes amyntula* (Boisduval), what are believed to be the type specimens have now been examined genitally and *herrii*'s alignment with *amyntula* is finally decided.

Grinnell (1901, Can. Entomol. 33:192) described *Lycaena amyntula* var. *herrii* from "two males and two females" which were collected by Poling in July 1899 and September 1900. The original description of the male states that it differs from typical *amyntula* "... in having a black margin about 1 mm wide; whereas, there is none in typical *amyntula*, or, if any, a very slight trace. On the underside the markings are much more heavy. The male of this variety is also much smaller than the male of typical *amyntula*" And the description of the female states, "... differs from typical *amyntula* by the replacement of the dark area of the primaries by a narrow black band about 1 mm wide, and on the secondaries by only two red crescents instead of five as in typical *amyntula*."

Then, Bethune-Baker (1913, Ent. News XXIV:97), while not questioning the placement of *herrii* within the genus, argued that the differences between *amyntula* and *herrii* were flimsy and that if Grinnell "... had had the advantage of having the type of *amyntula* before him that he would not have described the form."

The actual *comyntas/amyntula* debate was begun by Barnes and McDunnough (1916, Cont. Nat. Hist. N.A. III:109), who subsequently state that after examining a large series of *Everes* from southeastern Arizona, "... we should be inclined to refer *herrii* Grinnell to *comyntas* rather than *amyntula*" They state that this decision is based in part on the original description, which mentions the "... broader black border on the upper side and the better defined and larger spots on the under side . . ."; in part on the presence of "... red lunules near the anal angle on the secondaries above . . ." in many of the specimens, a feature closely associated with *comyntas*; and their decision is also based in part on the fact that the dates of capture point to a distinct double-broodedness. This multiple- versus single-brooded aspect had been suggested by Bethune-Baker (op. cit.), who, however, alluded to a partial second brood in *amyntula* in the southern end of its range.

Aside from the opinions of these early researchers as to the placement of *herrii*, another issue complicated matters. Were, in fact, *amyntula* and *comyntas* actually distinct? Because, if not, the *herrii* point was moot. Various writers, including Holland, Klots, Brown et al., dos Passos, and Howe, follow the separation of American *Everes* into the two taxa, while a smaller number, including Ehrlich, have lumped the two under *comyntas*. So, in several ways, the placement of *herrii* has been questionable.

However, what was not known until recently was the fact that both a *comyntas* and an *amyntula* "type" occur in southeastern Arizona, specifically, in Cochise County and environs. So, when Downey and Christenson (1970, Proc. No. Cen. Branch—E.S.A. 25(2):89) reexamined the male genitalia of the American *Everes* and reaffirmed the fact that there are indeed "... 2 discrete morphological types (species) . . .," the genitalic identity of the "types" of *herrii* needed to be disclosed.

At this point Julian Donahue of the County Museum in Los Angeles (LACM) proved to be most helpful. He located the four specimens which seemed to match the four mentioned by Grinnell (op. cit.), "... with notes by Comstock that they are probably the true types." Oddly, these four specimens were found to be all males. Donahue then dissected the two specimens taken in July 1899. The other two were sent to me. (The lower label on these two specimens reads "*Lyc. amyntula* v. *herrii*," while the upper label says "So. Ariz. Sept 1900. Poling.") All four were found to be *amyntula*. The smaller of the two males taken September 1900 is hereby designated as the lectotype.

Bethune-Baker (op. cit.) stated that the original four specimens were taken in Cochise County. To get more specific than that requires some conjecture. All known males of *Everes* from the Chiricahua and Peloncillo mountains have proven to be *comyntas*. A

female in the LACM collection taken by V. W. Owen in the Chiricahua Mtns., 9 May 1910, has considerable blue dorsal scaling and does appear to be an *amyntula*. Barnes and McDunnough (op. cit.) based their work on a large series from the "... Huachuca Mtns. and other mountain chains of S.E. Ariz." Since the publication of their work some 65 years ago, only a handful of *Everes* has been taken in the Huachuca Mtns., all of which have been *amyntula*. Also, *amyntula* has been confirmed from the Patagonia Mtns., just west of the Huachucas, but in Santa Cruz County. In light of the apparent absence of *comyntas* from the Huachuca Mtns., the mention of Barnes and McDunnough (op. cit.) of their 'large' series from that area, and the confirmed occurrence of *amyntula* in that area, it is here suggested that the Huachuca Mtns. are the probable type locality of *herrii*.

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NATURAL HISTORY OF *HYPNA CLYTEMNESTRA* CR.
(NYMPHALIDAE) IN COSTA RICA

With the exception of several old reports (e.g., Muller, 1886, Zool. Jahrb. Zeitschr. Syst. Geogr. Biologia der Tiere, Jena 1:417-678; Rober, 1914, *In* Seitz, Macrolepidoptera of the World, Vol. 5, Stuttgart, A. Kernan Verlag, 516 pp.) and a few recent studies (e.g., Muysshondt, 1973a, J. Lepid. Soc. 27:294-302; Muysshondt, 1974, J. Lepid. Soc. 28:81-89; Muysshondt, 1975, J. Lepid. Soc. 29:168-176), little has been published on the larval host plants and early stages of the Neotropical Charaxinae or Charaxidae (Nymphalidae). Emphasis is given to this fact by the statement of Rober (op. cit.) that only the pupa stage is known for the three species of *Hypna*. It is generally known, however, that the closely allied genus *Anaea* exploits a variety of larval host plants in different families, including the Lauraceae, Flacourtiaceae, and Euphorbiaceae (Muysshondt, 1973a, 1974, 1975, op. cit.; Young, 1981a, Acta Oecologia 2:17-30), and it would therefore, not be surprising to discover a similar feeding pattern for *Hypna*. In this note I report the description of larval and pupal stages of *Hypna clytemnestra* Cramer from one locality in Costa Rica, and also report the larval host plant to be *Croton* sp. (Euphorbiaceae). Both Rober (op. cit.) and Riley (1975, A field guide to the butterflies of the West Indies, London, Quadrangle, 224 pp.) confirm the lack of data on larval host plants of the genus as well as information on the early stages.

In Costa Rica, *H. clytemnestra* is very rare on the eastern slopes of the Cordillera Central (based on observations by Young, 1968-1982). I have captured a few adults at "Finca La Tigra," near La Virgen (10°23'N, 84°07'W; 220 m elev.), Heredia Province, during the short dry season (February-March). On 19 February 1981 a single "*Anaea*-type" caterpillar was discovered on a 4-meter tall *Croton* sapling (Fig. 1) at the edge of a steep forest ravine at Turrialba (9°54'N, 83°41'W; 602 m elev.), Cartago Province. As with the La Tigra site, this region is classified as Premontane Tropical Wet Forest. This caterpillar was subsequently reared by confining it with fresh host plant cuttings in a large clear-plastic bag. The single host plant individual was searched for additional caterpillars, but none were found. At the time of its discovery, the caterpillar was in the third instar. The ant, *Zacryptocerus scutulatus* (F. Smith), was abundant on the leaves and stems of the plant but did not interact with the *Hypna* caterpillar.

The single individual of *Croton* sp. with the caterpillar was the only one found within a 400-meter strip of the forest perimeter checked.

Following eclosion, the butterfly was identified as *Hypna clytemnestra* and probably the subspecies *clytemnestra* Cramer, given discussion of geographical distribution (e.g., Comstock, 1961, Butterflies of the American tropics, the Genus *Anaea*, Lepidoptera, Nymphalidae, New York, Amer. Mus. Nat. Hist., 214 pp.). In captivity the larva molted twice, suggesting that it was in the third instar at the time of discovery, since related forms typically have five instars (Muysshondt, 1973a, 1974, 1975, op. cit.; Young, 1981a, op. cit.). The third instar grew from 15 mm to 23 mm in five days and remained mottled in shades of green and brown. The head is studded with tiny whitish tubercles and one pair of stubby horns on the apex of the epicrania (Fig. 2). Alternating thoracic and abdominal segments bear bulbous tubercles of varying size and studded with tiny tubercles (Fig. 2). The spiracles are black. Third and fourth instars construct a silk-encased perch from the exposed midrib of a mature leaf of the food plant (Fig. 2). The larva rests and feeds from this perch (Fig. 2). In the fifth instar, which attains a length of 41 mm by the time of pupation, the thoracic and abdominal tubercles are reduced in size, but now each one bears a thick black spine (Fig. 2). The head is laterally flattened, with many tubercles (Fig. 2). In this instar the larva, in captivity, rests on the ventral side of the leaf. When disturbed or walking, the larva typically wobbles from side to side, walking forward a bit, and then backwards a bit, before moving ahead. The "wobbling" motion is also exhibited when the larva is reinforcing its silken perch with additional threads of silk. The head capsules of the fourth and fifth instars are shown in Fig. 3.

Pupation involves the larva assuming the "J" position, in this instance from the stem



FIG. 1. The sapling-size individual of *Croton* sp. (Euphorbiaceae) where a single third instar larva of *Hypna clytemnestra* was discovered. The plant in question is shown here immediately above the butterfly net. Note the large heart-shaped leaves of the sapling. See text for locality and habitat information.

of a leaf. As a prepupa the larva remains tightly curled, and the pupa is initially uniform green. Within twenty-four hours, however, the pupa (Fig. 4) turns dark green and develops a patchwork of silvery pubescence, particularly on the wing pads (Fig. 4). The pupa measures 20 mm long by 13 mm at its widest girth and laterally. The head is slightly forked, spiracles are yellow, and the cremaster red. At the posterior edge of

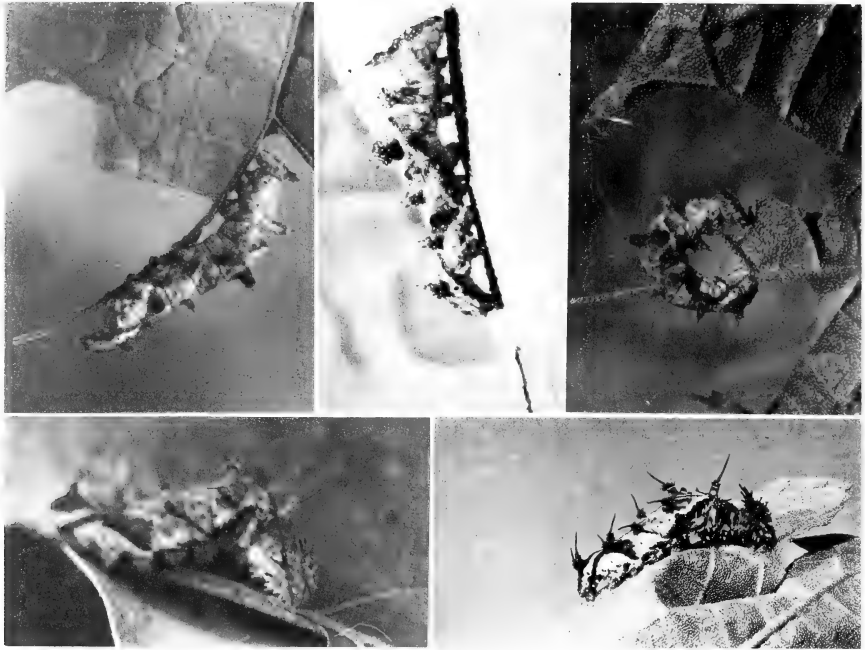


FIG. 2. The larva of *Hypna clytemnestra* and habits. **Top**, left to right: third instar in resting and feeding positions on the midrib perch at the tip of a leaf. **Bottom**, left to right: fifth instar.

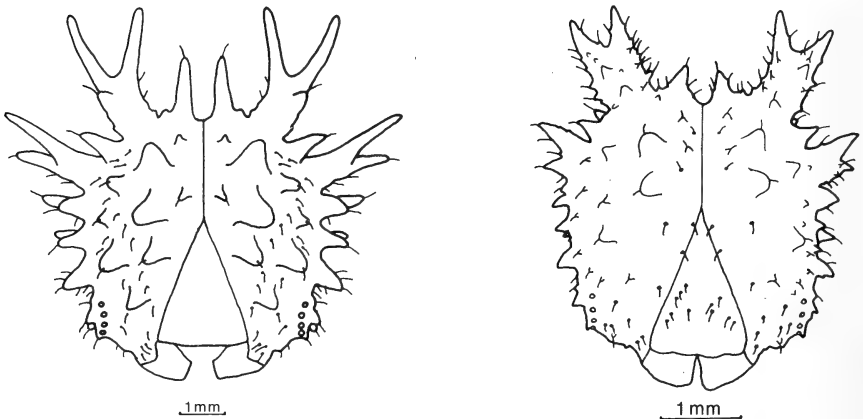


FIG. 3. Frontal view of head capsules of fourth (rt.) and fifth instars of the larvae of *Hypna clytemnestra*.

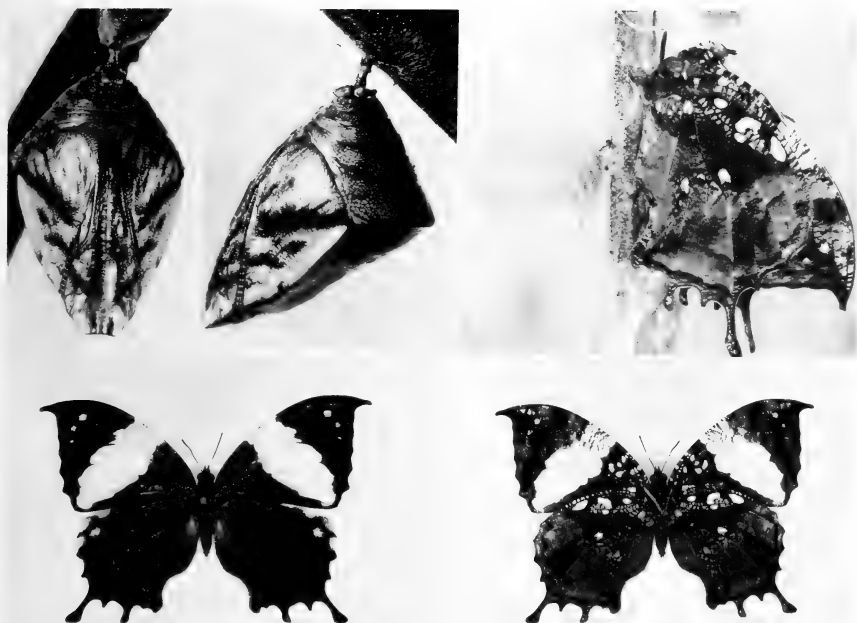


FIG. 4. Pupa, eclosion, and adult *Hypna clytemnestra*. **Top**, left to right: pupa ventral and lateral views respectively, and newly-eclosed adult resting adjacent to empty pupa shell. **Bottom**, left to right: dorsal and ventral views of the single reared adult.

the fifth abdominal segment there is a prominent ridge, marked by a thin line of gold color. On the day of eclosion the adult butterfly is seen clearly through the cuticle. The pupa stage lasted 16 days at the Milwaukee Public Museum room temperature (about 23°C at 3 PM). Eclosion (Fig. 4) is rapid, lasting about three hours. The adult obtained was a male with forewing length of 42 mm (Fig. 4).

This report constitutes the first description of the larval and pupal stages of *H. clytemnestra* and a larval food plant record. The Neotropical Charaxinae exploit a variety of plant families as larval food plants (Ehrlich & Raven, 1965, *Evolution* 18:586-608; Muysshondt, 1973a, 1974, 1975, *op. cit.*; Young, 1981a, *op. cit.*) and Muysshondt (1975, *op. cit.*) reported *Anaea (Memphis) pithyusa* R. Felder feeding on *Croton* in El Salvador. Other genera or subgenera are associated with other plant families. To this list we add that *Hypna*, although very distinct from *Memphis* in terms of the appearance and behavior of the early stages (larva and pupa) as well as adult characteristics, also exploits *Croton*. Furthermore, some genera or subgenera within the Charaxinae or Charaxidae may be associated with more than a single plant family. Young (1981a, *op. cit.*) found *Anaea (Memphis) morvus* feeding on *Nectandra* sp. (Lauraceae) in Costa Rica, while *A. (M.) pithyusa* feeds on *Croton* (Euphorbiaceae) in El Salvador (Muysshondt, 1975, *op. cit.*). Geographical changes in larval food plant associations at the genus or subgenus levels, or changes in such associations for different species may be operative, although further studies are required. Such data points to the difficulty in using food plant data in the determination of evolutionary lineages at levels lower than families or subfamilies in the Lepidoptera. Contemporary selection pressures may have

obliterated or changed the original food plant association (Janzen, 1980, *Evolution* 34: 611–612).

The distinctive dorsal tubercles of the larva of *Hypna*, and its characteristic "wobbling" behavior, represent two other phenotypic traits very different from most other Charaxinae. Midrib-perching is shared with other subgenera such as *Zaretis* and *Consul* (see Muysshondt, 1973a, 1974, op. cit.; Young, 1981a, op. cit.). Although *Hypna* is widespread in South America (Comstock, op. cit.) it is predicted to be associated with *Croton* through its range. There are no published records of *H. clytemnestra* from Costa Rica, although the form *clytemnestra clytemnestra* is known from Nicaragua and Panama, and also ranges from Colombia to Brazil (Comstock, op. cit.). As with most other tree or vine-exploiting nymphalids, and particularly the Nymphalinae and Charaxinae or Charaxidae (e.g., Young, 1981b, *J. Lepid. Soc.* 35:155–157), this species occurs primarily in tropical wet forests.

Muysshondt (1973b, *J. New York Entomol. Soc.* 81:164–174) reports the larval food plant of *Catonephele numilia esite* Felder in El Salvador to be *Alchornea latifolia* Swartz in the Euphorbiaceae, and places this species within the Catonephelinae. Such discoveries indicate the joint exploitation of the same plant family by different evolutionary lineages within the Nymphalidae. As discussed by Muysshondt (1975, op. cit.), Rydon (1971, *Entomol. Rec. J. Var.* 83:219–388) places the subgenera *Hypna*, *Anaea*, *Polygrapha*, *Consul*, and *Memphis* in the subfamily Anacinae as full genera. As mentioned above in terms of geographical and ecological determinants of larval food plant associations in Neotropical nymphalids, the euphorbiaceous-feeding habit of the larval stages of *Hypna* and *Memphis* probably cannot be used to support the view of a close evolutionary association between these two genera or subgenera (the latter, adopting Comstock's 1961 classification). Furthermore, the larva of *Hypna* is quite distinct both morphologically and behaviorally from that of *Memphis* (see Muysshondt, 1975, op. cit.). The pupa stage of *Hypna* is closer in general appearance to that of *Consul* (Muysshondt, 1974, op. cit.) than it is to that of *Memphis*, yet *Consul* is a piperaceous-feeder (Muysshondt, 1974, op. cit.).

ACKNOWLEDGMENTS

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LLOYD M. MARTIN MEMORIAL RESEARCH FUND

On 28 January 1982 a chapter in the annals of western Lepidopterology came to an end with the death of Lloyd Martin in Fresno, California. He was 69 years of age.

In 1969 Lloyd retired from the Natural History Museum, where he had been curator of Lepidoptera for 33 years. He was a charter member of The Lepidopterists' Society and served our organization in many capacities, including a term as President in 1972. For more than 50 years he had been a member of the Lorquin Entomological Society, in which he held important offices for many years.

Lloyd's many friends and colleagues will miss his irreverent and earthy humor, his humanity, his devotion to the study of Southwestern Lepidoptera, and his constant support and encouragement of young entomologists.

In tribute to his many significant contributions to the study of Lepidoptera, the Natural History Museum of Los Angeles County has established the "Lloyd M. Martin Memorial Lepidoptera Research Fund," to support the fields of inquiry to which he devoted most of his life and energies. Specifically, this fund will encourage field research in unexplored or little-known localities and the acquisition, preparation, and study of moths and butterflies of the western United States.

Contributions to this Memorial Fund may be of any size, payable to "LACM Foundation" and mailed to my attention.

JULIAN P. DONAHUE, *Los Angeles County Museum of Natural History, 900 Exposition Boulevard, Los Angeles, California 90007.*

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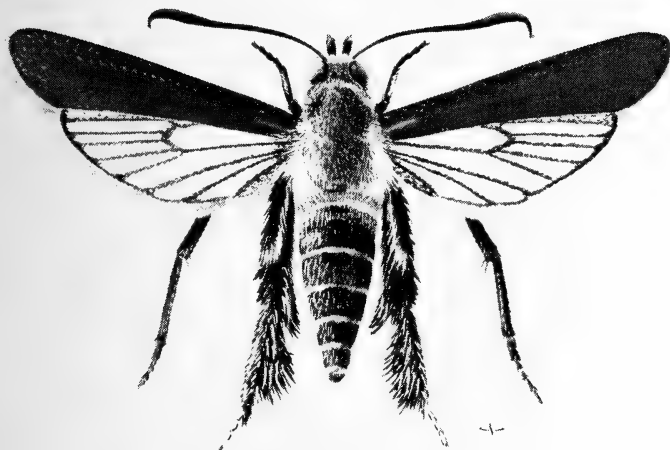
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Cover illustration: Adult of the squash vine borer, *Melittia cucurbitae* (Harris) (Sesiidae), which occurs in the eastern half of the United States and along the Gulf Coast into Vera Cruz, Mexico. The larvae are destructive borers in the vines of various cultivars of *Cucurbita* spp. (squash, pumpkins and gourds). Original drawing by Dr. Charles S. Papp, Sierra Graphics & Typography, 1722 J Street #19, Sacramento, CA 95814, USA.

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TERRITORIAL BEHAVIOR OF *NYMPHALIS ANTIOPA* AND *POLYGONIA COMMA* (NYMPHALIDAE)

ROYCE J. BITZER AND KENNETH C. SHAW

Department of Zoology, Iowa State University, Ames, Iowa 50011

ABSTRACT. The behavior of perching *Nymphalis antiopa* and *Polygonia comma* is described. Males of both species occupy and defend specific areas or territories. Territories of *N. antiopa* are much larger than those of *P. comma*. *P. comma* males, like *Vanessa atalanta*, patrol and defend the same areas. In contrast, *N. antiopa* males defend areas much larger than areas patrolled and change perch sites frequently. Territorial behavior of these two species and that of *V. atalanta* are compared and attempts are made to explain differences among the three species on the basis of varying degrees of competition for mating sites and females.

Male butterflies adopt one of two general strategies for locating mates, perching or patrolling (Scott, 1974). Patrolling species search for females, whereas perching species perch on trees, bushes, herbs or the ground and wait for females to fly by. Many of the fast flying, relatively short-winged nymphalids are perching species (Joy, 1902; Shields, 1967; Baker, 1972; Dimock, 1978; Bitzer & Shaw, 1979(80)). Nymphalids and other perching butterflies vary in the degree of site attachment and in the intensity with which they pursue butterflies that pass near their perches. This has led to a controversy over whether male butterflies show true territorial behavior (Baker, op. cit.; Scott, op. cit.; Silbergleid, 1977; Davies, 1978; Bitzer & Shaw, op. cit.).

We have described territorial behavior in the nymphalid, *Vanessa atalanta* (L.) (Bitzer & Shaw, op. cit.). Territorial behavior in this species is characterized by 1) outlining territories by intermittent patrols, 2) perching on one or two specific sites within territories and 3) chasing all intruders, including conspecifics, butterflies of other species and birds. Conspecifics are chased vertically in a characteristic spiral, while other species of butterflies and birds are chased horizontally to the limits of the territorial boundary. In this study we describe territorial behavior of two other nymphalids, *Nymphalis antiopa* (L.) and *Polygonia comma* Harris.

TABLE 1. Characteristics of nymphalid territorial behavior.

Species	Territory size (m)	Area (m) patrolled	% males patrolled	Patrolling frequency (%)	Patrol duration (s)	Interaction frequency (h)	No. perch sites/territory
<i>N. antiopa</i>	308 ± 124.7 (28-43 × 6-13) N = 5 ^b	^a (1-11 × 1-3) N = 5	100 N = 5	16.2 (13.2 & 21.3) N = 2 n = 66 ^c	12.1 ± 9.6 (2-58) N = 2 n = 66	1.8 ± 2.0 (0.3-4.7) N = 4 n = 12	many
	12.0 ± 5.9 (3-10 × 2-4) N = 10	12.0 ± 5.9 (3-10 × 2-4) N = 10	47 N = 10	6.2 ± 3.7 (3.1-12) N = 5	18.8 ± 25.4 (4-180) N = 5 n = 28	4.9 ± 4.4 (0-10.4) N = 8 n = 43	1-3
<i>V. atalanta</i>	86.6 ± 45.3 (7-37 × 4-11) N = 29	86.6 ± 45.3 (7-37 × 4-11) N = 29	100 N = 26	9.4 ± 4.6 (1-17) N = 26 n = 420	17.2 ± 18.7 (5-70) N = 26 n = 369	23.6 ± 21.5 (0-82) N = 24 n = 1218	1-2

^a Data insufficient to determine area patrolled.^b N = number of animals.^c n = number of events.

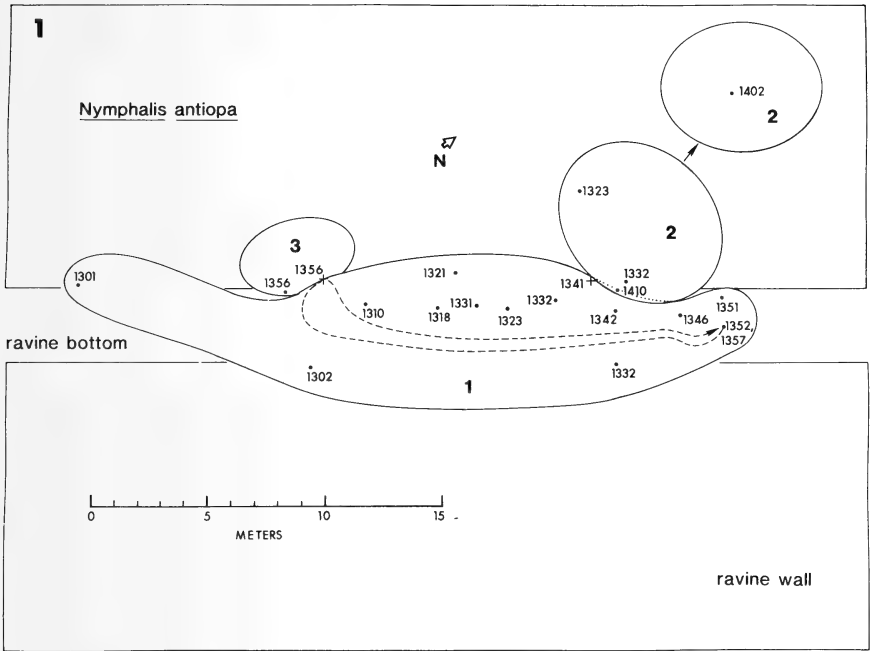


FIG. 1. Perching sites of *N. antiopa* males in ravine on 21 April 1979. Diagram shows southwest three-quarters of ravine: (●) perch sites at indicated times (CST); (—) total areas defended and patrolled by males identified by number; (+) site of interaction between adjacent males at indicated times; (---) flight path of male #1 to site of interaction with male #3 and back to same resting spot; (· · · · ·) boundary of territory #1 within boundary of territory #2.

OBSERVATIONS

Nymphalis antiopa

N. antiopa males were observed in a ravine (46 m long, 28 m wide) in Railroad Park, Ames, Iowa (a wooded, hilly area, 51.8 hectares) on 8 April 1977 and 14, 18 and 21 April 1979. Males entered the ravine between 1130 h and 1200 h (CST) and departed between 1530 h and 1600 h. Males chased other *N. antiopa* and other species of butterflies and birds from territories averaging $308 \pm 124.7 \text{ m}^2$ (Table 1). Occupants flew short patrols every few minutes, outlining areas much smaller than the area defended (Table 1). After a patrol, males seldom returned to the same perch (Fig. 1). On 21 April, during 30 successive landings, a territorial male landed 0–11 m ($\bar{x} \pm \text{S.D.} = 3.06 \pm 2.36 \text{ m}$) from his previous perch, returning to the same perch only twice.

On 18 and 21 April, males averaged 16.2 patrols/h (64 in 244 min) (Table 1) and 1.4% of their site occupation time (3.3 of 244 min) pa-

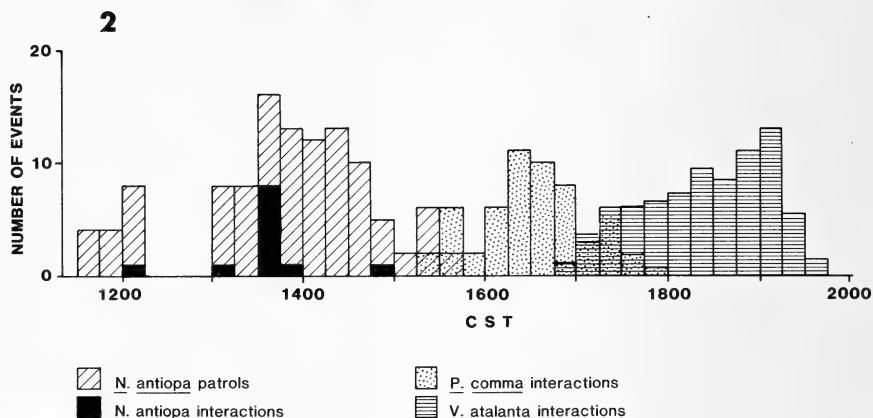


FIG. 2. Temporal distribution of activity of *N. antiopa*, *P. comma* and *V. atalanta*. *N. antiopa*—total number of patrols and interactions by single occupants for 14, 18, and 21 April 1979. *P. comma*—total number of interactions in a cluster of six perches and nine perches on 21 and 22 April 1979 respectively. *V. atalanta*—mean number of interactions/day for 10 days in mid-June 1979.

trolling. Length of patrols ranged from 2–58 seconds (12.1 ± 9.6 s) (Table 1). Frequency of patrolling was highest between 1315 h and 1445 h (Fig. 2) and was positively correlated with frequency of intruders entering the ravine. Eleven of 12 interactions occurred between 1310 h and 1450 h (Fig. 2). During the four days of observation, seven intruders entered the ravine from varying directions at an intrusion frequency of 0.8/h (7 intrusions in 528 min). The four ravine occupants (one each day) chased the seven intruders 12 times for an interaction frequency of 1.80/h (Table 1). Mean interaction time was 21.2 ± 9.9 s (range 10–40 s) and occupants spent 0.6% (3.2 of 528 min) of their time interacting with intruders.

Intruders entered the ravine flying about 5–6 m above the bottom of the ravine. The occupant flew from his perch, the angle depending upon the intruder's location, to intercept the intruder. After meeting they spiralled together and climbed vertically 10–14 m (Fig. 3). After they leveled off, the occupant chased the intruder around one-half to three-quarters of a circle, 9–15 m in diameter (Fig. 3). When circling, the occupant was usually 30–50 cm behind the intruder. Three to four times during each chase the occupant closed to within a few cm of the intruder. The intruder eventually broke out of the circle and flew out of the ravine (Fig. 3).

Because of the size of the ravine and the tendency for occupants to perch close to one end of the ravine, at times (3 times in 4 days) two

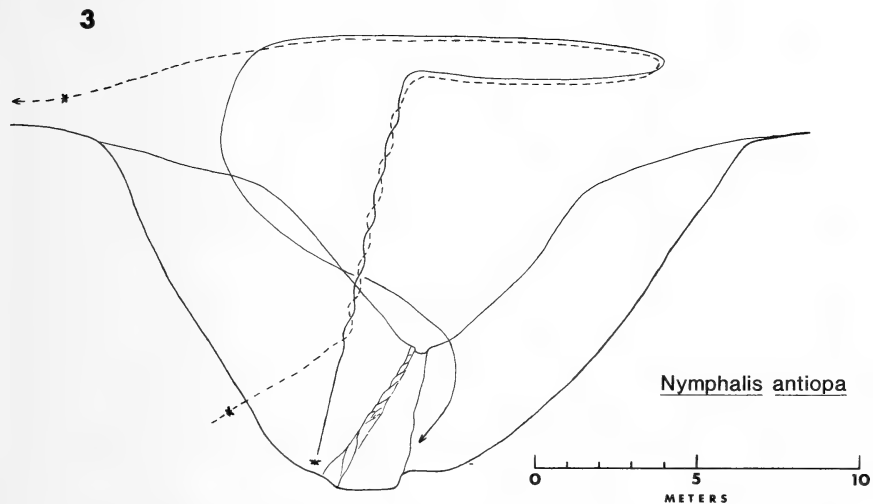


FIG. 3. Flight pattern during typical interaction between two *N. antiopa* males: (—) flight path of territory occupant; (---) flight path of intruder.

males temporarily occupied the same ravine. On 18 April the original occupant at the southwest end of the ravine patrolled northeastward and flew through a second male's territory. After six interactions (in 12 min), during which the perching sites of the two males moved northeastward toward the end of the ravine, the original occupant drove the second male out of the ravine. On 21 April the original occupant drove out two different males that temporarily perched in the ravine (Fig. 1). One intruder perched on the side of the northeast end of the ravine at 1323 h. After one interaction at 1341 h he was driven high on the slope, where he set up a small territory. He was observed patrolling and occupying the indicated resting spot at 1402 h. He remained in this new territory for at least 10 minutes, after which observations were concentrated on male #1. The same occupant drove another male out of the ravine after the intruder had perched for two minutes. In this interaction the occupant left his perch and flew about 18 m to the site of the perched intruder. When the intruder rose to meet the occupant, the intruder was driven from the ravine. The occupant apparently had spotted the intruder from his perch and eventually flew to investigate. Occupants also flew to investigate us or light-colored objects placed on a ledge near the bottom of the ravine. On 18 April the occupant flew out eight, 12 and 24 m from his perch to investigate us or the objects on the ledge.

On 14 April 1979 a female entered the ravine from the southwest.

The male intercepted her, and the interaction was similar to a male-male interaction, until they had flown about one-third of a circle. The male prodded the smaller female, who then fluttered her wings twice, three seconds apart, each flutter lasting approximately one second. When she fluttered, the yellow bands on her wing margins were highly visible. After interacting for 20 seconds, the male prodded her downward, and they both dropped into long grass near the top of the ravine. Seven minutes later we found them copulating, and they stayed in copula approximately two hours.

These observations suggest that *N. antiopa* males are unable to determine the sex of an intruder until an interaction is nearly over. By flying behind the intruder and prodding it, the male may be attempting to determine the intruder's sex. If the intruder flips its wings the occupant recognizes it as a female and prods her to drop to the ground. The vertical climb allows the butterflies to rise above the tree canopy to circle.

Besides chasing conspecifics, perching *N. antiopa* males also chased birds and falling leaves. *N. antiopa* is more discriminating than *V. atalanta* (Bitzer & Shaw, op. cit.) when chasing falling leaves. Although the wind blew many leaves into the ravine, the butterflies chased only those which drifted with a rocking motion at approximately the velocity of an intruder. On 8 April 1977 a perching male followed about 30 cm behind one of these leaves and prodded it two or three times before the latter landed on the ground. It is advantageous for a butterfly which perches in early spring not to waste time and energy chasing the large number of fallen leaves which blow about at this time. The butterflies did not discriminate between birds, however, and chased 98% of those which flew over. Their pursuits of birds suggest that *N. antiopa* males can adjust their angle of climb so as to intercept objects passing overhead at different velocities. Birds were chased horizontally until they left the ravine.

Polygonia comma

P. comma males of the Spring brood were observed on 27 March 1978 and 21 and 22 April 1979 in Railroad Park, Ames, Iowa. Males perched on fixed bare spots on the ground or on the sunlit sides of trees about 1-2 m above the ground. They began perching between 1515 h and 1530 h (CST) and left between 1715 h and 1800 h (Fig. 2). Earlier in the day (1200-1500 h) butterflies were seen flying up and down the sides of several ravines in the area.

Like *V. atalanta* (Bitzer & Shaw, op. cit.), *P. comma* males occupied one or a few fixed resting spots (Fig. 4). Unlike *V. atalanta*, they did not consistently outline a fixed territory by patrolling. On 21 April

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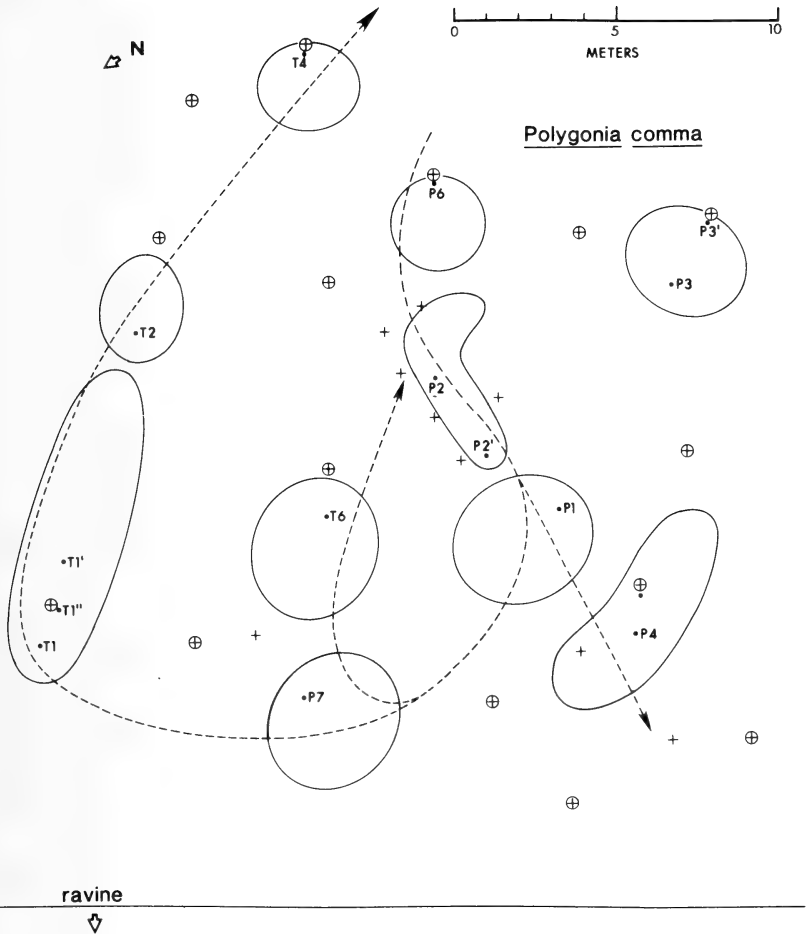


FIG. 4. Territories and perch sites of *P. comma* males on wooded hilltop, 21 and 22 April 1979: (—) areas patrolled by occupants or areas from which intruders chased; (●) perch sites; (⊕) trunk sites of canopy trees; (+) shrubs or 1-2 m saplings; (---) flight paths of intruders; (Ravine) top of south-east side of ravine in Fig. 1.

only one of the six butterflies patrolled the area around its resting spots (P2, 3 times), while on 22 April four of 10 butterflies patrolled fixed areas (Fig. 4). The areas outlined for the remaining butterflies in Fig. 4 indicate approximate areas from which passing intruders were chased. Butterflies rested on the same spots on 21 and 22 April. After one butterfly displaced another from his perch, the new occu-

pant used the same perch. This suggests that *P. comma* males, like *V. atalanta* (Bitzer & Shaw, op. cit.) choose perches by orienting to certain visual features of the environment, including light-dark contrast.

Intruders always entered from the north-northwest, and the similarity of flight paths suggests that these butterflies navigate along important visual features. On 22 April 18 of 24 patrolling butterflies flew along part or all of one of the three paths shown in Fig. 4, and four intruders went through all territories from P6 through P7 to T4. Although no data were recorded for 21 April (because so many butterflies were interacting simultaneously), most of the intruders passed through P6 and P2 while occupants chased them. Approximately 90% of these intruders continued through P1 and P7, while the remainder flew through P1 and P4 (Fig. 4).

Most interactions occurred between 1615–1645 h (Fig. 2), and the number of interactions varied among perches. Of six perches occupied on 21 April, eight interactions occurred in P1, 13 in P2, one in P3, none in P4, three in P6 and one in P7. These 26 interactions were observed in 87 minutes for a mean frequency of 17.9/h for the cluster of six perches. The greatest frequency for the cluster in a 15 minute period was 36/h between 1615 h and 1630 h. Of nine perches occupied on 22 April, 14 interactions occurred in P2, none in P3, one in P4, one in P6, none in P7, six in T1, one in T2, one in T4, and none in T6. These 24 interactions were observed in 154 minutes, giving a mean frequency of 9.4/h for the cluster. The greatest mean frequency in a 15 minute period was 16/h between 1645 h and 1700 h. The mean interaction frequency per hour per territory was 4.9 ± 4.4 (Table 1). Time of occupancy for sites with the highest frequency of interactions (P1, P2, T1) ranged from 35–115 minutes. Range of occupation for other perches was 0–30 minutes. Perches with the least number of interactions (P3 and P4) were not along the main intrusion routes.

We observed two types of *P. comma* interactions (Fig. 5). In 49 of 50 interactions the occupant dashed up at the intruder, flying about 1–2 m above the ground, and both butterflies spiraled tightly together, rising at a 50–60° angle to a height of 6–8 m in 3–5 seconds (Fig. 5A). Then the occupant began to chase the intruder up a half-circle, 40–50 m in diameter, rising at a shallower angle to 15–30 m. After one butterfly broke out of the circle, the other descended to the resting spot in a twisting path. We timed eight of these interactions, and they ranged from 12–40 seconds ($\bar{x} = 24 \pm 8.8$ s).

In the other type of interaction the occupant intercepted the intruder and both spiralled to a height of about 9 m before levelling off (Fig. 5B). Then one butterfly, 30 cm ahead of the other, dropped

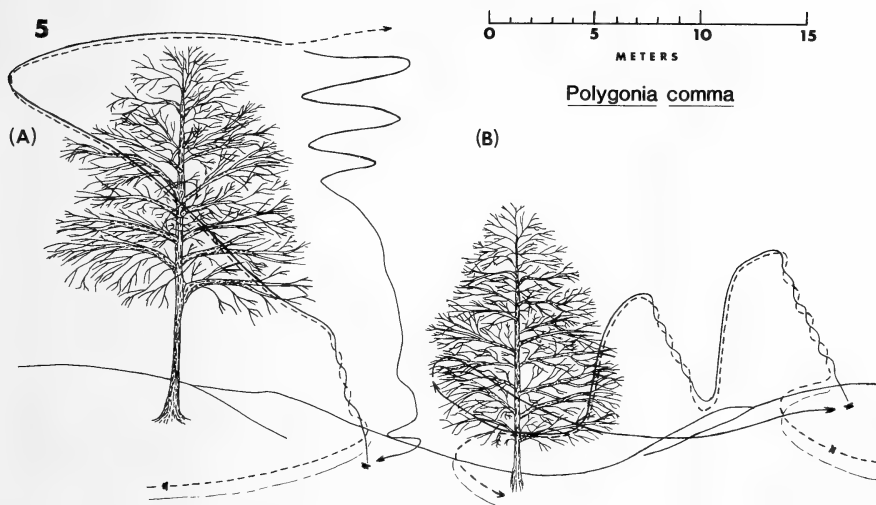


FIG. 5. Flight patterns during interactions of pairs of *P. comma* males: (—) flight path of territorial occupant; (---) flight path of intruder. **A**, typical interaction; **B**, single atypical interaction.

abruptly to about 2 m. Again the two spiralled and rose, now to about 6 m, then dropped again, this time just missing the trunk of a large tree. Once past the tree one butterfly chased the other along a straight line until both flew out of sight. Five seconds later and 30 seconds after the intruder had arrived, a butterfly flew back from the direction they had gone and landed on the perch. Baker (op. cit.) observed similar interactions in the nymphalids *Inachis io* (L.) and *Aglais urticae* (L.).

DISCUSSION

Based on Brown's (1975) definition of a territory as a "fixed area from which intruders are excluded by some combination of advertisement . . . , threat and attack," males of *N. antiopa* and *P. comma* occupy territories and exhibit territorial behavior. *N. antiopa* differs from *P. comma* and *V. atalanta* (Bitzer & Shaw, op. cit.) in that the area patrolled is not equivalent to the area defended. The behavior of the above three species is compared in Table 1, which is the basis for the following discussion. The differences among the three species may reflect varying degrees of competition for mating sites and females among the three species.

According to Huxley's (1934) "elastic disc theory," increasing competition for territories should decrease the area which can be successfully defended. *N. antiopa* males roamed over relatively large

areas of the occupied ravine, suggesting that territories were not in short supply. This was supported by the relatively low frequency of intruders and interaction frequencies, as well as the relative ease at which intruders were dislodged. This is in contrast to *V. atalanta* males which had much higher interaction frequencies and occasionally split territories with intruding males (Bitzer & Shaw, op. cit.).

Although they had the lowest interaction frequency, *N. antiopa* shows the highest mean frequency of patrolling. The latter may have been effected by the larger area which they defended and the variety of directions from which females and intruders entered the territories. The relatively large size of *N. antiopa* territories should increase the possibility that a female will fly through (Baker, op. cit.). Continually changing perches also may be correlated with the need to defend such larger territories and to spot potential mates. The relatively small areas patrolled and the shortest mean duration of patrols may be means of countering the energy demands of frequent patrols.

P. comma and *V. atalanta* males probably exhibited lower territory : male ratios (Baker, op. cit.) than *N. antiopa*. There were a greater number of *P. comma* males/unit area, and the territories (=areas patrolled and/or defended) were smaller. Although territories of *V. atalanta* are intermediate in size, there were highly desired or optimal territories that were always occupied night after night and year after year and were reoccupied within five seconds to five minutes after experimental removal of occupants (Bitzer & Shaw, op. cit.). The large number of *P. comma* males per unit area supports competition for territorial sites, but it is difficult to understand why some apparently premium sites (e.g., T1 and P1, Fig. 4) were not occupied both days of observation. The small size of *P. comma* territories apparently negated the need for patrols. There were patrols in only five territories in two days of observation and 17 of 38 patrols occurred in territory T1, the largest territory (Fig. 4).

In addition to greater competition increased compactness of territories and fixity of perch sites also could be effected by increasing tendency for intruders to enter defended areas along specific flight paths. Constancy of flight paths could be the result of at least two factors, prominent visual features and tendency for females to fly through as many male territories as possible. Baker (op. cit.) suggests that the nymphalids *Inachis io* and *Aglais urticae* establish mating territories along visual lines of demarcation, such as hedges, walls and rows of trees. Optimal territories (those most frequently occupied and with the highest frequency of interactions) of *V. atalanta* occurred where sidewalks intersect and near sides of buildings on the Iowa State University campus (Bitzer & Shaw, op. cit.) and along the

tree-lines of forest margins in more natural habitats (Bitzer & Shaw, unpublished observations). Females of polygynous species have greater investment in offspring than males and should be very selective of mates (Trivers, 1972). The opportunity to fly through a number of male territories, possibly two or more times, along a given flight path (Fig. 4) should greatly enhance a female's ability to choose a genetically superior male, possibly expressed by his ability to occupy a highly contested territory, his chasing vigor or endurance, and/or the nature of his aphrodisiac (see discussion of the possibility that males of polygynous insect species have individual "signatures" which females can use to identify them during a testing period; Lloyd, 1981). If females do fly along specific, visually demarcated lines and through as many territories as possible, there should be intense competition for territories along these lines. Non-territorial males would be expected to fly the same paths, assessing, during their flight interactions with territorial males, the feasibility of attempting to displace a territory holder or of establishing a new territory.

When competition is intense males would benefit if they could recognize females early in an interaction. The observation of one male-female interaction suggests that *N. antiopa* males may not recognize an intruder's sex until late in the interaction (approximately 20 s after the beginning of the interaction). In contrast, *V. atalanta* males may be able to discern an intruder's sex within five seconds after first encountering an intruder. When interaction frequencies are high and there is an increased risk that another intruder will occupy his territory before he can drive the current intruder away, a *V. atalanta* male will cut the interaction short after a few seconds of hovering by driving him horizontally to the edge of his territory (Bitzer & Shaw, op. cit.). One suspected male-female interaction supports rapid sex recognition. After a few seconds of hovering with an intruder, the two butterflies dropped downward through a bush (a move not unlike that of the *N. antiopa* male and female; Bitzer and Shaw, unpublished observations). Unfortunately, an extensive search failed to uncover the pair.

A number of perching species, including some nymphalids, continually change perches, and this has led some investigators to doubt whether any perching butterflies are territorial (Scott, op. cit.). If males change perches this suggests that there is no selective advantage to occupying a fixed perch. *N. antiopa* males defend areas larger than they patrol; therefore, it is advantageous for them to change perches within the defended area. Since mating territories of many nymphalids are chosen, not for female resources they contain, but because they possess prominent visual markers affecting female flight paths

(Baker, op. cit.; Bitzer & Shaw, op. cit.), lack of prominent visual markers would negate males occupying fixed perches. Shields (op. cit.), in his study of hilltopping species, reported that three species of *Vanessa*, including *V. atalanta*, changed perches frequently. A published photograph of the study area indicates scrub vegetation showing little variation in height and apparent lack of easily differentiated visual lines of demarcation. Scott (op. cit.) reports four species of butterflies with different mate-locating behaviors in different parts of their ranges. Males from different populations of two species chose different topographic features for perching sites; in the other two species, some populations perched while others only patrolled. Whether a species occupies, defends and/or patrols fixed areas may be conditional upon local ecological conditions, such as availability of easily demarcated visual lines, predation pressure, and density of conspecific and interspecific competitors.

If ecological conditions affect fixity of perch sites between species and between populations of the same species, could they affect flight patterns used by occupants to pursue intruders? In our earlier paper (Bitzer & Shaw, op. cit.) we suggested that the vertical spiral helix of *V. atalanta* facilitated the occupant dropping quickly back into his territory to pursue other intruders, while possibly disorienting the intruder in the overhead canopy. In contrast the series of dives and climbs of *I. io* and *A. urticae* (Baker, op. cit.) seem more adapted to driving the intruder up to 200 m from his territory in open country. Baker showed that the distance that intruders are driven from the territory is a compromise between the distance necessary to reduce the chance of the intruder returning and the time required for the owner to return before his territory is occupied by another conspecific. The flight pattern of *N. antiopa* (Fig. 3) appears adapted for driving the intruder to the edge of the ravine and out of sight of the ravine bottom. The two flight patterns of *P. comma* suggest that this species may be able to adapt its flight pattern based upon the nature of the tree canopy and the intensity of competition for perching sites. Forty-nine of 50 occupant-intruder interactions involved driving the intruder above the canopy. However, one interaction was very similar to that of *I. io* and *A. urticae*, which characterize butterflies of more open terrain.

Interspecific competition for perching sites, such as occurs in hilltopping species (Shields, op. cit.), may result in selection for species to mate at different times of the day. Otherwise, perching butterflies would expend considerable energy chasing intruders of other species. Pairs of the three species reported on here may have undergone such selection. The territorial periods of *N. antiopa* and *P. comma* and

those of *P. comma* and *V. atalanta* overlap slightly, i.e., when territorial activities are just beginning or just terminating (Fig. 2). *N. antiopa*'s preference for ravines also may spatially isolate them from *P. comma*. However, one observation emphasizes the importance of temporal isolation between these two species. *N. antiopa* and *P. comma* males occupied the same area on different days, a level area near the top of a ravine.

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A NEW SPECIES OF *AGROTIS* OCHS. (NOCTUIDAE) FROM SABLE ISLAND, NOVA SCOTIA

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ABSTRACT. A new species of *Agrotis* Ochs. from Sable Island, Nova Scotia is figured and described.

Recent biological surveys of Sable Island, Nova Scotia by the staff of the Nova Scotia Museum have added much to the local knowledge of the Lepidoptera of the island. One of the more interesting captures taken during these studies was a small series of pale *Agrotis* Ochs. resembling *Agrotis volubilis* Harv. and *Agrotis stigmosa* Morr. (formerly *Agrotis volubilis* f. *stigmosa* Morr.). Subsequent investigation of these specimens plus additional material collected by the staff of the Biosystematics Research Institute, Ottawa, during the summer of 1967 showed that they represented an undescribed species with distinguishing characters in the female genitalia.

Agrotis volubilis occurs from Newfoundland (Morris, 1980) and Nova Scotia (Ferguson, 1954) south to North Carolina, west to the Pacific (Forbes, 1954). *Agrotis stigmosa* occurs from Massachusetts west to North Dakota (Ahmandi, 1979). The early stages and host plants of *A. stigmosa* are unknown. The larva of *A. volubilis* has been reared from *Achillea millefolium* L. (McCabe, 1981).

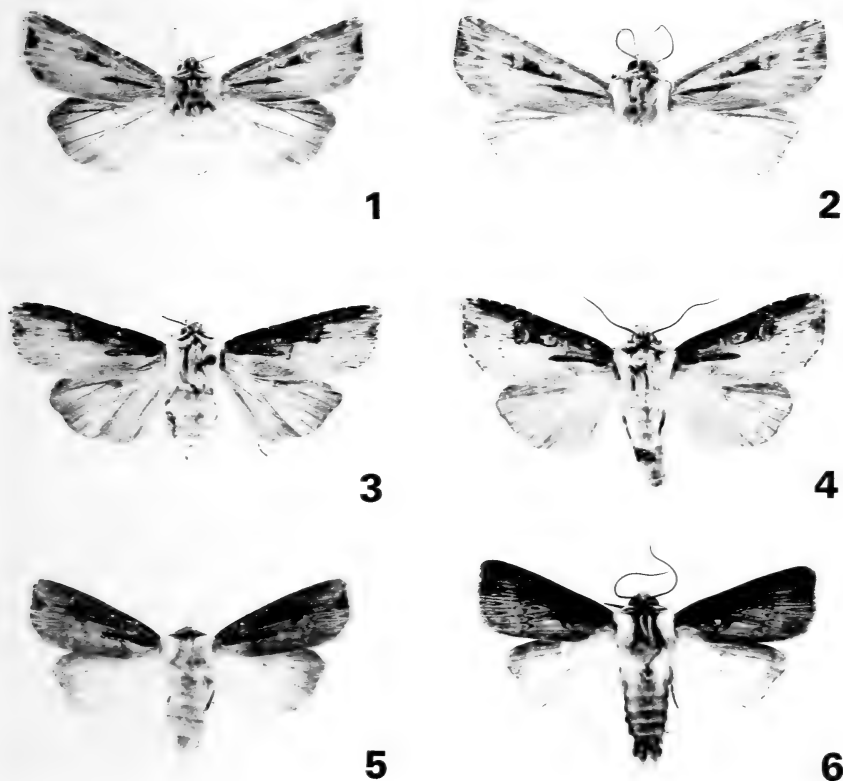
***Agrotis arenarius*, new species**

Description. Upperside of forewing overall much lighter and with lines and markings less distinct than in *volubilis* and *stigmosa*. Ground of forewing light sandy brown. Costal area slightly darker with some light-grey scaling along R and Cu. A dark "W"-shaped patch present in terminal area opposite cell. Subterminal area with a series of dark, elongate, "V"-shaped marks between the veins. Reniform and orbicular spots concolorous with costa, overlain with light-grey scales and brown annuli. Reniform outlined on inner and outer edges with a narrow band of black scales. Orbicular with a similar outline on posterior half. Area between reniform and orbicular and on outer edge of reniform darker. Basal dash and claviform spot fused, outlined with black and filled with dark brown. Postmedial and antemedial lines present but faint and indistinct, most readily visible as light-brown patches at costa. Fringe concolorous.

Upperside of hind wing lighter in male, mainly dirty white with a fuscous border. Hind wing of female more suffused with fuscous overall. Veins and discal spot in both sexes delineated with darker brown scales. Fringe white.

Underside of forewing with markings as in *stigmosa* and *volubilis* but much lighter, lacking the brownish shades present in those species. Ground of undersides light sandy brown. A darker shade present in cell extending from base to postmedial line. Subterminal and postmedial lines darker and distinct. Discal spot blackish.

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FIGS. 1-6. *Agrotis* spp.: **1**, *A. arenarius* ♀, holotype; **2**, *A. arenarius* ♂, allotype; **3**, *A. stigmosa* ♀, Chatham Lab., Light Trap, 28 May 1935; **4**, *A. stigmosa* ♂, Brooklyn, Long Island, New York, 13 May 1903; **5**, *A. volubilis* ♀, Kentville, King's Co., Nova Scotia, 24 May 1979; **6**, *A. volubilis* ♂, Sheffield Farm near Canning, King's Co., Nova Scotia, 10 June 1980. All about $\times 2$.

Underside of hind wing dirty white. Costal area darker. Discal spot blackish.

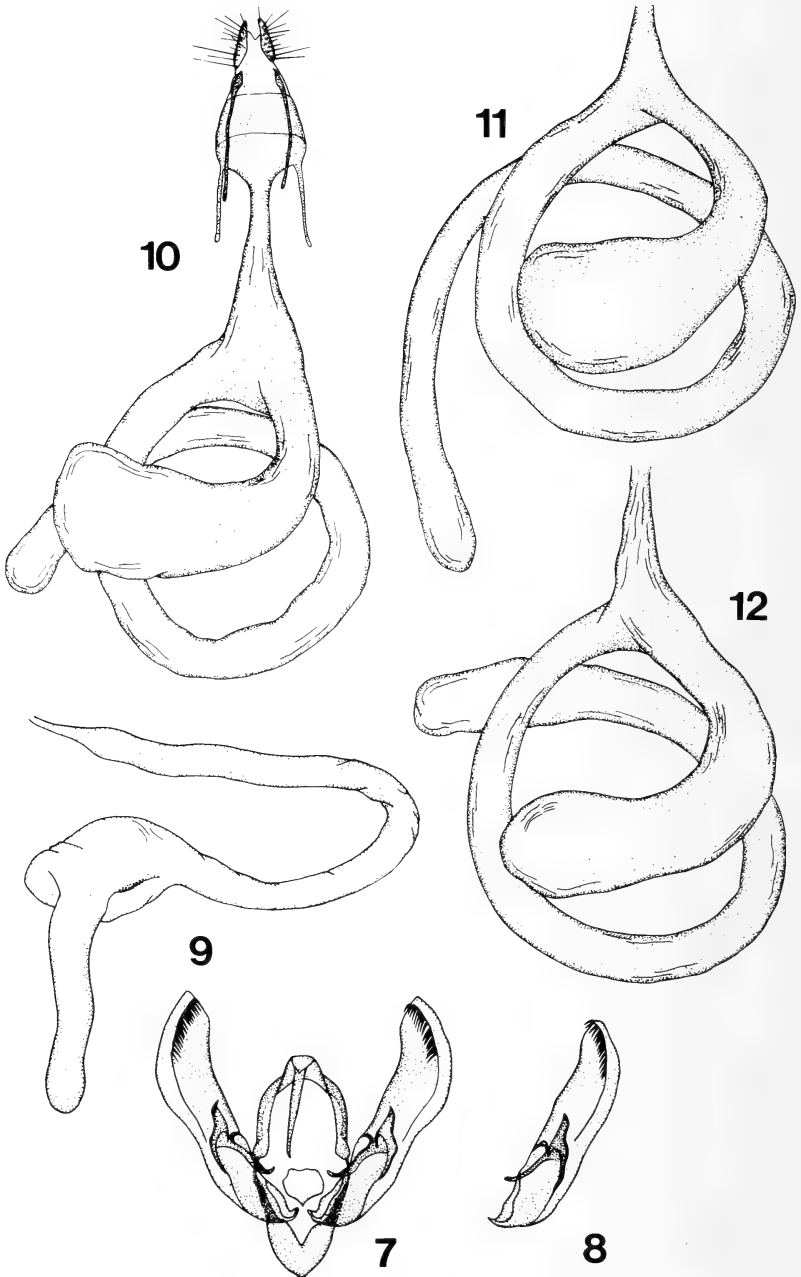
Vestiture of head and body as in *stigmosa* and *volubilis*. No visible differences in antennae, palpi, or other external structures.

Length of forewing: males, 13.8-17.7 mm; females, 16.7-18.5 mm; holotype female, 18.3 mm; allotype male, 17.2 mm. Mean wing length: male paratypes (10), 17.44 mm; female paratypes (6), 17.83 mm.

Male genitalia (Figs. 7-9). Identical to those of *Stigmosa* and *volubilis*. In some specimens of *arenarius* the valve is more convex apically, but this is a variable character and cannot be used to separate *arenarius* from *stigmosa* and/or *volubilis*.

Female genitalia (Fig. 10). Appendix bursae shorter in *arenarius* than in both *stigmosa* (Fig. 12) and *volubilis* (Fig. 11). Female genitalia otherwise similar.

Types. HOLOTYPE: ♀, Henry House, Sable Island, Nova Scotia, 2 July 1980, E. Quinter (Fig. 1). ALLOTYPE: ♂, Same data as holotype but taken 4 July (Fig. 2). PARATYPES: 1 ♂, 1 ♀, same data as holotype but taken 3 July 1980; 1 ♂, 1 ♀, same data as



FIGS. 7-12. Genitalia of *Agrotis* spp.: 7, *A. arenarius* ♂, allotype, aedeagus omitted; 8, *A. arenarius* ♂, right valve of paratype, Sable Island, Nova Scotia; 9, *A. arenarius* ♂, aedeagus of allotype; 10, *A. arenarius* ♀, holotype; 11, *A. volubilis* ♀, Sheffield Farm, King's Co., Nova Scotia; 12, *A. stigmosa* ♀, Chatham Lab., Light Trap.

holotype; 2 ♂♂, same data as allotype; 4 ♂♂, 2 ♀♀, same data as holotype, 3 ♂♂, 1 ♀, Meteorological Station, Sable Island, Nova Scotia, 15 July 1977, B. Wright; 1 ♀, West Light, Sable Island, Nova Scotia, 25 July 1976, B. Wright. Holotype and allotype have been deposited in the American Museum of Natural History collection. Paratypes have been deposited in the Canadian National Collection, Nova Scotia Museum, and the K. Neil collection.

Distribution. This species is known only from Sable Island, Nova Scotia.

Early stages. Unknown, but appears to be associated with *Ammophila breviligulata* Fern., as adults have been taken most commonly where the grass is most abundant on Sable Island.

REMARKS

Arenarius represents the second endemic moth to be recorded from Sable Island, the first being *Orgyia leucostigma sablensis* Neil and like that species, represents a Pleistocene relict which survived glaciation on the offshore refugium of which Sable Island is the last trace. Adults have been taken from early June until late July.

ACKNOWLEDGMENTS

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A NEW SPECIES OF *SCHINIA* (NOCTUIDAE)
FROM MANITOBA AND SASKATCHEWAN WITH
DESCRIPTION OF ITS LIFE HISTORY

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ABSTRACT. *Schinia verna*, closely related to *S. honesta* (Grote), is described as new. The new species is a resident of the parkland belt of Manitoba and Saskatchewan and feeds in the larval stage in the flowering heads of *Antennaria neodioica* Greene. The immature stages of the new species are described.

While undertaking field work in the Glenboro area of southern Manitoba in the spring of 1979, my wife and I collected and reared a new species of *Schinia*, closely related to *Schinia honesta* (Grote, 1881). The following year a specimen of the undescribed species, collected at Saskatoon, Saskatchewan, was submitted to the Biosystematics Research Institute, Agriculture Canada, Ottawa, for identification.

***Schinia verna*, new species**
(Figs. 1, 2)

Description. Eyes greatly reduced, elliptoid. Antennae filiform in both sexes. Foretibia with a conspicuous, elongate apical spine on inner side and a shorter apical spine on outer side; two or three additional slender, inconspicuous spines on either side of foretibia proximal to apical spines.

New species smaller and paler than *Schinia honesta* (Fig. 3), which it most closely resembles in maculation. New species with dark areas of wing suffused with reddish and with pale areas more extensive than in *honesta*.

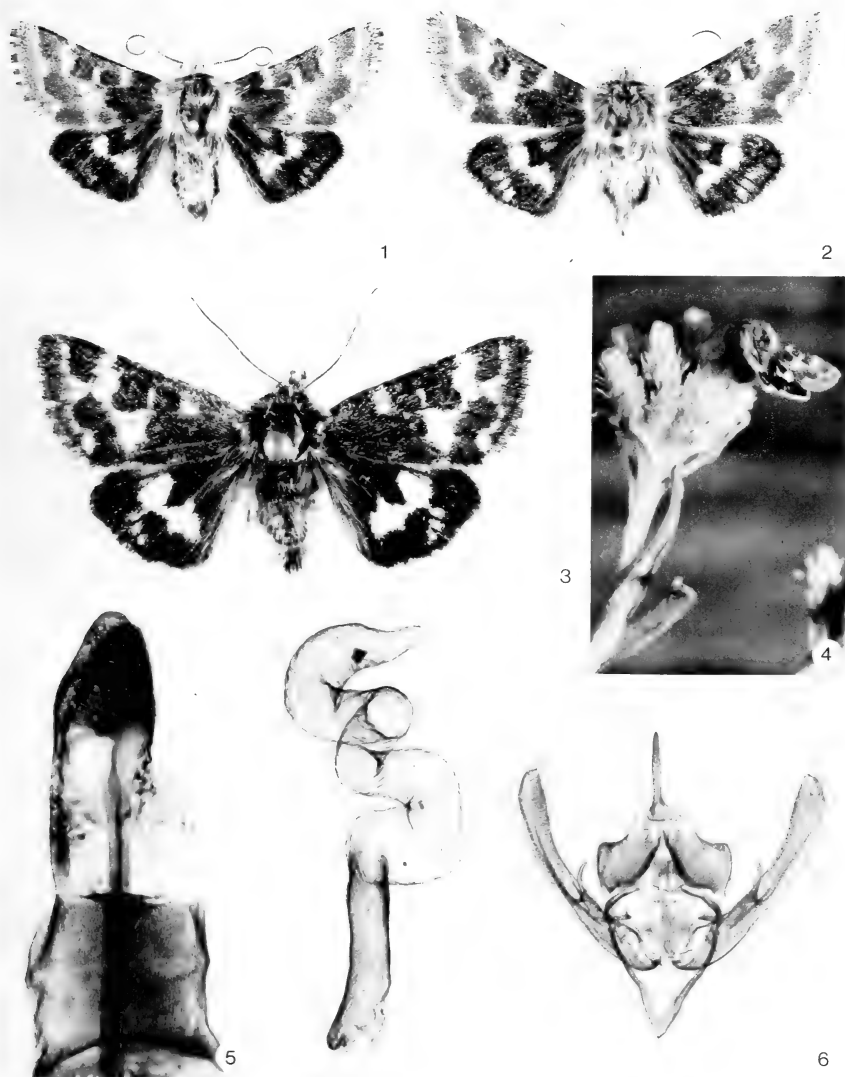
Vestiture of head and thorax hair-like, light grey suffused with mauve; abdomen black-scaled with an overlay of pale-grey hair. Underside of body white.

Forewing olive-brown, heavily suffused with mauve or reddish-brown and marked with light grey and white. Reddish suffusion lost in worn specimens. Transverse anterior line indicated only by color change, roughly triarcuate, the median arc very broad and deep; often an elongate narrow notch anterior to median arc. Basal space olive-brown, suffused with reddish; pale grey at immediate base. Transverse posterior line sinuous, evident as a grey shade or indicated only by color change. Median space white, shaded with grey posteriorly and often with a narrow grey band along costal margin. Orbicular spot prominent, circular. Reniform spot only slightly larger than orbicular; both spots concolorous with basal space. Subterminal line white, forming an inward notch opposite cell and another toward anal angle. Subterminal space concolorous with basal space, often shading to grey proximally. Terminal space pale grey. Fringe grey with white points.

Hind wing black, with a white central area containing a large black discal spot. Some pale shading in black outer-marginal area. Fringe white with a darker basal shade.

Underside of forewing white with a black basal dash, black reniform and orbicular spots and black and grey subterminal band. Fringe white with dark intervenal dashes. Underside of hind wing white with a dark-grey discal spot and dark-grey patch near anal angle; suffused with grey basally. Fringe white.

Expanse: 19.9 ± 1.6 mm (16 specimens).



FIGS. 1-6. *Schinia* spp.: **1 & 2**, *S. verna*, n. sp., holotype and allotype, Glenboro, Manitoba; **3**, *S. honesta* (Grote), Monument Pk., Linn Co., Ore.; **4**, *S. verna* ovipositing in head of *Antennaria neodioica* Greene; **5**, *S. verna*, female genitalia; **6**, *S. verna*, male genitalia.

Male genitalia (Fig. 6). Indistinguishable from those of *honesta* (see Hardwick, 1958, p. 69), except for their proportionately smaller size.

Female genitalia (Fig. 5). Very similar to those of *honesta* and differing chiefly in the conformation of the ovipositor valve, which is broadly rounded apically in *verna* rather than pointed as in *honesta*.

Type material. HOLOTYPE: ♂, Glenboro, Manitoba, 11 June 1979, D. & V. Hardwick. ALLOTYPE: ♀, same locality and collectors, 6 June 1979. PARATYPES: 8 ♂♂, 6 ♀♀, Glenboro, 9 to 12 June 1979, D. & V. Hardwick; 1 ♂, Saskatoon, Saskatchewan, 23 May 1980. The type material is in the Canadian National Collection (Type No. 16876).

Life History and Habits

The population of *Schinia verna* from which the type series was taken is located in south-central Manitoba, north of Glenboro, in an area which has recently been incorporated into Spruce Woods Provincial Park. The meadow which constitutes the habitat of the species here is in a semi-wooded region of spruce and aspen. It was formerly part of the farm of Mr. Wm. Shewfelt and is still grazed by his cattle; the meadow supports a variety of spring-blooming plants.

Two species of *Antennaria* (pussy toes), are present in the area, *A. neodioica* Greene and *A. aprica* Greene. *Eutricopis nexilis* Morrison, a heliothentine that feeds on a number of species of *Antennaria* from eastern to western North America, was flying abundantly among the patches of pussy toes. The first few specimens of *S. verna* were netted and killed on the assumption that they were also *E. nexilis*. Although eggs and larvae of *S. verna* were only found in the heads of *Antennaria neodioica*, partially grown larvae would also readily accept the heads of *A. aprica* as food.

The very large egg of *verna* is deposited (Fig. 4) deeply within the flowering head of the food plant. The newly hatched larva usually burrows directly to the achene layer and feeds on the seeds and also on the tissue of the receptacle. The early instars are very cannibalistic, and a number of dissected heads contained the remnants of both *S. verna* and *E. nexilis* larvae as well as a healthy first or second stadium *verna* larva. First instars hatching in previously occupied heads have the habit of crawling out of the head and seeking another to enter. The survival rate among these small wanderers is probably not very high. In most cases observed the displaced first instars could not penetrate a second head and fell from the food plant.

Second instars seem quite capable of migrating from one head to another. Commonly, larvae remain in the initial head until reaching the second stadium, at which time they seek another, entering the second head from the top. Second stadium and early third stadium larvae continue to feed within the head, and their habit of attacking the receptacle as well as the seeds usually causes a complete disintegration of the head with the florets and pappus falling free.

Late third instars and subsequent stadia feed from outside the head. Third and fourth instars often tie adjacent *Antennaria* heads together to form a protective shelter from which they feed; on becoming pre-



FIGS. 7-10. *Schinia verna*, n. sp., on *Antennaria neodioica* Greene; **7**, molting nest of fourth stadium larva; **8**, same, opened to show larva; **9**, ultimate stadium larva, lateral; **10**, same, dorsal.

molt, they form a very definite nest of floral parts (Figs. 7, 8) in which they can remain quiescent until moulting is completed.

Last instars feed exposed, attacking the base of the head from a position on the stem (Fig. 10). Larvae of *Schinia verna* mature in five stadia and require a mean period of 17.1 days from hatching to the

cessation of feeding to complete their development. The mature larva retires to the ground and digs a short tube below the surface at the end of which it forms its pupal cell. The species is univoltine, the pupae remaining in diapause until the following spring.

Immature Stages

Egg. Very large. Translucent white when deposited. Showing little change until two days after deposition, when anterior end becomes suffused with pink. On day of hatching pink suffusion fades, and mandibles become visible at micropylar end. All eggs observed had an incubation period of three days.

First instar. Head, prothoracic and suranal shields black. Trunk dirty-white with small black setal bases. Mean duration of stadium, 3.1 days.

Second instar. Head black. Prothoracic and suranal shields somewhat paler. Trunk medium greenish-grey, becoming paler toward end of stadium. Setal bases black, proportionately much larger than in first stadium. Mean duration of stadium, 2.6 days.

Third instar. Head capsule black. Prothoracic and suranal shields dark brown. Trunk medium grey with large black setal bases. Mean duration of stadium, 2.5 days.

Fourth instar. Head black with a large brown patch on either side; often a whitish triangle on frons. Prothoracic shield black with a yellowish transverse median band. Suranal shield black with an anchor-shaped yellowish median mark. Trunk medium grey with a variably expressed, yellow, transverse median shade on each segment, yellow shading becoming more intense toward end of stadium. Setal bases large, black. Rims of spiracles dark brown. Mean duration of stadium, 3.3 days.

Fifth instar (Figs. 9, 10). Head fawn dorsally and laterally and finely mottled with light brown; frons dull white; a black inverted V through adfrontal areas; a pair of black spots above inverted V and a black patch in ocellar area. Prothoracic shield black with a pale-yellow transverse median band. Suranal shield undistinguished from remainder of trunk. Trunk uniform greyish-white. A variably expressed transverse yellow shade on dorsum of each segment. Setal bases very large and black, giving larva a checkered appearance. Spiracles small, dark brown. Mean duration of stadium, 5.6 days.

Pupa. Well sclerotized; orange-brown, without green suffusion across appendages. Mesothoracic legs relatively long, terminating only a short distance anterior to apex of proboscis. Metathoracic legs evident as triangulate plates distal to apex of proboscis. Anterior third of each of abdominal segments 5 to 7 not raised above remainder of segment; anterior third of these segments finely and only sparsely pitted and not more darkly pigmented than remainder of segments. Spiracles set into shallow oval pits; rims of spiracles elevated to form short but definite tubes. Cremaster reduced to 2, rather stout, usually curved bristles, borne at apex of a conical prolongation of 10th abdominal segment.

Remarks

The spring of 1979 was a very late one in central Canada, and the flight data for the type series may indicate a period of activity that is later than normal. The type locality was revisited during the first week of June of 1980; no adults were collected and the few larvae found were all in the fourth and fifth stadia.

As noted previously *Schinia verna* is most closely related to *S. honesta*, which is distributed in montane western North America from southern British Columbia southward to the Rocky Mountains of Colorado and the Sierra Nevada of California. The new species is smaller

and more delicately colored than is *honesta*. The food plant and immature stages of *honesta* are unknown. It will be interesting to ascertain how closely the immatures resemble those of *S. verna*.

ACKNOWLEDGMENTS

I take pleasure in naming the new species after my wife, Verna, in thanks for her continuing assistance in the field. I also acknowledge the assistance of Mr. Eric Rockburne of the Biosystematics Research Institute for the preparation of genitalic slides and of illustrations accompanying this paper. Mr. Wm. Shewfelt was most hospitable in showing me various topographic features in the region of his homestead in southern Manitoba.

LITERATURE CITED

- GROTE, A. R. 1881. New western moths. *Papilio* 1:75-78.
HARDWICK, D. F. 1958. Taxonomy, life history, and habits of the elliptoid-eyed species of *Schinia* (Lepidoptera: Noctuidae) with notes on the Heliiothidinae. *Can. Entomol. Suppl.* 6:116 pp.

A NEW GENUS AND NEW SPECIES OF GEOMETRID MOTH FROM TEXAS

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ABSTRACT. A new genus and new species of geometrid moth are described from West Texas. Although clearly belonging to the subfamily Ennominae, tribe Ourapterygini, this distinctive moth seems to have no close relatives. Its larva and foodplant are unknown.

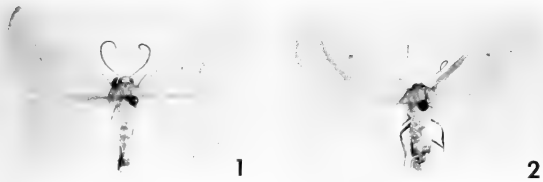
A geometrid from West Texas, first brought to my attention by Mr. André Blanchard 10 years ago, is undescribed and furthermore, does not fit the description of any known genus. It is clearly a member of the very large, possibly heterogeneous tribe Ourapterygini by reason of the single, massive, asymmetrical furca of the male genitalia, occurring in combination with a double accessory cell in the forewing, and it shows some affinity with the group that includes such genera as *Lychnosea* Grote, *Caripeta* Walker, *Snowia* Neumögen, *Destutia* Grossbeck, *Besma* Capps, *Lambdina* Capps, *Cingilia* Walker, *Nepytia* Hulst, *Eusarca* Hübner, and *Somatolophia* Hulst. The Texas species does not fit any of these, however, nor any of the neotropical genera that were investigated in the effort to place it. Species of most ourapterygine genera typically have a cluster or transverse row of hooklike spines at the extremity of the gnathos. The present species lacks these but instead has an extended, rather massive and recurved gnathos unlike any other. The so-called furca is also unusually enlarged but shows every indication of being homologous to those of the genera mentioned above.

More than anything else the moth has the appearance of a small, pale, tawny-yellow, evenly colored *Sicya morsicaria* (Hulst), or even a small, narrow-winged *Tetracis crocallata* Guenée (although the forewing has only the slightest suggestion of an angulate outer margin). However, the genitalia at once remove it from close association with either of those genera, and indeed the species seems to have no really close relatives.

***Sicyopsis blanchardata*, new genus, new species**

(Figs. 1-6)

As *S. blanchardata* is the only included species, it is not possible to differentiate between generic and specific characters; thus, the descriptions are combined.



FIGS. 1, 2. *Sicyopsis blanchardata*, n. gen., n. sp.: 1, holotype male; 2, allotype female (about natural size).

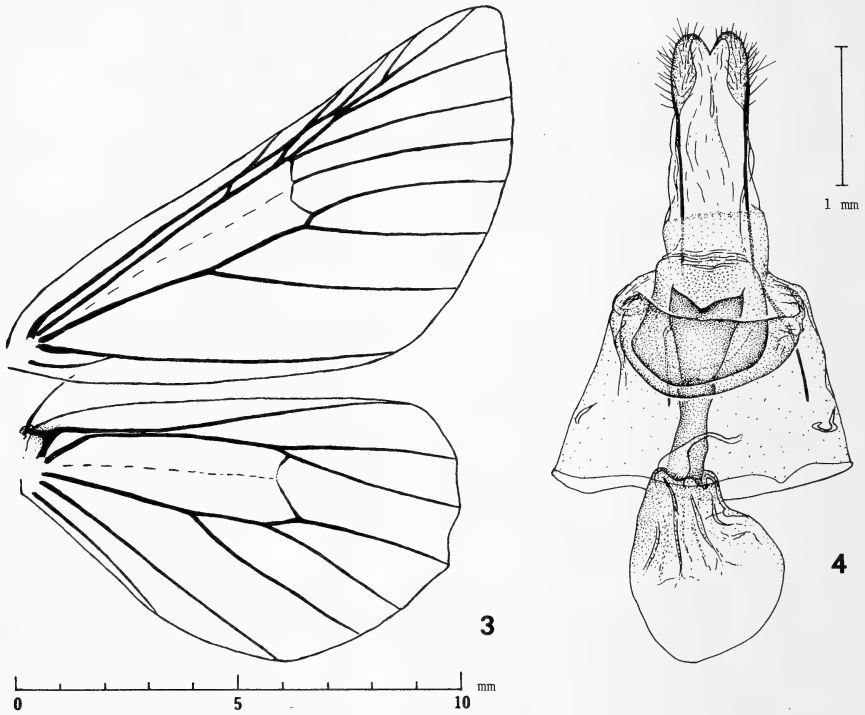
Description. Front smooth, convex, covered with closely appressed, elongated, mostly singly notched scales, its surface in lateral profile nearly parallel to, and just slightly farther out than that of adjoining eye surfaces; front about $1\frac{1}{2}$ times as wide at top as at bottom; eyes of both sexes large, each about equal in width (in radial view) to length of labial palpi, but slightly smaller in female than in male; palpi short, those of male usually slightly exceeding front, of female not exceeding front; tongue well developed; male antennae simple but thickened dorsoventrally, compressed, with quadrate, finely setose segments (prismatic); female antennae simple, filiform; legs with tibiae hardly swollen, epiphyses extending to ends of foretibiae, and both pairs of hindtibial spurs present in both sexes; vestiture of thorax predominantly of long, hairlike scales, intermixed with a few short, broad scales.

Wings somewhat narrow, forewings with costa nearly straight, outer margin slightly angulate in females, usually evenly convex in males. Forewings light tawny yellow to cream colored, with or without an almost straight, light-brown, oblique, postmedial band from near middle of inner margin to a point on costa just basad of apex, and a small, brown discal spot; fringes concolorous with wings; hindwings paler, unmarked; underside unmarked. Venation (Fig. 3) typical of group of genera to which species seems to belong; for example, almost exactly like that of *Destutia excelsa* (Strecker), except that accessory cells of forewing variably less elongated in the four specimens examined for venation characters. Length of forewing: holotype, 14 mm; other males, 13–14 mm; allotype, 14 mm; other females, 13–15 mm.

Male genitalia (Figs. 5, 6). Uncus, gnathos, and costa of valve stout, heavily sclerotized; gnathos elongated and abruptly recurved at about the middle, broad and flattened toward end but tapering to a blunt point apically; small, lightly sclerotized socii present; juxta invaginated, pouchlike, with a large, broad, single, curved, asymmetrical furca arising from it. As in related forms, ventral lamella of furca attached to juxta, and dorsal lamella to a thinly sclerotized plate of the anellus; furca bearing group of short spines toward its tapered extremity, transtilla incomplete; aedeagus slender, with 7–8 small cornuti.

Female genitalia (Fig. 4). Ductus bursae and ostium forming a nearly straight, stout, rigidly sclerotized, funnel-shaped unit; sterigma large, doubly invaginated as shown. Lack of signum unusual for the tribe.

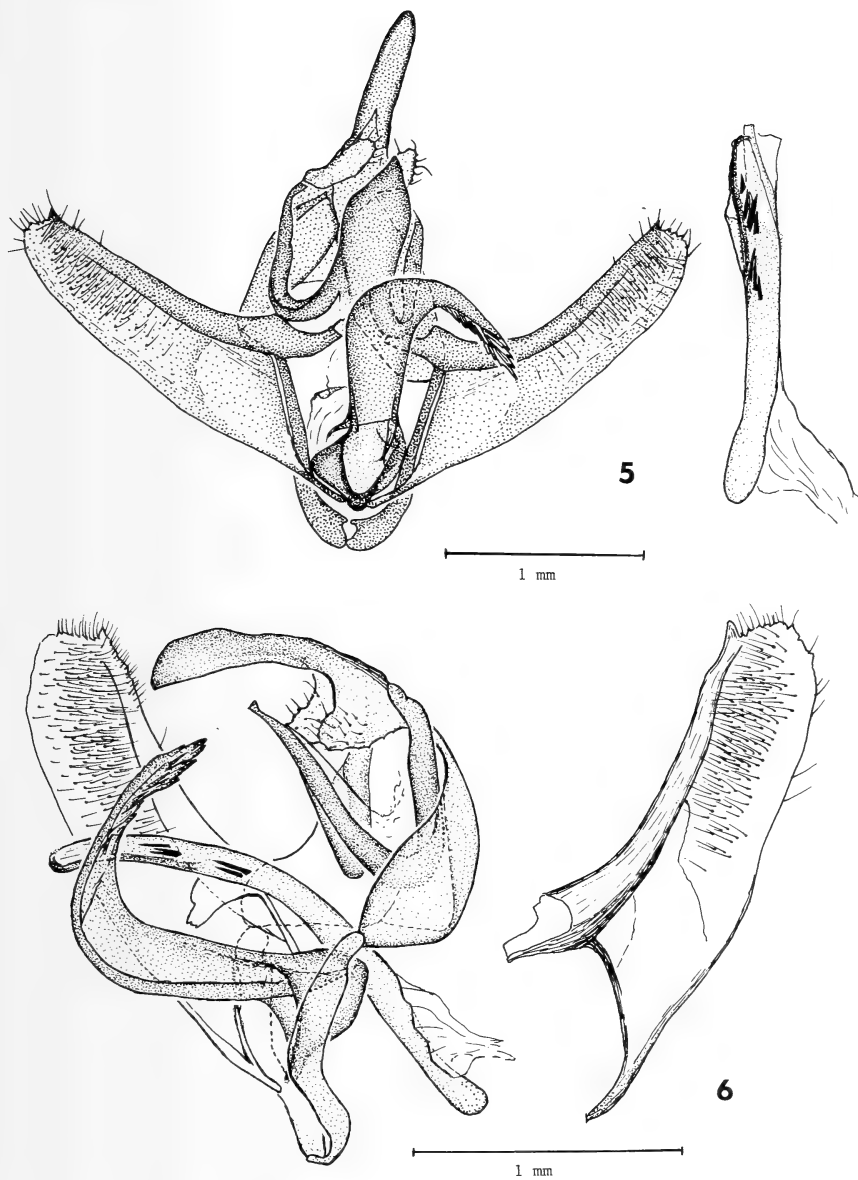
Types. HOLOTYPE MALE (Fig. 1): Smith Canyon, 5750 ft, Guadalupe Mountains, Culberson Co., Texas, 22 May 1973, D. C. Ferguson. ALLOTYPE FEMALE: Panther Pass, 6000 ft, Chisos Mountains, Brewster Co., Texas, 2 June 1973, D. C. Ferguson. PARATYPES: 1 ♂, same data as for holotype; 1 ♂, 1 ♀, McKittrick Canyon, 5000 ft, Guadalupe Mountains, Culberson Co., 23 May 1973, D. C. Ferguson; 4 ♂♂, Bear Canyon, 5400 ft, Guadalupe Mountains, 3 Sept. 1969, A. & M. E. Blanchard; 4 ♂♂, 2 ♀♀, Bear Canyon, 5700 ft, Guadalupe Mountains, 4 Sept. 1969, A. & M. E. Blanchard; 1 ♂, Pine Canyon, 5700 ft, Guadalupe Mountains, 28 Aug. 1967, A. & M. E. Blanchard; 9 ♂♂, Sierra Diablo Wildlife Management Area, 6000 ft, 20 mi. NNW of Van Horn, Culberson Co., 20 May 1968 (1), 5 June 1969 (4), 14 July 1971 (2), 30 Aug. 1970 (1), 24 Sept. 1967



FIGS. 3, 4. *Sicyopsis blanchardata*: 3, wing venation; 4, female genitalia, from USNM slide 56097 (Guadalupe Mts.).

(1), A. & M. E. Blanchard; 1 ♂, same locality, 30 May 1973, D. C. Ferguson; 10 ♂♂, same locality, 30 Aug. 1970 (6), 31 Aug. 1970 (4), J. G. Franclemont; 2 ♀♀, same locality and collector, 30 Aug. 1970; 1 ♀, 10 mi. north of Van Horn, Culberson Co., 2 Sept. 1979, E. C. Knudson; 23 ♂♂, Green Gulch, 5500 ft, Chisos Mountains, Big Bend National Park, Brewster Co., 10 May 1966 (1), 14 May 1966 (1), 27 June 1965 (2), 1 July 1965 (1), 14 Sept. 1971 (5), 2 Oct. 1967 (10), 5 Oct. 1965 (2), 7 Oct. 1965 (1), A. & M. E. Blanchard; 1 ♀, same locality and collectors, 27 Aug. 1965; 1 ♀, same locality, 6 June 1973, D. C. Ferguson; 10 ♂♂, Chisos Basin, Big Bend National Park, 29 June 1965 (1), 30 Aug. 1964 (1), 27 Sept. 1965 (4), 2 Oct. 1966 (3), 7 Oct. 1966 (1), A. & M. E. Blanchard; 3 ♀♀, same locality and collectors, 30 Aug. 1964, 24 Sept. 1963, 5 Oct. 1967; 1 ♂, same locality, 14 May 1977, E. C. Knudson; 3 ♂♂, Government Spring, Big Bend National Park, 13 May 1966, 29 Sept. 1965, 4 Oct. 1967, A. & M. E. Blanchard; 9 ♂♂, Oak Spring, Big Bend National Park, 4 Oct. 1965 (2), 5 Oct. 1967 (5), 5 Oct. 1965 (2), A. & M. E. Blanchard; 1 ♂, K-Bar Research Station, Big Bend National Park, 25 Sept. 1971, A. & M. E. Blanchard.

All localities cited are in West Texas. The Guadalupe Mountain localities are in Guadalupe Mountains National Park in canyons on the east side of the range. The holotype, allotype, and some of the paratypes are in the collection of the U.S. National Museum of Natural History; other type material is in the collections of A. Blanchard, J. G. Franclemont, and E. C. Knudson.



FIGS. 5, 6. *Sicyopsis blanchardata*, male genitalia: **5**, ventral view, aedeagus removed, from slide AB 1257 (Big Bend National Park). **6**, ventrolateral view, right valve removed, aedeagus *in situ*, from slide AB 1376 (Green Gulch). Drawings by A. Blanchard and the author.

Distribution. All known localities are given above. Not known from Mexico, but inasmuch as many were collected virtually within sight of the border, it undoubtedly occurs there.

Flight period. 10 May–7 October.

Early stages. Unknown.

Remarks. This species has been named in honor of Mr. André Blanchard of Houston, Texas, who collected most of the material and who personally conducted me to the localities where those that I collected were found. He also provided the drawings for Figs. 3, 5, and 6, which I modified for publication. I also acknowledge the assistance of A. Blanchard, E. C. Knudson, and J. G. Franclemont for providing information or access to their collections.

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BOOK REVIEW

A REVISION OF *PHYCIODES* HÜBNER AND RELATED GENERA, WITH A REVIEW OF THE CLASSIFICATION OF THE MELITAEINAE (LEPIDOPTERA: NYMPHALIDAE) by L. G. Higgins. 29 October 1981. Bulletin of the British Museum (Natural History), Entomological Series, Vol. 43, No. 3, pp. 77–243, 490 figs.

This concludes Higgins' 30-year study of the melitaeines of the world. In the present volume the Phycioidini and ten genera are described and named for the first time. At the species-group level eight new names are introduced. Many shifts from the species-group arrangements of Arthur Hall (1928–1930) and William T. M. Forbes (1945, 1946) have been necessary. Higgins' work had the advantage of the huge collections of the British Museum (Nat. Hist.) and Hall's very large collection in the Booth Museum, Bristol, England. In the British Museum alone Higgins had before him 76% of the types involved.

For each name noted in his complete synonymies for every accepted species, Higgins notes the author, original citation, type locality and repository of the type. In the cases of five authors the type repositories evaded him. Reakirt's types are in the Strecker Collection, Field Museum of Natural History, currently on long-term loan to the Allyn Museum in Sarasota, Florida. David Bauer's types are in his own collection, South Lake Tahoe, California. Brehme's types may be with the material from the Brooklyn Museum now in the U.S. National Museum of Natural History, Washington, D.C. I have no idea where Fender's type of *P. mylitta* ab. "maceyi" may be. Cockerell's two abs. of *camillus*, "rohweri" and "tristis," probably have been lost.

None of the newly proposed generic names affect species names in the United States and Canada. A comparison between Higgins' arrangement and Brown's arrangement of *Phyciodes* in the new Catalogue/Checklist shows the usual differences in assignment of status, i.e., species, subspecies and synonyms, between two serious students of any topic. Higgins' approach is more conservative than Brown's. There are two differences that are more substantial: Where Higgins used *campestris* Behr, 1863 (following Barnes & McDunnough, 1917), Brown reverted to the earlier use of *pratensis* Behr, 1863 as the species name, following Strecker's Catalogue of 1876 as a "first revision." Whereas, Higgins overlooked *callina* Boisduval, 1869, as a misspelling of *collina* Behr, 1863, Brown considers it a subspecies of *mylitta*, with *arizonensis* Bauer being a synonym.

No price is noted on my copy of the revision. I am sure that Classey will be handling it and suggest that anyone interested write to him at his England headquarters.

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PROLONGED DIAPAUSE AND PUPAL SURVIVAL
OF *PAPILIO ZELICAON* LUCAS
(LEPIDOPTERA: PAPILIONIDAE)

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ABSTRACT. Pupae of *Papilio zelicaon* are capable of at least a two-year diapause. Univoltine populations utilizing ephemeral native host plants had a greater incidence of prolonged diapause than multivoltine populations using the introduced *Foeniculum vulgare*. A laboratory strain, derived from multivoltine individuals and selected for decreased diapause, exhibited a corresponding loss of prolonged diapause. Mortality was high among pupae overwintering twice and complete in three-year-old individuals. Pupal water and dry material (fat body, etc.) weight loss was gradual over a 541 day period and paralleled survivorship. Prolonged diapause is regarded as an adaptive response to environmental uncertainty, especially that related to the phenology of host plants associated with univoltine and multivoltine populations.

Univoltine (one brood/year) populations of the swallowtail butterfly, *Papilio zelicaon* Lucas, typically occur in rocky or exposed areas at mid to high elevations in the California Coast Range and Sierra Nevada. These populations feed on native species of Umbelliferae (especially *Angelica*, *Lomatium*, *Pteryxia*, and *Tauschia* spp.) that are suitable for larval development approximately 2 to 4 months each year (Emmel & Shields, 1978). Multivoltine (several broods/year) populations occur in California coastal, Sacramento, and San Joaquin Valley areas, where they feed primarily on the introduced weed *Foeniculum vulgare* Mill. (Shapiro, 1974a, b) but occasionally attack *Citrus* spp. (Coolidge, 1910; Horton, 1922; Shapiro & Masuda, 1980). The temporal suitability of *Foeniculum* and *Citrus* as larval hosts varies among individual plants and location but, based on the annual availability of new foliage and succulent leaves, host suitability ranges from 8 to 12 months (Emmel & Shields, op. cit.).

P. zelicaon undergoes a photoperiod-induced pupal diapause, the incidence of which is modified by temperature and host plant species (Sims, 1980). The intensity of pupal diapause (=duration under specified environmental conditions) varies between individuals and among populations; individuals from a lab strain have reduced response to diapause-inducing conditions (Sims, in press). Some southern California populations (Oliver, 1969) appear to have reduced chilling requirements for diapause termination compared to central California populations. Some pupae remain in a diapause of at least two years'

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duration, either under artificial indoor conditions (Hynes, 1949) or outdoors exposed to naturally varying temperature and photoperiod (Emmel & Shields, op. cit.; Emmel, pers. comm.). The purpose of this study was to document the occurrence of prolonged diapause in several univoltine and multivoltine *P. zelicakon* populations and to obtain estimates of overwintering survival in normal and prolonged diapause pupae. Observations were made on progressive pupal weight loss as one possible mortality agent of diapausing pupae.

METHODS

Ova were obtained from females field-collected in univoltine (Butts Canyon, Napa Co., CA, el. 500 m, and Donner Pass, Placer Co., CA, el. 2100 m) and multivoltine (Suisun Marsh, Solano Co., CA, el. <10 m and Rancho Cordova, Sacramento Co., CA, el. <30 m) populations. Techniques used to establish and maintain colonies were similar to those of Sims (1980). Larvae were reared on *Foeniculum* under a 14 h light/10 h dark (LD 14:10) photoperiod at 23.5°C. Diapause pupae reared under similar conditions were also obtained from the F₃-F₅ generations of a laboratory stock which originated from the two multivoltine populations. Within 90 days of pupation, diapause pupae (in 1 pt. cardboard containers) were placed in a sheltered outdoor cage exposed to normal fluctuations of temperature, humidity, and photoperiod at Davis, Yolo Co., CA, el. 10 m, during the years 1975-1977. Emergence and mortality data were recorded daily during spring and summer and weekly during the remainder of the year.

Desiccation tolerance of diapausing pupae was studied by recording survivorship and wet weights of 24 pupae from Donner Pass over a 541 day period. Pupae were maintained at LD 15:9, 26.5°C with a relative humidity of 35 ± 5%. The laboratory conditions used subjected the pupae to much more desiccation stress than they are likely to experience in their normal habitat. Mortality in pupae was indicated by greatly accelerated water loss. The presence of unidentified disease in many dead pupae was suggested by abdominal swelling and exposure of the intersegmental membrane revealing discolored internal body fluids. Water and dry weight loss over the 541 days was estimated by weighing samples of pupae at the beginning and end of this period. Weighed living pupae were slit open, dried at 90°C for 48 h in a vacuum oven, and reweighed.

RESULTS

Progeny of four females from Rancho Cordova (combined n = 69) and three females from Suisun Marsh (n = 64) were compared to prog-

TABLE 1. Numbers of *P. zelicaon* pupae diapausing a second winter inside a field cage in Davis, CA.

Lab strain			Multivoltine			Univoltine		
Popula- tion/ female	# dia- pause/ total alive	% dia- pause	Popula- tion/ female	# dia- pause/ total alive	% dia- pause	Popula- tion/ female	# dia- pause/ total alive	% dia- pause
F ₃ /1	0/8	0.0	Rancho Cordova/1	11/17	68.4	Donner/1	4/4	100.0
F ₃ /2	0/8	0.0	Rancho Cordova/2	4/16	25.0	Donner/2	8/12	66.7
F ₃ /3	0/12	0.0	Rancho Cordova/3	1/28	3.6	Donner/3	1/3	33.3
F ₃ /4	0/8	0.0	Rancho Cordova/4	0/8	0.0	Butts Canyon/1	6/13	46.1
F ₄ /1	0/11	0.0	Suisun/1	5/9	55.6			
F ₄ /2	0/5	0.0	Suisun/2	4/17	23.5			
			Suisun/3	0/38	0.0			
Total ^a	0/52	0.0	Total	25/133	18.8	Total	19/32	59.4

^a Univoltine total is significantly greater than laboratory or multivoltine (Duncan's Multiple Range Test, $P < 0.05$).

eny of three Donner Pass and one Butts Canyon female ($n = 32$). Six females from the multivoltine-derived laboratory colony provided 52 pupae for comparison with the wild type populations. Results are given in Table 1. The proportion of living non-emerged pupae of those overwintering for the first year was arc-sine transformed using the tables provided by Mosteller and Youtz (1961). Transformed data were analyzed using ANOVA procedures (Sokal & Rohlf, 1969) and Duncan's Multiple Range Test (DMR). Differences among the populations within the uni- and multivoltine areas and between the F₃ and F₄ generations of the laboratory strain were not significant; therefore, a comparison was made between the combined laboratory strain, multivoltine, and univoltine populations. The difference between these groups was significant ($F_{2,14} = 10.26$, $P < 0.002$). No pupae from the laboratory strain overwintered a second time; whereas, 19% of the multivoltine and 59% of the univoltine individuals did so. The difference between the latter two groups is significant ($P < 0.05$, DMR).

Emergence and survivorship of diapausing pupae older than one year was examined in 97 laboratory strain (generations F₃-F₅) individuals that had been previously chilled from November 1974 to March 1975 for 126 days at 2°, 5°, 11°, or 16°C at LD 0:24. Of 97 pupae maintained in an outdoor cage over the 1975-1976 and 1976-1977 winters, 24 ♂♂ and 27 ♀♀ developed the first spring. Fifteen of these adults were either dead inside the pupa or emerged very weak and/

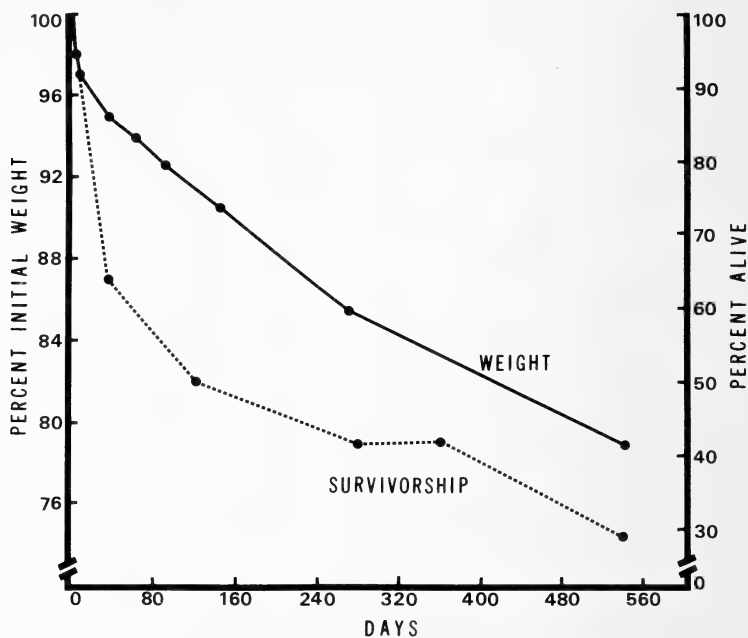


FIG. 1. Weight loss (percent of initial weight remaining) and survivorship of 24 *Papilio zelicaon* pupae under LD 15:9, 26.5°C conditions.

or crippled. Thus, only 37.1% (36/97) of the pupae produced adults that appeared to have adequate vigor for normal reproductive activity. The 44 unemerged pupae (45.6%) died without showing signs of development, while 2/97 (2.1%) remained alive in diapause. These latter two pupae plus 13 surviving two-year-old uni- and multivoltine pupae died while overwintering a third time. There was no difference between percent emergence or mortality of individuals previously chilled at the different temperatures. Prolonged diapause in the populations of *P. zelicaon* studied, therefore, appears to be normally of two years' maximum duration. Mortality is high in second-year pupae and complete in three-year-old individuals.

Figure 1 illustrates weight loss and survivorship of 24 *P. zelicaon* pupae over a 541 day period. A steep decline in weight, corresponding to water loss during hardening of the pupal integument, occurred during the first week of pupation. Subsequent weight loss was gradual and nearly linear over time. The survivorship curve in Figure 1 roughly parallels the progressive loss of pupal weight. The highest mortality rate (50%) occurred during the first 120 days; the remaining pupae had a high probability of survival (83%) to day 360. Although weight

TABLE 2. Depletion of water and dry weight of *P. zelicaon* pupae over a 541 day period at LD 15:9, 26.5°C conditions and RH = 35 ± 5%.

Pupal age (days) ^a	Total water (g)	Total dry weight (g)	Water/dry weight	Percent dry weight loss	Percent water loss	Total percent weight loss
1 (10)	0.814	0.238	3.419	—	—	—
541 (6)	0.593	0.160	3.700	32.68	27.14	28.39

^a Number in parentheses indicates numbers of pupae sacrificed.

loss and survivorship are probably not related in a simple way, it is possible that mortality of some pupae, especially those older than one year, occurred due to water or energy reserve depletion. The six surviving pupae at day 541 were 84% (\bar{x} day 1 = 0.955 g; \bar{x} day 541 = 0.802 g) of their own day 1 weight.

Table 2 provides an analysis of water and dry weight loss over 541 days. Rates of weight loss of both water (27.1%) and dry material (fat body, etc.) (32.7%) are similar, although the actual weights of water (0.221 g) and dry matter (0.078 g) lost differ greatly. Similar initial and final ratios of water to dry weight (3.419 to 3.700) suggest homeostatic maintenance of water/fat body quantities by the pupae.

DISCUSSION

The data presented here provides evidence for both individual female brood variation and population differentiation in the incidence of prolonged pupal diapause in *P. zelicaon*. Prolonged diapause was most frequent in univoltine populations and least frequent in a laboratory strain founded from multivoltine individuals.

The laboratory strain of *P. zelicaon* was selected for continuous development at LD 14:10, 23°C; thus, pupae diapausing under these "long-day" conditions were eliminated from the culture. By the F₃ generation this procedure had significantly decreased the incidence of diapause (Sims, in press) as well as eliminated any manifestation of prolonged diapause (Table 1). This dual response to selection suggests that the regulation of both diapause initiation and diapause intensity is under genetic control.

Comparison in Davis of diapause intensity in *P. zelicaon* from low elevation (up to 500 m) coast range, coastal, and central valley populations seems justified by the similarity of winter temperature monthly means (8–11°C) in these areas. Higher elevation (750–2100 m) Sierra Nevada populations experience much lower winter temperature means, often spending several months under snow cover with temperatures at or near 0°C. Despite this, pupae from populations at all elevations examined exhibit a maximum diapause termination re-

sponse (under constant temperatures) at 11°C (Sims, 1980). Thus, overwintering of higher elevation pupae under lower elevation valley conditions should provide an adequate approximation of prolonged diapause frequency.

Prolonged diapause has been found in a number of other temperate zone Lepidoptera that overwinter as pupae (Biliotti, 1953; Rabb, 1966; Powell, 1974; Prentiss, 1976; Shapiro, 1980) although it is not limited to the pupal stage (Yothers & Carlson, 1941; Surgeoner & Wallner, 1978).

Differences in photoperiod response and diapause intensity of latitudinally and altitudinally separated populations are commonly observed (Danilevskii, 1965; Beck, 1980; Sims, 1980) but interpopulation differentiation and temporal variability in the occurrence of prolonged diapause is less well known. Significant interpopulation variation in prolonged diapause has been found in sawflies (Prebble, 1941; Eichhorn, 1977), Cecidomyiidae (Sunose, 1978) and Lepidoptera (Surgeoner & Wallner, op. cit.). Prebble (op. cit.) obtained results similar to those of this study; uni- and bivoltine populations of *Gilpinia polytoma* (Hartig) (Hymenoptera, Diprionidae) were found to have considerably more prolonged diapause than multivoltine populations.

A major ecological difference between univoltine and multivoltine *P. zelicaon* populations is the growth phenology of the host plants (Emmel & Shields, op. cit.). Native perennial species of umbellifers used by lower elevation univoltine populations senesce rapidly with the advent of warm, dry weather in May and June. *Pteryxia terebinthina* (Hook.) C. & R., a host used by the Donner Pass and other high elevation Sierra Nevada populations (Emmel & Emmel, 1974), has a similar senescence in mid-July to August, placing a severe food limitation on occasional partial second broods unable to find or utilize alternate host species (Sims, 1980). Possibility of killing frosts in early fall increases the hazards for second brood individuals at higher elevations. The unpredictable quality and quantity of available food plants for larval development during the latter part of the growth season presents a considerable environmental risk for *P. zelicaon*. This food plant risk is partially buffered on *Foeniculum* since this "weedy" species has a longer growth season and occurs in a greater diversity of habitats than native hosts. In mesic areas *Foeniculum* may have tender young foliage throughout the season, and the plant commonly sends out fresh growth following disturbance. Variation in precipitation as it effects host plant growth is not the only possible environmental risk that may influence prolonged diapause in *P. zelicaon*.

Studies on other insects have demonstrated the adaptive value of prolonged diapause in the avoidance of biotic hazards such as disease, predators, and parasites (Price & Tripp, 1972; Minder, 1973).

Relatively dry areas of the temperate zone, including the Mediterranean climate of central California, tend to have particularly variable rainfall patterns (Rumney, 1969). Records from Sacramento provide a good example of this variability. Here, 120 years of data (1849–1969) show a mean seasonal rainfall of 45.5 cm with a range of 11.9–92.5 cm (Figgins, 1971). In seven of the 120 years the seasonal total was less than one-half the mean and the 1975–1976 and 1976–1977 seasons subjected populations to consecutive extreme drought years (15.6 and 19.5 cm rainfall, respectively). The effect of drought on host plants and population levels and/or population persistence through time is still poorly understood for *P. zelicaon*. For *Euphydryas editha* Boisduval, a species frequently co-occurring with *P. zelicaon* in central California, drought can reduce population size through larval starvation (White, 1974) or be a factor involved in local population extinction (Ehrlich et al., 1980).

Within the context of current thought on life history adaptations in insects, the presence of prolonged diapause in *P. zelicaon* represents a "bet-hedging" strategy in which individual females spread the risk of their reproductive effort over more than one season (den Boer, 1968; Stearns, 1976). This explanation implies, but does not demonstrate, the unpredictable risk of complete reproductive failure among the diapause progeny from a single female emerging in a given year. It is also possible that, even without the risk of a catastrophic season, the value of R_0 (net reproductive or replacement rate during a growth season) will be small enough in some years to select for the allocation of progeny into both normal and extended diapause categories (Istock, 1981). On an evolutionary scale the presence of prolonged diapause suggests that the long-term benefits of this response outweigh the disadvantages of the increased mortality rate demonstrated in this study.

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OBITUARY

DR. RENÉ LICHY (1896-1981)

Professor Lichy was an outstanding lepidopterist who lived and worked for many years in Venezuela. I first knew him in 1938, and we have exchanged papers and occasional letters ever since. He taught on the faculty of the Universidad Central de Venezuela, was a member of the Academia de Ciencias Fisicas-matematicas y Naturales de Venezuela, an honorary member of both the Sociedad Venezolana de Ciencias Naturales and Sociedad Venezolana de Entomologia. He was the honorary curator for Lepidoptera at the Museo de Ciencias Naturales in Caracas. He joined the Lepidopterists' Society soon after its foundation.

The last twenty years or so of his life were spent in France, the land of his origin. There he was associated with the Department of Entomology at the Museum d'Histoire Naturelle in Paris. He continued his great interest in Venezuelan Lepidoptera and furthered his world-wide studies of Sphingidae. René Lichy died on 6 April 1981. He is survived by three children and three grandchildren. His daughter and her three children live in France. Also, refer to Freiche & Lemaire (1981, *Bull. Soc. Ent. France* 86(9&10):313-314).

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NOTES ON THE BIOLOGY OF
AGONOPTERIX ALSTROEMERIANA (CLERCK),
WITH DESCRIPTIONS OF THE IMMATURE
STAGES (OECOPHORIDAE)

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ABSTRACT. Larvae collected from *Conium maculatum* L. (Umbelliferae) in Tompkins County, New York, were reared and determined as *Agonopterix alstroemeriana* (Clerck), recorded in the United States only since 1973. The larva forms a tubular roll on leaves of *Conium maculatum*, its sole host. Pupation occurs in late May and early June; adults emerge in mid- to late June.

The last instar larva is greenish in color, with a dorsal and two subdorsal dark green stripes. Earlier instar larvae are predominantly yellow with black head capsules. Ultimate instar larvae of *A. alstroemeriana* can be distinguished from other species of *Agonopterix* by the black posterior margins of the epicrania, the conspicuous pinacula, and scalelike setae dorsal to the tarsal claws.

Larvae of *Agonopterix alstroemeriana* (Clerck) were collected and reared on *Conium maculatum* L. (Umbelliferae) at three different sites in Tompkins County, New York, during the summers of 1977, 1978, and 1979. *A. alstroemeriana* is recorded in North America only since 1973 (Hodges et al., in press); since it is not included in the recent revision of the Oecophoridae of North America (Hodges, 1974), this paper documents for the first time the biology of this European species in eastern North America.

METHODS

Larvae were collected from *C. maculatum* growing in Coy Glen, Brooktondale, and the city of Ithaca, all in Tompkins County; *C. maculatum* was one of 12 species of Umbelliferae examined at weekly intervals from May through August 1979 for a study on insect associates of umbellifers (Berenbaum, 1981). All larvae were reared on *C. maculatum* in a controlled-environment chamber, with day/night temperatures of 26.5°/15.5°C and photoperiod of 16/8 h.

For morphological examination larvae were fixed in boiling water and preserved in 70% ethanol. Twenty-six reared adults and six larvae

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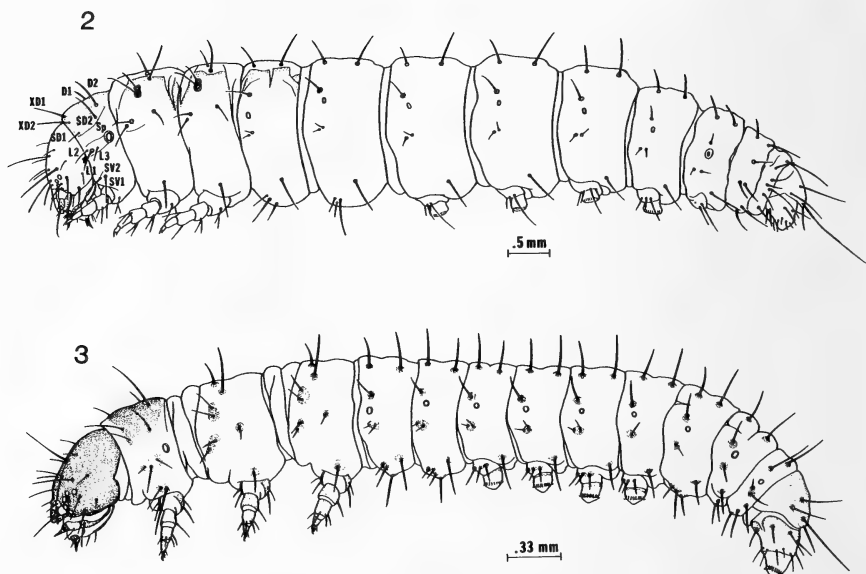


FIG. 1. Leaf rolls on *Conium maculatum* used as larval shelter for *A. alstroemeriana*.

were examined in detail; microscopic slides of the genitalia, wings and larval mouthparts were stained in mercurochrome and mounted in balsam after clearing in clove oil.

Natural History

Laboratory rearing suggests that adults overwinter and lay eggs in early spring; this is not inconsistent with other species in the genus *Agonopterix* (Hodges, 1974). Early instar larvae can be found in Tompkins County in early May, at which time they form characteristic tight tubular leaf rolls on leaves of *Conium maculatum*. Weekly census of stands of *C. maculatum* revealed a steady decline in numbers of caterpillars during June and July, when adult emergence takes place (Table 1). Both flowering and nonflowering individuals of *C. maculatum* are attacked. In addition to rolling leaves, *A. alstroemeriana* also webs together flowers and developing seeds. Inspection of *C. maculatum* throughout July and August failed to reveal larvae; presumably, *A. alstroemeriana* is univoltine in New York, as are the other umbellifer-feeding oecophorids in the area (Hodges, 1974). Larvae have a tendency to abandon leaf rolls frequently, particularly after disturbance; on a given plant, then, a high proportion of leaf rolls are



FIGS. 2, 3. Larva of *A. alstroemeriana*: **2**, mature larva showing dorsal setae (D1, D2), lateral setae (L1, L2, L3), subdorsal setae (SD1, SD2), spiracle (SP), subventral setae (SV1, SV2), and cervical shield setae (XD1, XD2); **3**, penultimate instar larva.

vacant. Population densities can reach high levels, with up to 40 caterpillars per stem.

A weekly census of insects on 11 other species of Umbelliferae in Tompkins County, some of which grow sympatrically with *C. maculatum* (e.g., *Pastinaca sativa* L. and *Daucus carota* L.) in abandoned fields and ditches, did not reveal *A. alstroemeriana*. In New York as in Europe (Stainton, 1861; Schütze, 1931; Toll, 1964), *C. maculatum* appears to be the sole host for *A. alstroemeriana*.

Description of Last-Instar Larva (terminology after MacKay, 1972)

General. Mature larva (Fig. 2) light green with three dark green longitudinal stripes. Prothoracic shield concolorous with body except for black posterior margin of epicranium and small ocular spot. Fully grown larva approximately 10 mm long. Smaller larvae lacking green stripes, with both head and cervical shield blackish-brown (Fig. 3).

Head (Figs. 4–9). Mandible with seven apical teeth and two lateral setae (Fig. 4). Molar grooves on teeth 1, 3 and 4 but most prominent on first tooth. Epicranium with black posterior margin (Fig. 5). Proximomedial area of hypopharyngeal complex (Fig. 6—terminology after Godfrey, 1972) covered by very fine setae. One pair of stipular setae present. Spinneret (Fig. 7) with rounded apex and silk pore. Labial palpi with second segment reduced and third segment hairlike, with hairlike papilla on the basal segment. Adfrontal area and labrum as shown (Fig. 8) (terminology after Hinton, 1946). Adf_1 between epicranial and adfrontal sutures; Adf_2 more widely separated. Frontal

TABLE 1. Per stem number of *A. alstroemeriana* larvae on *Conium maculatum* in Coy Glen, Ithaca, New York (summer 1979).

Date	Mean number \pm S.E.
24 May	21.4 \pm 5.87
31 May	13.8 \pm 2.96
7 June	11.8 \pm 3.20
14 June	14.6 \pm 5.80
21 June	5.8 \pm 1.50
28 June	0.4 \pm 0.40
5 July	0.2 \pm 0.20
12 July	0.2 \pm 0.20
19 July	0.0 \pm 0.00

¹ Five stems examined on each sampling date.

² No *A. alstroemeriana* present on subsequent sampling dates (through 31 August).

setae located above frontal punctures; clypeal setae near the edge or outside of frontal triangle. Labrum with three lateral setae and three medial setae—L1 and L2 closer together than to L3, and M1, M2 and M3 in a triangle. On epicrania (Fig. 9), P2 only slightly higher than P1 and A1 and A3 much longer than A2; L1 as shown.

Thorax. On the prothorax (Fig. 2), XD1, XD2 and SD1 in a straight line; SD2 separate from D1 and D2. Three prespiracular setae and two setae in the SV group; cervical shield unmarked. Chaetotaxy of metathorax: D1 and D2 closer to each other than on abdominal segments; SD1 and SD2 on the same pinaculum as L1 and L2; L3 widely separated. SV1 behind coxa. All thoracic legs with two scalelike setae dorsad of tarsal claw.

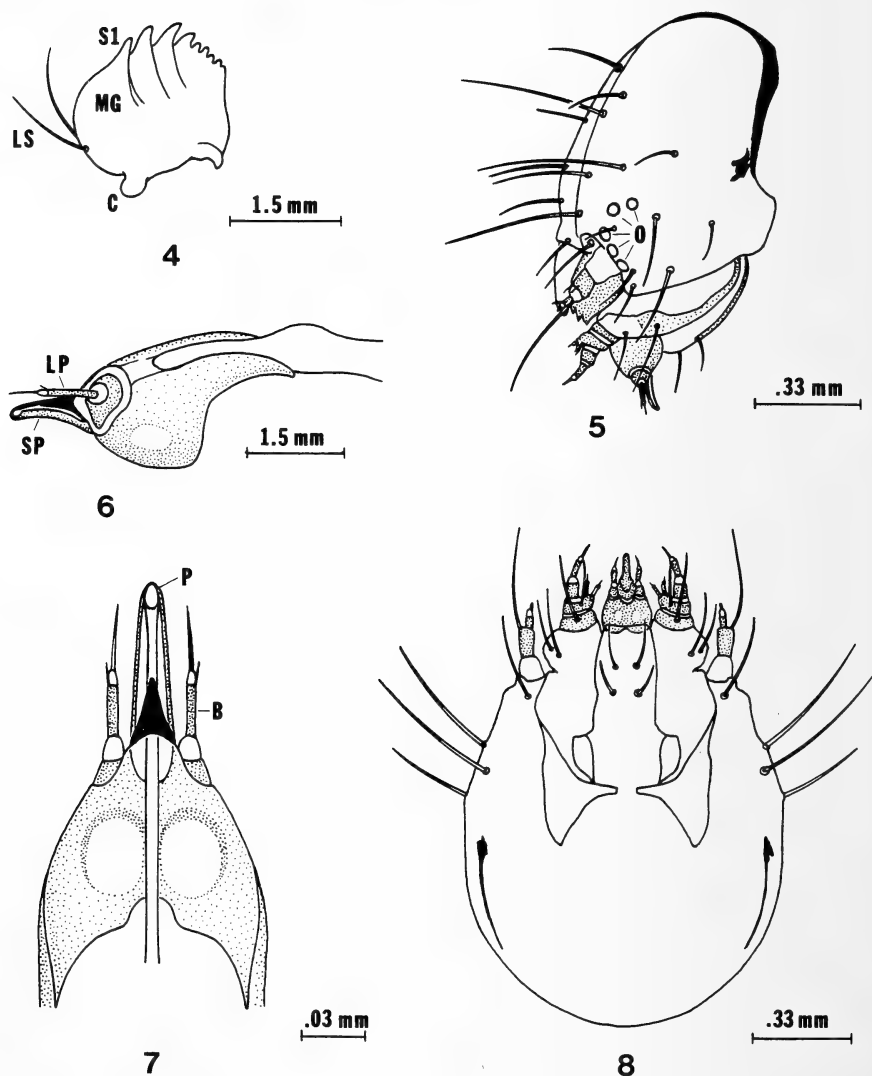
Abdomen. One ventral seta present on each side of midline of abdominal segments (Fig. 10). D1 and D2 widely spaced; SD1 above spiracle, L1 and L2 below it and close to each other. L3 close to SV group. SV setae for abdominal segments 1, 2, 7, 8 and 9 are 2, 3, 2, 1 and 1 respectively. Chaetotaxy of abdominal segment 9 as shown.

Pupa. Pupa (Figs. 11–13) red-brown and pubescent, covered with dense fine hairs. Antennae long and curled around wing pads; vertex rounded and prominent. Mesothoracic and metathoracic legs exposed; prothoracic femora concealed by maxillae. Segments 5 and 6 with proleg scars. Cremaster present as small tubercle with 4 hooked setae. Another pair of setae visible in dorsal view on each side of cremaster. Sexes distinguished by the position of genital openings, with ostium ductus ejacularis on the ninth segment and ostium bursae on eighth segment. Total length of pupa approximately 6–7 mm.

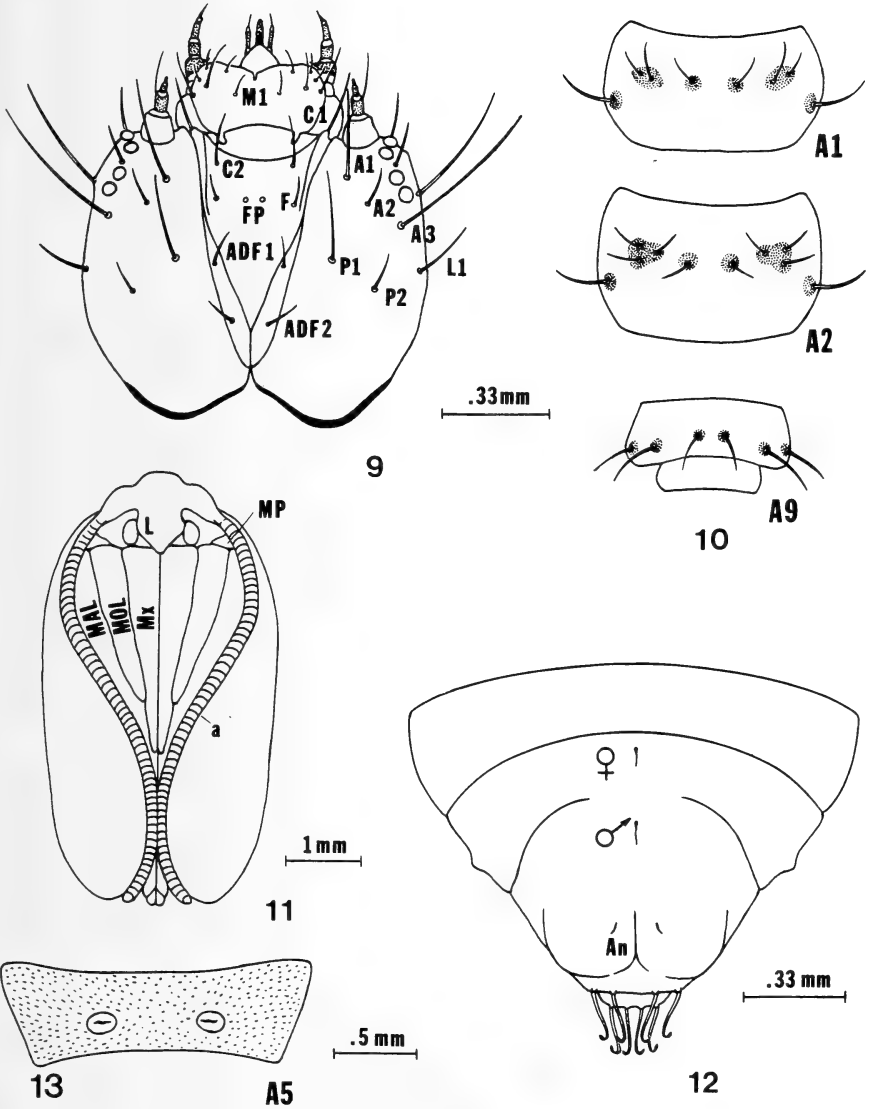
Adult (Fig. 14). As described (Stainton, 1861; Clarke, 1941).

DISCUSSION

The larvae of *A. alstroemeriana* should be confused with no other eastern North American *Agonopterix* species. Mature larvae can be distinguished from larvae of *A. clemensella* by the markings on the epicrania and the conspicuous pinacula, and from larvae of *A. flavicomella* by the absence of a black cervical shield. The host plant also appears to be definitive—*Conium maculatum* is the only host recorded for *A. alstroemeriana*, and *A. alstroemeriana* is the only oecophorid reported to feed on *Conium*. Larvae of *A. clemensella*, in fact, die when confined to foliage of *C. maculatum* (personal observation).



FIGS. 4-8. Structures of larval head of *A. alstroemeriana*: **4**, mandible, mesal view, showing condyle (C), lateral mandibular setae (LS), molar groove (MG), and first scissor-like tooth (S); **5**, lateral view of epicrania showing markings with ocelli (O); **6**, hypopharyngeal complex, lateral view showing labial palps (LP) and spinneret (SP); **7**, spinneret, dorsal view, showing basal segment of labial palps (B) and silk pore (P); **8**, head, ventral view.



FIGS. 9-13. Structures of immature stages of *A. astroemeriana*: **9**, larval head, dorsal view, showing adfrontal setae (ADF1, ADF2), clypeal setae (C1, C2), frontal setae (F), frontal punctures (FP), first lateral setae (L1), first medial setae (M1), anterior setae (A1, A2, A3), lateral setae (L1) and posterior setal group (P1, P2, P3); **10**, larval abdominal segments 1, 2, and 9, ventral view, showing lateral setae (L3), subventral setae (SV1, SV2, SV3) and ventral setae (V1); **11**, pupal head and thorax, mesal view, showing antennae (A), labrum (L), mesothoracic legs (MOL), maxillary palps (MP) and maxillae (MX); **12**, terminal abdominal segments of pupa showing male and female genital openings superimposed, ventral view, showing anal slit (An) and cremaster (C); **13**, fifth abdominal segments of pupa showing proleg scars and a portion of the fine setae covering most of the abdominal segments, ventral view.



FIG. 14. Adult of *A. alstroemeriana*.

The adult is a typical *Agonopterix* in form and maculation, lacking the longitudinal streaks characterizing species of *Depressaria*. The only American oecophorid similar in coloration to *A. alstroemeriana* is *Martyrhilda canella* (Busck). Tufted labial palps and a simple distal process of the sacculus distinguish *Agonopterix* from *Martyrhilda*; moreover, *M. canella* has a dark head and lacks a brick red spot below the black patch on the forewings. The key to *Agonopterix* by Hodges (1974) may be amended as follows to include *A. alstroemeriana*:

0. Head, thorax and basal streak of costa pure white, concolorous; discal cell of forewing with a black patch lying above a brick red spot -- *A. alstroemeriana*
 0'. Not as above ----- 1 (start key)

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GEOGRAPHIC DISTRIBUTION AND CHECKLIST OF THE BUTTERFLIES OF KERN COUNTY, CALIFORNIA

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ABSTRACT. A checklist of the 126 species of butterflies which are known to occur in Kern County, California is presented. Also considered is information concerning the distribution and flight periods for each species found regularly within the county boundaries. Briefly discussed are the natural features and geography of the area, considering some of its characteristic plant life and climatic conditions.

Butterflies and Kern County Geography

Kern County is located in south-central California and embraces 8064 square miles of very diversified territory, which includes the southern San Joaquin Valley, several mountain ranges and an arid portion of the Mojave Desert. Elevations range from 91 m (300 ft) above sea level at Lost Hills on the Valley floor to 2692 m (8831 ft) on the summit of Mt. Pinos (actually located on the Kern-Ventura County line), and 2583 m (8475 ft) on Owens Peak in the southern Sierra Nevada.

The diversity in elevation, habitats and plant life support an unusually large and varied butterfly fauna for an area the size of Kern County. At present, 126 species and a number of additional subspecies of butterflies have been collected within the county boundaries. Most of these are "residents" or regular visitors which establish transient populations most years. A few are accidental to the region and occur here only as rare strays or migrants from adjacent areas where they are better established. These special cases will be discussed in the checklist portion of this paper.

Kern County can be divided into three general areas geographically. Each area supports its own plant and animal life, including the butterflies.

(1) San Joaquin Valley: An arid lowland valley which is heavily used for agricultural purposes. *Citrus* and alfalfa (*Medicago sativa* L.) are among the predominate crops grown in the region, which are important to numerous kinds of butterflies. Rainfall is about 0.127 m (5 inches) per year, which is not enough to support much natural plant growth. What plants do grow here are adapted to low annual rainfall and very long, hot and dry summers.

Most butterflies occurring in this region are species which are common and widespread in the western United States. These butterflies readily adapt to man's presence and influence and will be found in cities, residential areas, gardens, parks, and in agricultural fields. A

few other butterflies favor riparian habitats along the Kern River or Poso Creek. The Kern River drains the southern Sierra, including Mt. Whitney, and flows throughout the year (until it reaches Bakersfield and is diverted into irrigation canals and urban use) providing water for agricultural and urban development. Bakersfield with an unofficial population of some 250,000 is the largest city in the county and a number of smaller cities and towns lie nearby.

Some of the species occurring on the Valley floor are butterflies which more normally would be expected out on arid stretches of the Mojave Desert. Among these are *Pholisora libya*, *Pontia beckerii*, *Anthocharis cethura morrisoni* and *Danaus gilippus strigosus*. These fly in undisturbed areas away from cities and agricultural fields and can be found in *Atriplex* wastelands, on alkali flats, in ravines or in swampy areas still found in otherwise dry arid country. Others like *Pyrgus scriptura* occur along irrigation ditches or roadsides.

(2) Western Mojave Desert: The portion which lies in Kern County receives less than 0.254 m (10 inches) of rainfall in most years. As is true throughout the county, precipitation is strongly seasonal with most rainfall occurring in the winter and spring months.

Vegetation is generally very sparse. What few plants grow in this area are adapted to highly arid conditions, high summer temperatures and sandy soils. Some common plants of the region are creosote bush (*Larrea divaricata* Cav.), several varieties of rabbitbrush (*Chrysothamnus* spp.), saltbrush (*Atriplex* spp.), buckwheats (*Eriogonum* spp.), Joshua tree (*Yucca brevifolia* Engelm. in Wats.) and several varieties of cacti. Various kinds of wildflowers can be found during the spring months.

Most of the Kern County desert is flat and unremarkable, and few species of butterflies can be expected. Much better conditions exist where the desert and mountain regions meet. A great many desert butterflies occur on the arid east slope of the Sierra Nevada, in adjacent canyons or in the high desert valleys. Walker Pass, elevation 1600 m (5250 ft), in the southern Sierra is a particularly well known locality often visited by lepidopterists. Other lucrative areas for collectors are Red Rock Canyon, Jawbone Canyon and Kelso Valley. At least 70 species of butterflies have been recorded from the Kelso Valley region alone, which makes this area exceptionally interesting. Several species more commonly encountered in the mountains can be found commonly in desert washes out of their usual habitat. Most "desert" species of the region fly during the spring months of April and May, but a few species can be found through the summer and fall months as well.

Two "rare" desert species with very sporadic distributions in southern or southeastern California are *Pseudocopaeodes eunus* and *Ple-*

bulina emigdionis. Both of these butterflies are locally common around Weldon, located along the south fork of the Kern River near Lake Isabella and on the northern edge of Kelso Valley.

Still, the Kern County desert lacks the rich desert fauna of other deserts located to the south and east. Several "desert" species common in Arizona or in southeastern California are encountered in this region only as rare strays or as small transient populations in years of favorable rainfall.

(3) Montane areas: Mountains ring the San Joaquin Valley on three sides. These include the arid Temblor Range (part of the Coast Range) to the west; the Transverse Ranges (including Frazier Park and Mt. Pinos) to the south; the Tehachapi Mountains to the southeast; and the southern Sierra Nevada, Greenhorn and Piute mountain ranges to the east and southward. The Greenhorn and Piute ranges are actually subranges of the Sierra, but are best considered separately, because each of these three areas differ considerably ecologically and in butterfly fauna. Most plants and animals (including the butterflies) of these mountain ranges are characteristic of the Upper Sonoran or Transition Life Zones.

The mountains of Kern County are very rich in butterflies. For example, over 100 butterfly species have been collected within a radius of 15 miles from the town of Lake Isabella, which is adjacent to the southern Sierra, Greenhorn and Piute mountain ranges. Butterflies are found in these regions from late February or early March well into October or even November in some years.

In the mountains grow several different species of conifers, including incense cedar (*Calocedrus decurrens* (Torr.)), ponderosa pine (*Pinus ponderosa* Lawson), Jeffrey pine (*Pinus jeffreyi* Grev. & Balf., in A. Murr.), sugar pine (*Pinus lambertiana* Dougl.), some lodgepole pine (*Pinus contorta murrayana* Grev. & Balf.), digger pine (*Pinus sabiniana* Dougl.), white fir (*Abies concolor* (Gord. & Glend.)), red fir (*Abies magnifica* Murr.) and California juniper (*Juniperus californica* Carr.). Along streams or in the mountain canyons are found white alder (*Alnus rhombifolia* Nutt.), sycamore (*Platanus racemosa* Nutt.), cottonwoods (*Populus* spp.) and several kinds of willows (*Salix* spp.). A number of species of oaks (*Quercus*) and buckwheats (*Eriogonum*) grow on the drier slopes. Many varieties of annual wildflowers and grasses are also found in these several mountain ranges.

The Transverse Ranges are represented in Kern County by the Tejon Mountains and are actually part of the Coast Range. Mt. Pinos and Frazier Mountain (the summit of which is actually in adjacent Ventura County) are both well over 2440 m (8000+ ft) elevation and are rich in butterflies. A number of species with very limited distribution (i.e.,

Colias harfordii, *Chalceria heteronea clara*, *Icaricia neurona* and *Speyeria coronis hennei*) occur in this region.

The Tehachapi Mountains rise to an elevation of 2435 m (7988 ft) on the summit of Double Mountain above Tehachapi Mountain Park near the town of Tehachapi. A trail leads to this mountain summit where is found the rare *Speyeria egleis tehachapina* and the somewhat more common *Speyeria coronis hennei*. Only the latter species sometimes descends the lower slopes to the Mountain Park below. The highly sought *Speyeria adiate atossa* once flew with *Speyeria egleis tehachapina* on the mountain summits but could be found descending to much lower elevations in shaded woodlands and along small streams.

The Temblor Range is a low arid range located on the west side of the San Joaquin Valley. There are relatively few species in these foothills but one prized butterfly which does occur here is *Mitoura siva mansfieldi*, a subspecies distinguished by its dark green coloration underneath. Despite an abundance of junipers in these foothills, *mansfieldi* is scarce and hard to find.

The southern Sierra Nevada become very arid south of the Tulare County line. The range (not including the Greenhorns or Piutes because these are being considered separately) continues south to near the edge of the Mojave Desert at Butterbredt Peak (also known as Butterbread Peak), which has an elevation of 1829 m (6000 ft). On these seemingly arid hillsides and hilltops fly the rare *Pholisora alpheus oricus* and the southern Sierra subspecies of *Papilio indra*.

The Kern County Sierra is too arid and low in elevation to support the array of boreal species found further north in the Canadian, Hudsonian and Arctic-Alpine Life Zones of the truly high Sierra. However, several of these high elevation species do occur just 10 to 15 miles north of the county line and may occasionally stray southward to Kern County. Some of these may yet be found on Owens Peak or in adjacent mountain areas accessible only by well marked foot-trails. More study of this region is definitely needed.

The Greenhorn Mountains receive heavy winter snows and are the most heavily wooded mountains in the county. The forested areas are poor butterfly habitats, but favorable places for lepidoptera exist in moist meadows, along roads or in various kinds of disturbed places. For many years this has been the well known habitat of *Speyeria hydaspe viridicornis* and the only known southern California locality for *Clossiana epithore sierra*, as cited in Emmel & Emmel (1973).

The Piute Mountains are located south of the previous mountain range and Lake Isabella and are generally drier than the Greenhorns, yet somewhat surprisingly, are much richer for butterflies in general.

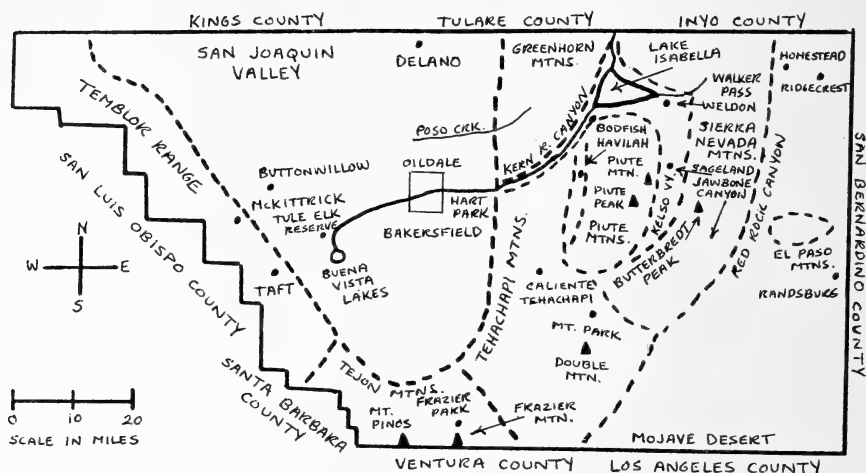


FIG. 1. Map of Kern County, California, showing geographical features and collecting localities.

The highest summits are Piute Mountain at 2538 m (8326 ft) and Piute Peak at an elevation of 2570 m (8432 ft). Lepidopterists visit here rather regularly for *Papilio indra*, *Mitoura siva juniperaria*, *Icaricia neurona*, *Speyeria egleis tehachapina*, the very variable *Thessalia leanira* population of this region, *Occidryas editha editha* and a number of other interesting species.

Our knowledge of the Kern County fauna is incomplete, and questions still remain to be answered. But, it would appear unlikely that many new species remain to be discovered in this area. A few will likely be found in the southern Sierra along the Tulare-Kern County line or in the Greenhorn Mountains. More work remains to be done in compiling distributional data, even on the floor of the San Joaquin Valley where unusual or unexpected species have turned up in recent years.

Sources of Information for the Kern County Checklist

I have actively collected in Kern County for 18 of the past 23 years, while Jim Brock has collected and studied the fauna of the region since 1968. In 1975 the two of us met and undertook the joint project of compiling a county list and defining the distribution of each species. Jim Brock was especially active in eastern Kern County, and his field work provided the basis for much of my own studies in recent years. Today, each of us has extensive collections of Kern County butterflies, which provide much of the basis and documentation for this paper.

During the course of our project an effort has been made to visit poorly collected localities overlooked by others. These include numerous places on the floor of the San Joaquin Valley, the Kern River Valley, Kelso Valley and in the southern Sierra. The result has been a wealth of new information and data to add to that already obtained by other workers who had already contributed heavily to this project.

Emmel & Emmel (op. cit.) treated many of the species found in Kern County in their book on southern California butterflies and a number of scientific papers (too numerous to list) have dealt with some aspect of the region's butterfly fauna.

A number of lepidopterists have contributed data or information used in this paper. These include John Burns, Julian P. Donahue, John F. Emmel, Gary File, Rick Hewett, Weldon Kirk, Robert Langston, John Luttrell, William W. McGuire, Ed Moran, James Mori, Paul Opler, Jerry Powell, Allen Rubbert, Ed Sampson and Charles Sekerman. Past workers who contributed to our present knowledge include John Adams Comstock, Charles M. Dammers and H. Morrison.

Introduction to the Kern County Checklist

The annotated checklist section of this paper considers 126 species for which there are definite records of capture from within the county boundaries. About 10 of these actually represent strays of species not normally found in the region or butterflies of questionable status which may not be a true part of the Kern County fauna.

Following the main checklist is another listing of "doubtful or questionable records," which considers a few additional species having been accredited to Kern County but which are based on questionable data, determinations or evidence.

In listing the butterflies in the checklist, I have *generally* followed the nomenclature and phylogenetic order used in "A Catalogue/Checklist of the Rhopalocera of America North of Mexico" (Lee D. Miller & F. Martin Brown, 1981, Mem. Lepid. Soc. No. 2).

For species found in Kern County on a regular basis, information is presented regarding distribution and normal flight periods. Specific records are cited to add authority to the text and document previously unpublished information but are not given in the case of common species unless in some way significant. The dates given for flight periods are representative of when the butterfly normally occurs (or has been collected) and are not the result of an exhaustive study of the collection data of the various contributors. While earlier and later collection data undoubtedly exist for many of the butterflies considered, the dates given provide a fairly accurate picture of the year-to-

year flights for most species or subspecies. Of course, more data are needed on several of the less commonly encountered butterflies.

Also considered in the text are unusual populations, comments regarding taxonomy, or other information of interest not published or generally well known. An effort has been made not to simply duplicate or restate information already published somewhere else in the literature.

The varied topography of Kern County supports a number of undescribed or atypical populations. Some of these will undoubtedly be described as new subspecies by other lepidopterists in the near future. Any mention or description of these given in this paper is merely intended to show how a specific population differs from other described known populations. These comments are not intended as a formal description of any "new" subspecies. Which of these unusual or atypical populations warrant names or recognition in the nomenclature will be left to the taxonomists and specialists in their respective fields.

To conserve space in the checklist a distribution code is used to represent various general localities where the butterflies can be found. Such a code represents the names of the major valleys, canyons and mountain ranges. The names of cities and towns or the citations of specific locality data will not be coded. The code is as follows:

(1) Code for the major valleys or lowlands:

SJV: The San Joaquin Valley, often including Bakersfield.

KRV: The Kern River Valley, often including Kernville, Lake Isabella and Weldon.

(2) Code for the desert regions:

MD: The Mojave Desert.

RRC: Red Rock Canyon and vicinity.

WP: Walker Pass, often on the dry eastern slope of the Sierra.

JC: Jawbone Canyon, located at the south end of the Sierra.

KV: Kelso Valley, often including Sageland and arid foothills.

(3) Code for the mountain regions:

MTNS: Mountains, distribution general throughout most of the mountain areas of Kern County.

SNM: Sierra Nevada Mountains, including the area along the Kern-Tulare County line southward to Butterbrecht Peak.

GM: Greenhorn Mountains, including Cedar Creek and Mountain Park.

PM: Piute Mountains, including areas adjacent to Bodfish and Havilah; also includes Hooper Hill.

TM: Tehachapi Mountains, includes Tehachapi Mountain Park and the Caliente region.

TJM: Tejon Mountains, including Frazier Park and Mt. Pinos.

TR: Temblor Range, including McKittrick and Taft.

KRC: Kern River Canyon, including Miracle and Democrat Hot Springs and the area around Richbar.

Specific records given in the text are those of the author unless otherwise stated.

AN ANNOTATED CHECKLIST OF THE BUTTERFLIES OF KERN COUNTY, CALIFORNIA

HESPERIIDAE

1. *Polygonus leo leo* (Gmelin).

Jim Brock collected a single worn specimen of this skipper 5 miles east of Caliente on 6 IX 73. This record probably represents a wind blown stray. It is almost certainly not a regular member of the county fauna.

2. *Thorybes pylades* (Scudder).

Distribution: SNM, GM, TM, TJM. Flight: 13 VI to 23 VI.

Widely distributed but rarely encountered. Most records are from the Frazier Park region where *pylades* probably first appears in May.

3. *Erynnis brizo lacustra* (Wright).

Distribution: GM, PM, TM, TJM. Flight: 3 IV to 30 VI.

4. *Erynnis propertius* (Scudder & Burgess).

Distribution: MTNS. Flight: 11 III to 11 VII.

5. *Erynnis tristis tristis* (Boisduval).

Distribution: KRV, SJV, PM (Hooper Hill). Flight: 25 IV to 24 IX.

Common at Bakersfield in 1962 and 1963, *tristis* has since become exceedingly scarce in the southern San Joaquin Valley.

6. *Erynnis pacuvius* (Lintner).

John Burns examined material of this species from Kern County (in 1980) and determined that two subspecies occur here:

a. *Erynnis pacuvius lilius* (Dyar).

Distribution: GM, PM. Flight: 11 VI to 21 VII.

b. *Erynnis pacuvius callidus* (Grinnell).

Distribution: TM, TJM. Flight: 31 V to 21 VII.

Generally *callidus* is found further south and southwest than *lilius*. Sympatry has not been observed.

7. *Erynnis funeralis* (Scudder & Burgess).

Distribution: SJV, KRV, PM, MD. Flight: 10 IV to 9 X.

Common throughout most of southern California, *funeralis* is rare in Kern County. Like *E. tristis*, this species was common in Bakersfield in 1962 and 1963.

8. *Erynnis persius persius* (Scudder).

The status of this widely distributed *Erynnis* in Kern County is presently unknown. It is included on the county list on the basis of a single specimen collected by Jerry Powell at Delano on 12 VII 55 (Burns, 1964). John Burns (pers. comm.) suspects that *persius* may be "resident" within the county boundaries and is probably much more widely distributed here than the lone record would suggest. It has been collected at Big Meadow in the southern Sierra, Tulare County, which is just a few miles north of the county line.

9. *Pyrgus scriptura* (Boisduval).

Distribution: Western SJV. Flight: 27 II to 3 X.

Most of our records are from Buttonwillow and Lost Hills. *Scriptura* appears to be absent from agricultural areas around Bakersfield and the eastern side of the San Joaquin Valley. Very local.

10. *Pyrgus communis albescens* Plötz.

Distribution: SJV, KRV, KV, MD, MTNS, at lower elevations. Flight: 25 II to 9 XI.

11. *Heliopetes ericetorum* (Boisduval).

Distribution: SJV, KRV, KV, JC, MTNS. Flight: 30 IV to 9 X.

12. *Pholisora catullus* (Fabricius).

Distribution: SJV, KV, PM, east slope of Breckenridge Mountain. Flight: Mountains and desert: 3 IV to 7 VI. SJV: 20 VIII to 5 IX. Probably double brooded in the southern San Joaquin Valley. The mountain and desert populations appear to be single brooded.

Catullus appeared to be absent from the floor of the southern San Joaquin Valley until a small population was found in a swampy area adjacent to the Kern River flood canal on the Tule Elk State Reserve on 20 VIII 81.

13. *Pholisora libya* (Scudder).

Two variable and geographically separated populations occur in Kern County. Out on the Mojave Desert (including Homestead and Jawbone Canyon) and on the east slope of the Sierra Nevada there is a rather mixed population which shows characteristics of nominate *libya* and the larger *lena* (Edwards) but which tends toward *lena* (John F. Emmel, pers. comm.). Individuals of this eastern Kern County population are frequently encountered which have the undersurface of the hind wings entirely colored with white scales.

In the western San Joaquin Valley (Maricopa, Taft, Buttonwillow, McKittrick and Lost Hills) is an undescribed subspecies (Emmel & Emmel, 1973) distinguished by its larger size and washed-out appearance of the underside of the hind wings.

Flight of *P. libyallena*: 6 V to 26 V; 21 VIII to 30 IX.

Flight of SJV subspecies: 28 IV to 18 V; 20 VI to 12 IX. The spring brood of the SJV populations is the heaviest flight; later broods are unreliable and made up of few individuals. This is in contrast with the desert population which has its heaviest flight in the late summer and early fall.

14. *Pholisora alpheus oricus* Edwards.

Distribution: SNM (Butterbredt Peak). One record for KV. Flight: 21 V to 15 VI. Probably appears in late April.

A rare butterfly throughout most of its range, *oricus* is locally abundant on the eastern and southern slopes and canyons of Butterbredt Peak where the *Atriplex* foodplant grows.

15. *Copaeodes aurantiaca* (Hewitson).

Distribution: Homestead, WP, KV, Caliente Canyon. Flight: 1 V to 22 X.

Aurantiaca breeds in small numbers in the desert areas and in low arid mountain canyons. Tom Rubbert collected a specimen in the San Joaquin Valley at Bakersfield on 17 VI 50. Allen Rubbert has a specimen from the same locality which lacks data as to the date of capture.

16. *Hylephila phyleus* (Drury).

Distribution: MD, SJV, KRV, Caliente region. Flight: 8 IV to 12 XII.

17. *Pseudocopaeodes eunus eunus* (Edwards).

Distribution: Weldon, Onyx and probably elsewhere in KRV. Formerly known from SJV where relict populations may still exist. Flight: 14 VI to 21 VIII in KRV.

John Adams Comstock (Comstock, 1927) reported that *eunus* was known from the southern San Joaquin Valley at that time. C. M. Dammers collected at least one female specimen (now in the Los Angeles Museum) at Panama (near Bakersfield) on 18 VIII 29. This population may have disappeared with the destruction of its saltgrass habitat due to urban and agricultural development of the region. At least no recent records for

this species in the San Joaquin Valley are known to the author. However, *eunus* can still be found commonly in saltgrass habitats at Weldon and Onyx where it appears to fly continuously throughout the summer months. Ron Leuschner discovered this population on the Kern River Preserve at Weldon on 13 VI 81.

18. *Hesperia juba* (Scudder).

Distribution: SNM, GM, PM, TM, TJM, WP, KV. Usually uncommon. Flight: 9 V to 20 VI; 11 IX to 14 X. More common in the fall.

19. *Hesperia comma* (Linnaeus).

Two distinct populations occur in Kern County:

a. *Hesperia comma harpalus* (Edwards).

Distribution: KRV, KV, SNM, WP, PM (east slope). Flight: 19 VI to 5 IX.

b. *Hesperia comma* near *tildeni* Freeman.

Distribution: PM (west slope), KRC, TM, GM, TJM. Flight: 1 VII to 9 X.

This population of *comma* is smaller and lighter than *harpalus*. How this population is actually related to other Sierran and Coast Range populations is presently under study by William W. McGuire. The Sierran subspecies *yosemite* Leussler probably does not occur in Kern County.

20. *Hesperia columbia* (Scudder).

Distribution: Kernville, PM, TJM. Flight: 31 III to 24 V; 12 IX. Ray Stanford collected a specimen on the summit of Mt. Pinos on 29 VI 63, an extreme collection date. Most records are for May.

Columbia is intensely local and uncommon and few records exist for Kern County. It has been collected in numbers at two localities in Ventura County adjacent to the Kern County line. It should be found at several additional localities as more favorable habitat areas are explored in the future.

21. *Hesperia lindseyi* Holland.

Distribution: GM, PM, TM, TJM. Flight: 14 V to 12 VII.

Usually uncommon and local in occurrence.

22. *Polites sabuleti sabuleti* (Boisduval).

Distribution: SJV, KRV, KV, Havilah, TM, TJM. Flight: 4 V to 1 XI. Probably first appears in April.

Individuals which resemble *chusca* (Edwards) are regularly found in most county populations.

23. *Polites sonora sonora* (Scudder).

Distribution: GM, TM. Flight: 13 VI to 11 VII.

24. *Atalopedes campestris campestris* (Boisduval).

Distribution: MD, SJV, KRV, KRC, PM, TM, TJM. Flight: 28 III to 13 XI.

25. *Ochlodes sylvanoides sylvanoides* (Boisduval).

Distribution: MTNS. Flight: I VII to 9 X.

26. *Ochlodes agricola* (Boisduval).

Three subspecies occur in Kern County:

a. *Ochlodes agricola agricola* (Boisduval).

Distribution: TM, TJM. Flight: Late May to early July.

b. *Ochlodes agricola verus* (Edwards).

Distribution: Havilah, PM, KV. Flight: 26 V to 21 VII.

c. *Ochlodes agricola nemorum* (Boisduval).

Distribution: Kernville, SNM, GM. Flight: 19 V to 7 VII.

Nemorum blends with *verus* on the northern edge of the Piute Mountains around Bodfish.

27. *Paratrytone melane melane* (Edwards).

Distribution: KRC along Clear Creek at Miracle Hot Springs. Flight: 14 V to 21 V; 10 VIII.

Widespread elsewhere in southern California, this skipper thus far has been found only at the above mentioned locality where it is uncommon.

28. *Lerodea eufala* (Edwards).

Distribution: MD, SJV, KRV. Flight: 23 III to 12 XII. Most records are from August through October.

MEGATHYMIDAE

29. *Megathymus coloradensis martini* Stallings & Turner.

Distribution: SNM (arid slopes), WP, KV. Flight: 3 IV to 25 V.

This large skipper is rarely taken in numbers but probably has a wider range out on the desert floor where stands of the *Yucca* larval foodplant are rather common.

PAPILIONIDAE

30. *Battus philenor* (Linnaeus).

This is not a regular member of the county fauna and apparently occurs only as a stray. There is only one definite record: 13 miles west of Shafter (a male on alfalfa); 30 VI 57; collected by Paul Opler. Which subspecies this record represents is questionable. Either the nominate subspecies or northern California *hirsuta* (Skinner) could stray into the county at times.

31. *Papilio rudkini* Chermock & Chermock.

Distribution: SNM (Butterbredt Peak), one record for RRC by Jim Brock (5 IV 74). Flight: 5 IV to 26 V.

This desert swallowtail is an uncommon find in Kern County, but there are several records for adults and larvae (on *Tauschia parishii* (C. & R.)) on Butterbredt Peak. (*Thamnosma montana* Torr. & Frem. is the usual host in most of its range.) Many lepidopterists believe that *rudkini* is probably a subspecies of *Papilio polyxenes* Fabricius.

32. *Papilio zelicaon zelicaon* Lucas.

Distribution: SJV, MTNS. Flight: 25 II to 25 X.

33. *Papilio indra phyllisae* J. Emmel.

Distribution: SNM (Butterbredt Peak and vicinity), PM (Piute Mountain Vista; also 1 mile west of Kelso Valley Road Summit at east end of Piute Mountains). Flight: 13 IV to 30 VII. This subspecies has a small second brood which flies during the month of July.

Though presently known from but three localities in the county, *phyllisae* will undoubtedly be found on several of the higher peaks in the southern Sierra Nevada where the *Tauschia parishii* foodplant is widely distributed.

34. *Pterourus rutulus rutulus* (Lucas).

Distribution: SJV, KRV, MTNS. Flight: 8 III to 25 X.

35. *Pterourus multicaudata* (Kirby).

Distribution: GM (Cedar Creek), PM, TM, TJM. Flight: 29 V to 30 VII. Probably appears in early May on east slope of Breckenridge Mountain near Havilah.

Multicaudata tends to be local in occurrence and uncommon but is sometimes locally abundant. It prefers canyon bottoms with small streams where oak woodland and coniferous forest meet.

36. *Pterourus eurymedon* (Lucas).

Distribution: MTNS. Flight: 24 IV to 21 VII.

PIERIDAE

37. *Neophasia menapia menapia* (Felder & Felder).

Distribution: GM, PM, TM. Flight: 9 VII to 20 VIII.

38. *Pontia beckerii* (Edwards).

Distribution: SJV, KRV, MTNS, MD. Flight: 22 III to 3 XI.

One of the surprises of this survey was finding a large population of this butterfly on the floor of the San Joaquin Valley. A few *beckerii* adults had been collected around Bakersfield prior to 1981, but it was assumed that these individuals represented strays from other areas. Actually, *beckerii* appears to be well established in the foothills northeast of Bakersfield (southeast edge of Hart Park, 20 VI 72; 6 to 16 VI 81) and north of Oildale (Poso Creek 8 miles north of Oildale, 18 V to 26 VI 81). It was also abundant along the Glennville-Woody Road 8 to 20 miles north of Oildale on 26 VI 81. The bladderpod plant, *Isomeris arborea* Nutt., grows commonly in this portion of the San Joaquin Valley and is likely used as a larval host.

39. *Pontia sisymbrii sisymbrii* (Boisduval).

Distribution: MTNS, WP, KV, Kernville. Flight: 25 II to 30 V.

40. *Pontia protodice* (Boisduval & LeConte).

Distribution: Entire county. Flight: 12 II to 24 XI.

41. *Artogeia rapae* (Linnaeus).

Distribution: Entire county except arid portions of desert. Flight: All months, but mostly from March through October.

42. *Euchloe hyantis* (Edwards).

Two sets of populations occur in Kern County:

a. *Euchloe hyantis lotta* (Beutenmüller).

Distribution: MD, SNM, PM (east slope), TM (arid southern and eastern slopes). Flight: 12 III to 15 V.

b. *Euchloe hyantis* (Edwards) ssp. "Mt. Pinos block segregate." (Opler, 1968, 1969; also Emmel & Emmel, 1973)

Distribution: TJM. Flight: 5 V to 8 VI.

This population is uncommon and rarely collected in numbers.

43. *Anthocharis cethura morrisoni* Edwards.

Distribution: Western SJV, TR, SNM, PM (Hooper Hill and arid eastern slope), KRC (Miracle Hot Springs), KV, WP, RRC. Flight: 19 II to 15 V. Certain populations (KRC and SJV) have been noted to forego emergence in years of unfavorable rainfall.

This subspecies is distinguished by the dark green coloration of the hind wings. Most females of the lower Kern River and valley populations lack the "orange-tip" though females from eastern Kern County often do.

44. *Anthocharis sara sara* Lucas.

Distribution: KRV, TR, MTNS, KV. Flight: 17 II to 21 VI. The early spring brood (*reakirtii* Edwards) is the most common. The larger and lighter second brood is relatively scarce.

45. *Falcapica lanceolata lanceolata* (Lucas).

Distribution: SNM, GM, PM, TJM, KRC, WP, Erskine Creek near Lake Isabella. Flight: 28 II to 19 VI.

Though generally considered to be a rare species, *lanceolata* is often abundant along Erskine Creek and in the Piute Mountains just south of Bodfish.

46. *Colias eurytheme* Boisduval.

Distribution: Entire county. Flight: 20 II to 5 XI.

This species is often a serious economic pest in the San Joaquin Valley.

47. *Colias harfordii* Hy. Edwards.

Distribution: KV, PM, TM, TJM. Flight: 28 V to 26 VIII. Another flight in late September and October is probable since *harfordii* was observed and collected in numbers on the north slope of Frazier Mountain in Ventura County (just across the county line) on 9 X 81.

Most records for the county are from Frazier Park and Mt. Pinos. Elsewhere, it tends to be very rare and unreliable. The northernmost records for *harfordii* are from the Piute Mountains (near Liebel Peak, 21 VII 78) and Kelso Valley (the area around Sageland) where the butterfly occurs in June.

48. *Zerene eurydice* (Boisduval).

Distribution: TM, TJM. Flight: 23 VI to 11 VII.

Though common in much of southern California, this butterfly is scarce in Kern County. It is uncommon in the Transition Zone of Tehachapi Mountain Park and around Frazier Park. It can sometimes be fairly common on dry hillsides near the McGill Campground on Mt. Pinos. *Eurydice* appears to be single-brooded at these localities though multiple-brooded elsewhere in southern California.

49. *Zerene cesonia cesonia* (Stoll).

This species is uncommonly found in Kern County, but it evidently establishes transient breeding populations out on the desert floor. Many were seen in Jawbone Canyon and on Tom's Hill in April and May of 1978. I know of two definite records: Weldon Kirk collected a specimen at Tehachapi Mountain Park in August of 1962 (specific date unknown); and I have a record for Koehn Dry Lake, 18 IV 78.

50. *Phoebis sennae marcellina* (Cramer).

This is not a regular member of the county fauna, though it may occasionally breed on *Cassia* plants out in the Mojave Desert. Ed Sampson collected a single male near Arvin in the San Joaquin Valley on 10 III 68. It has been collected on Frazier Mountain just south of the county line in Ventura County.

51. *Eurema mexicana* (Boisduval).

This is another species which reaches the area periodically and which may establish transient populations on *Cassia* plants out on the desert floor. There are definite records for Frazier Park, Bodfish, Weldon and Lakeview (in the San Joaquin Valley) where Ed Sampson collected a specimen on 16 V 66. Most of the other records are also for the month of May.

52. *Abaeis nicippe* (Cramer).

Distribution: MD (including Ridgecrest) with other records of strays or transients from north of Kernville, Bodfish, PM, WP, JC and Caliente Canyon. Flight: 6 III to 9 X.

This species may not be permanently established in Kern County and may need to periodically reestablish itself here after cold winters. Records for early March in 1978 indicate that it does successfully overwinter at times.

53. *Nathalis iole* Boisduval.

This is another species which enters the region only occasionally. Records exist for the Mojave Desert, adjacent mountain ranges (PM, TM, TJM) and even the San Joaquin Valley. Most of these records are for May or early June.

LYCAENIDAE

54. *Tharsalea arota arota* (Boisduval).

Distribution: MTNS, KRV. Flight: 20 V to 10 VIII.

55. *Gaeides xanthoides xanthoides* (Boisduval).

Distribution: MTNS, KRV, KV. Flight: 21 V to 4 VIII.

56. *Gaeides gorgon* (Boisduval).

Distribution: MTNS, KV. Flight: 14 V to 19 VI.

57. *Chalceria heteronea clara* (Hy. Edwards).

Distribution: PM, TM, TJM. Flight: 22 VI to 26 VII.

Clara has a very restricted range in southern California where it tends to be scarce and local in occurrence. Many former habitat areas have disappeared because of human influence. It is still common in certain canyons and washes in the Tejon Mountains. Most records are from around Lebec and Frazier Park.

58. *Epidemia helloides* (Boisduval).

Distribution: SJV (rare), KRV, Havilah, KRC, Paris-Lorraine, Frazier Park. Flight: 30 IV to 1 XI.

59. *Habrodais grunus grunus* (Boisduval).

Distribution: MTNS. Flight: 26 VI to 4 IX.

60. *Atlides halesus estesi* Clench.

Distribution: SJV, KRV, TM, TJM, TR. Flight: 10 III to 21 X.

This spectacular butterfly is sometimes abundant in residential areas of Bakersfield, along the Kern River at Hart Park and in the Caliente region. Usually, it is rather scarce.

61. *Satyrium behrii behrii* (Edwards).

Distribution: KV, PM (east slope), TM, TJM. Flight: 14 VI to 10 VII.

62. *Satyrium californica* (Edwards).

Distribution: MTNS. Flight: 3 VI to 20 VII.

63. *Satyrium sylvinus* (Boisduval).

Sierran *S. sylvinus sylvinus* may be the subspecies found in the Greenhorn Mountains. Two other subspecies occur in Kern County:

a. *Satyrium sylvinus dryope* (Edwards).

Distribution: KRC, TM, TJM. Flight: 1 VI to 4 VIII.

Dryope is usually found at lower elevations than the next subspecies. It is also less common than *desertorum*.

b. *Satyrium sylvinus desertorum* (Grinnell).

Distribution: KRV, MTNS. Flight: 29 V to 10 VIII.

Sylvinus from Havilah and the Greenhorn Mountains appear darker underneath

than *desertorum* from the Tehachapi Mountains. These need further study before they can be properly placed taxonomically.

64. *Satyrrium auretorum spadix* (Hy. Edwards).

Distribution: TR, GM, TM, TJM. Flight: 8 VI to 30 VII.

65. *Satyrrium tetra* (Edwards).

Distribution: PM, TM, TJM. Flight: 19 VI to 26 VII.

66. *Satyrrium saepium saepium* (Boisduval).

Distribution: MTNS. Flight: 14 V to 26 VII.

67. *Callophrys dumetorum dumetorum* (Boisduval).

Distribution: SNM, PM, KRC, TJM, KV. Flight: 20 II to 22 V.

Many Kern County populations seem atypical and warrant further study.

68. *Mitoura spinetorum* (Hewitson).

Distribution: MTNS. Flight: 30 IV to 17 IX.

This hairstreak is rarely found in numbers. It is sometimes common on flowers or along streams at Tehachapi Mountain Park or in the Caliente region. Gary File has one record for Hart Park in the San Joaquin Valley, 17 IX 73.

69. *Mitoura nelsoni nelsoni* (Boisduval).

Distribution: GM. Flight: 6 VI to 17 VII.

70. *Mitoura siva* (Edwards).

Two subspecies occur in Kern County:

a. *Mitoura siva juniperaria* Comstock.

Distribution: SNM, Bodfish, PM, TJM. Flight: 3 IV to 30 VII.

b. *Mitoura siva mansfieldi* Tilden.

Distribution: TR. Flight: Late March to 17 IV.

71. *Incisalia augustus iroides* (Boisduval).

Distribution: MTNS. Flight: 19 III to 6 VI.

72. *Incisalia eryphon eryphon* (Boisduval).

Distribution: GM, PM. Flight: 11 VI to 9 VII.

73. *Strymon melinus pudica* (Hy. Edwards).

Distribution: Entire county. Flight: 3 III to 7 X.

74. *Brephidium exilis* (Boisduval).

Distribution: SJV, KRV, MD, MTNS (usually at low elevations). Flight: 27 II to 15 XI.

75. *Leptotes marina* (Reakirt).

Distribution: SJV, KRV, MD, MTNS. Flight: 3 IV to 3 X.

76. *Hemiargus ceraunus gyas* (Edwards).

This butterfly appears to periodically establish itself in the lower mountain canyons of the Tehachapi and Piute Mountains. It has been collected at Miracle Hot Springs in Kern Canyon, south of Bodfish in the Piute Mountains, 5-10 miles east of Caliente, 3 miles north of Twin Oaks and even in the San Joaquin Valley where a fresh female was collected along the Kern River at Hart Park, 23 IX 1982. Flight: 21 V to 23 IX.

77. *Hemiargus isola alce* (Edwards).

I collected a single fresh female near Buttonwillow in the San Joaquin Valley on 2 IX 80. Mesquite (*Prosopis*) still grows in a few places on the valley floor and out on the Mojave Desert and may support populations of this butterfly.

78. *Everes comyntas comyntas* (Godart).

This species may be a "resident" somewhere in the county but no populations are presently known. I found a small transient population along the Kern River at Hart Park (4 VIII 70) which was subsequently destroyed by flooding.

79. *Everes amyntula amyntula* (Boisduval).

Distribution: TM, Frazier Park. Flight: 18 III to 5 VII.

80. *Celastrina ladon echo* (Edwards).

Distribution: GM, PM, KRC, TM, TJM. Flight: 4 III to 14 VII.

81. *Euphilotes battoides* (Behr).

Two subspecies occur in Kern County:

a. *Euphilotes battoides bernardino* (Barnes & McDunnough).

Distribution: MTNS (including El Paso Mtns. and TR), WP, KV, JC. Flight: 26 V to 26 VII.

Eastern Kern County desert populations of *battoides* have been called *martini* (Mattoni) but are better viewed as atypical *bernardino*, according to John F. Emmel (pers. comm.).

b. *Euphilotes battoides comstocki* (Shields).

Distribution: Piute Mountain Vista, TM. Flight: 18 VII to 22 VII. Adults undoubtedly fly into the month of August.

Jim Brock recently discovered a large colony of *comstocki* on Piute Mountain Vista (or Lookout). Prior to his discovery this subspecies was known in California from only a few specimens collected in the Tehachapi Mountains (22 VII 18) by John A. Comstock. Adults are associated with a yellow flowered *Eriogonum*.

82. *Euphilotes enoptes* (Boisduval).

The taxonomic arrangement of this species in Kern County is very perplexing and open to considerable subjective opinion. Oakley Shields (1977) felt at that time the variable and atypical populations found in the southern Sierra, Piutes, Tehachapi and Mt. Pinos areas should best be viewed as forms of *E. enoptes enoptes*. Since Shields wrote his paper other populations have been discovered which do not appear to fit into this concept. My presentation of this species is tentative pending further study by other workers.

a. *Euphilotes enoptes enoptes* (Boisduval).

Distribution: MTNS. Flight: 24 IV to 26 VII.

b. *Euphilotes enoptes tildeni* (Langston).

Distribution: TR. Flight: Late August to early September. Jim Brock has one record for 27 III 77.

A large population exists on dry hillsides in the Temblor Range. Most records are from along Highway 58 near the Kern-San Luis Obispo County line.

c. *Euphilotes enoptes mojave* (Watson & Comstock).

Distribution: SNM (east and south slopes), MD, KV, JC. Flight: 9 IV to 26 V.

d. *Euphilotes enoptes* (Boisduval) ssp. Butterbreedt Peak population.

Distribution: SNM (Butterbreedt Peak and vicinity), PM (east slope), KV. Flight: Late April to early June.

This population is similar to *mojave* (which practically "surrounds" the Butterbreedt Peak locality) but is much larger and is associated with *Eriogonum nudum* Dougl. ex Benth. which is used as the larval host (John F. Emmel, pers. comm.).

e. *Euphilotes enoptes* (Boisduval) ssp. Fall-flying population.

Distribution: Some of the same areas where *enoptes enoptes* flies in the spring. Hooper Hill, PM, KV, SNM, JC. Flight: 31 VIII to 9 X.

This *enoptes* is distinguished by bolder black spots on the ventral side and by darker suffusion of the forewings beneath. John Emmel reports that this same "subspecies" occurs on the north slopes of other southern California mountain ranges and in Inyo County.

83. *Euphilotes pallescens elvirae* (Mattoni).

Distribution: SNM (arid slopes), WP, PM (Harris Grade), Tehachapi. Flight: Mid-June to late September.

Shields (1977) notes that many specimens from Walker Pass resemble *pallescens* (Tilden & Downey).

84. *Philotiella speciosa speciosa* (Hy. Edwards).

Distribution: RRC, Randsburg and other locations in MD. No populations are presently known at Havilah (the type locality) or in the southern San Joaquin Valley of Kern County. Flight: Mid-April to 13 V.

85. *Glaucopsyche piasus piasus* (Boisduval).

Distribution: SNM, GM, PM, TJM, KV. Flight: 3 IV to 18 VI.

A huge population exists near Sageland in Kelso Valley where adults fly in desert washes (in association with a *Lupinus* spp.) out of the usual montane habitat.

86. *Glaucopsyche lygdamus* (Doubleday).

Three distinctive populations occur in Kern County:

a. *Glaucopsyche lygdamus australis* Grinnell.

Distribution: TM, TJM. Flight: 20 V to 14 VII.

b. *Glaucopsyche lygdamus columbia* (Skinner).

Distribution: SNM, GM. Flight: March to early May.

Langston (1969) has *columbia* extending the length of the Sierra Nevada; whereas, *incognitus* Tilden is restricted to the central Coast Ranges. Kern County *columbia* has larger black spots underneath than the more northerly populations of this subspecies.

c. *Glaucopsyche lygdamus* (Doubleday) ssp.

Distribution: KRC, PM, WP, KV. Flight: 12 III to 26 V.

This population is distinguished by bold black spots on both wings underneath and a smaller size than *columbia*. The females often have considerable blue scaling above and resemble *australis* in this respect. This "subspecies" appears to be intermediate between the two previously discussed subspecies.

87. *Lycaeides melissa paradoxa* (Chermock).

Distribution: TJM, TM, KRV, KV. Flight: 3 IV to 3 X.

88. *Plebejus saepiolus saepiolus* (Boisduval).

Distribution: SNM (Fay Creek), GM, PM. Flight: 19 VI to 11 VII.

Some Kern County material resembles southern California *hilda* (Grinnell & Grinnell).

89. *Plebulina emigdionis* (Grinnell).

Distribution: TJM including San Emigdio Canyon (the type locality), KRV including Weldon. Flight: 23 IV to 11 IX.

Emigdionis is very abundant on *Atriplex* at Weldon (Paul's Place).

90. *Icaricia icarioides evius* (Boisduval).

Distribution: MTNS, KV. Flight: 3 IV to 14 VII.

91. *Icaricia acmon acmon* (Westwood & Hewitson).

Distribution: Entire county. Flight: 21 III to 9 X.

92. *Icaricia lupini* (Boisduval).

Two subspecies occur in Kern County:

a. *Icaricia lupini monticola* (Clemence).

Distribution: MTNS, WP, KV, KRV. Flight: 10 IV to 14 VII.

b. *Icaricia lupini chlorina* (Skinner).

Distribution: TM, TJM. Flight: May to early July.

Populations of *chlorina* are very uncommon. Paul Opler found it in the hills west of Lebec (9 VI 57) associated with *Eriogonum nudum*.

93. *Icaricia neurona* (Skinner).

Distribution: SNM (Pacific Crest Trail 6–9 miles north of Weldon), KV (wash 1 mile south of Sageland), Erskine Creek nr. Lake Isabella, PM (1–2 miles south of Bodfish and on Hooper Hill), TM, TJM. Flight: 30 IV to 26 VIII. Possibly flies well into September in some years. In some areas two or more broods are indicated.

This blue is often locally abundant in the Piute Mountains just south of Bodfish where it frequents canyon bottoms and roadsides.

RIODINIDAE

94. *Apodemia mormo* (Felder & Felder).

Populations of this species vary considerably, and much confusion exists about the taxonomy of the species. Kern County populations are perplexing and await further study by a specialist. At least three distinct groups exist:

a. *Apodemia mormo* nr. *mormo* (Felder & Felder).

Distribution: El Paso Mountains, Homestead, Randsburg, JC. Flight: 18 IV to 13 V; 21 VIII to 9 X.

Fall flying specimens from Homestead and Jawbone Canyon closely resemble *deserti* Barnes & McDunnough. These populations fly in association with *Eriogonum inflatum* (Benth.) S. Stokes or with *Eriogonum heermannii* Dur. & Hilg. (Jim Brock, pers. comm.).

b. *Apodemia mormo* nr. *tuolumnensis* Opler & Powell.

Distribution: TR, SNM, KV, PM, TJM. Flight: 30 VII to 3 X.

Is associated with *Eriogonum wrightii* Torr. Locally common.

c. *Apodemia mormo virgulti* (Behr).

Distribution: SNM, KV, PM, WP. Flight: 13 IV to 26 V. Dark form: 27 VIII to 2 X.

Individuals associated with *Eriogonum fasciculatum* Benth. (Jim Brock, pers. comm.) which have a very dark phenotype are regularly encountered on Hooper Hill and in the Piute Mountains during late August and September. These represent a later brood of *virgulti*.

LIBYTHEIDAE

95. *Libytheana bachmanii larvata* (Strecker).

This is not a regular member of the county fauna. Several individuals of *bachmanii* were observed flying southward through Bakersfield in September and October of 1963. I captured one such individual on 6 X 63. Another specimen had been captured two years earlier in Bakersfield by Glenn Broadwater. No such migrations have been noted since 1963.

HELICONIIDAE

96. *Agraulis vanillae incarnata* (Riley).

Distribution: SJV, one record for Caliente. Flight: 13 IV to 3 XII.

NYMPHALIDAE

97. *Speyeria coronis hennei* (Gunder).

Distribution: TM, TJM. Flight: 6 VI to 28 VIII.

Hennei is often uncommon and hard to find. It prefers the high elevation cooler slopes of Mt. Pinos and Double Mountain and rarely descends to lower warmer elevations.

98. *Speyeria callippe macaria* (Edwards).

Distribution: MTNS. Flight: 14 V to 3 VIII.

Unsilvered *laurina* Wright occurs in all the Kern County populations so I consider it to be a "form" rather than a valid subspecies. I have one record of *macaria* from Bakersfield, 2 VI 62.

99. *Speyeria egleis tehachapina* (Comstock).

Distribution: Above 7000 feet elevation in TM, PM. Limited to summit peaks and ridges in TM. Flight: 30 VI to 24 VII. Records exist for August (Emmel & Emmel, 1973).

This endemic subspecies is found only in Kern County. On Double Mountain a forest fire consumed much of the summit area in 1979, but adults could still be found afterwards, perching on the blackened soil and rocks on the summit.

100. *Speyeria adiate atossa* (Edwards).

Distribution: TM, TJM. Flight: June to early September.

Some recent authors (Miller & Brown, 1981; Pyle, 1981) view the *adiaste* (Edwards) group to be subspecies of *Speyeria egleis* (Behr). However, *S. egleis tehachapina* and *S. adiate atossa* were once sympatric in the Tehachapi Mountains. This is strong evidence that the two are best viewed as distinct species.

Though numerous lepidopterists have visited colony sites and habitat regions of where *atossa* was once found, there are still no records of capture since 1959. It has probably become extinct because of drought or overgrazing (Emmel & Emmel, 1973; Howe, 1975).

101. *Speyeria hydaspes viridicornis* (Comstock).

Distribution: GM. Flight: 2 VI to 3 VIII.

102. *Clossiana epithore sierra* (Perkins).

Distribution: Tiger Flat Campground, GM. Flight: 24 VI to 11 VII.

This species still flies in the Greenhorn Mountains north of the Tulare County line but its status at Tiger Flat Campground is questionable. The author knows of no records for the past few years, and several visits to the colony site in June and early July (1981) failed to turn up a single specimen.

103. *Thessalia leanira* (Felder & Felder).

At least two distinct populations occur in the county:

a. *Thessalia leanira* nr. *wrightii* (Edwards).

Distribution: SNM (Pacific Crest Trail), GM (near Kernville), Erskine Creek nr. Lake Isabella, Bodfish, PM, Havilah. Flight: 24 IV to 19 VI.

This population is extremely variable. About 70% of the population near Bodfish is *wrightii*; 25% resemble *daviesi* (Wind) or nominate *leanira*; and the remaining 5% resemble the brick red desert subspecies, *cerrita*.

b. *Thessalia leanira cerrita* (Wright).

Distribution: RRC, WP. Flight: 1 IV to 21 V.

104. *Charidryas palla palla* (Boisduval).

Distribution: MTNS, KV. Flight: 1 V to 6 VII.

Palla is extremely variable from population to population even within the county boundaries. In the southern Sierra (Fay Creek 6 miles north of Weldon) and in Kelso Valley the *palla* pattern tends towards obsolescence and individuals may even resemble *C. neumoezeni*. Populations to the west have progressively more heavily patterned individuals which little resemble the *palla* found to the east.

At Kelso Valley the ranges of *palla* and *neumoezeni* overlap. There appears to be no evidence of any intergradation taking place, however, as the *neumoezeni* population shows no tendency to assume *palla* characteristics, and the two species are allochronic in their occurrence. Thus, *neumoezeni* flies in desert washes in April and *palla* in those same desert washes in May. I have never found the two species on the wing at the same time, though only 4 or 5 days separate the flight periods of the two at this locality.

105. *Charidryas neumoezeni neumoezeni* (Skinner).

Distribution: MD, KV. Flight: 5 IV to 7 V.

106. *Charidryas gabbi* (Behr).

Distribution: TJM. Flight: Late May to June.

The status of this species is uncertain. *Gabbi* is frequently reported from the Frazier Park region, but many of these records are based on misidentifications of the heavily patterned *C. palla* which inhabits the area. However, I feel that at least some of these records are valid as *gabbi* is known to be present in nearby areas, and there is apparent contact between *palla* and *gabbi* at Frazier Park and on the north slope of Frazier Mountain. I collected a small series of *Charidryas* adults in this region (22 VI 79) which show startling mixed characteristics of the two species. John F. Emmel examined these specimens and concluded that there is obvious gene flow between the two entities in western Kern County. Further field work and study is needed.

107. *Phyciodes pratensis* (Behr).

Distribution: SNM, GM, KRV, Havilah, Miracle Hot Springs in KRC. Flight: 9 V to 8 IX.

Miller and Brown (1981) favor the use of *pratensis* over that of the more commonly used name, *campestris* (Behr).

The Kern County population of this species is atypical and may represent an undescribed subspecies. Most individuals tend towards *montana* (Behr), but specimens which approach nominate *pratensis* are not unusual (approx. 30–35% of the population).

108. *Phyciodes mylitta mylitta* (Edwards).

Distribution: KRV, MTNS. Flight: 15 III to 24 X.

A few records of strays exist for the southern San Joaquin Valley.

109. *Occidryas chalcedona chalcedona* (Doubleday).

Distribution: MTNS. Flight: 23 IV to 4 VII.

Material from the mountains of northeastern Kern County have enlarged light yellow spots and tend towards *olancha* Wright.

110. *Occidryas editha editha* (Boisduval).

Distribution: WP, SNM, GM (Cedar Creek), PM, KRC (rare). Flight: 20 IV to 8 VII. Tends to be very local.

111. *Polygonia satyrus satyrus* (Edwards).

Distribution: MTNS, KRV, SJV (Kern River at Hart Park; Poso Creek 8 miles north of Oildale). Flight: 17 III to 4 IX. One record for 19 I 76 at Richbar in KRC.

Very dark forms resembling *neomarsyas* dos Passos are frequently encountered in the early spring while the lighter *chrysoptera* Wright is found during the summer months.

112. *Polygonia zephyrus* (Edwards).

Distribution: PM, GM, Mt. Pinos. Flight: 12 IV to 17 VII.

Zephyrus tends to be local in occurrence and less common in Kern County than it is in the Sierra further north. It is usually found at higher elevations than *P. satyrus*.

113. *Nymphalis californica californica* (Boisduval).

Distribution: KRV, MTNS. Flight: 21 II to 11 VII; 4 X to 6 X.

This species periodically undergoes dramatic fluctuations in numbers. In 1972 and 1973 *N. californica* was very abundant. In the drought years 1977 and 1978 I saw none at all. It occasionally strays into the southern San Joaquin Valley with records from Bakersfield (27 V 52, 4 males leg. Allen Rubbert; 4 X 61; 14 V 72) and the Kern River at Hart Park (6 X 71).

114. *Nymphalis antiopa antiopa* (Linnaeus).

Distribution: KRV, SJV, MTNS. Flight: All months.

115. *Aglais milberti furcillata* (Say).

Distribution: KRV, MTNS. Flight: 20 II to 20 VII.

This species can be very common at times in the Piute, Greenhorn and Tehachapi mountain ranges. A few records also exist for the lowlands as it has been collected along the Kern River at Hart Park (31 III 72; 4 IV 72) and at Bakersfield (22 IV 51, 2 males leg. Allen Rubbert). Jim Brock found larvae at Hart Park on nettle (*Urtica holosericea* Nutt.) in 1972. These records only prove that *furcillata* sometimes strays to the Valley floor and establishes small transient populations. It is not found at these localities in the spring on a yearly basis.

116. *Vanessa virginiensis* (Drury).

Distribution: JC, SJV, KRV, MTNS. Flight: 12 II to 24 X.

117. *Vanessa cardui* (Linnaeus).

Distribution: Entire county. Flight: All months. Has been noted to overwinter on low foothills around Hart Park. It is sometimes extremely abundant during migrations.

118. *Vanessa annabella* (Field).

Distribution: Entire county. Flight: All months.

119. *Vanessa atalanta rubria* (Fruhstorfer).

Distribution: SJV, KRV, MTNS. Flight: All months.

120. *Junonia coenia* Hubner.

Distribution: Entire county. Flight: 20 II to 7 XI.

121. *Basilarchia lorquini lorquini* (Boisduval).

Distribution: SJV (Kern River at Hart Park; Poso Creek 8 miles north of Oildale), KRV, MTNS. Flight: 9 IV to 24 X.

122. *Adelpha bredowii californica* (Butler).

Distribution: KRV, MTNS. Flight: 12 IV to 3 XI.

SATYRIDAE

123. *Coenonympha californica californica* Westwood.

Distribution: KRV, MTNS. Flight: 25 II to 3 X.

I collected four specimens of this species along Poso Creek, 8 miles north of Oildale, on 4 V 81. These may represent an established population. The species is not generally found on the floor of the San Joaquin Valley.

124. *Cercyonis sthenele silvestris* (Edwards).

Distribution: MTNS, WP, KV. Flight: 28 V to 18 IX.

I follow the prevailing view of recent authors that *silvestris* is a subspecies of *sthenele* (Boisduval) and not *Cercyonis oetus* (Boisduval) as listed in Miller & Brown (1981).

DANAIDAE

125. *Danaus plexippus* (Linnaeus).

Distribution: Entire county. Flight: All months.

The Monarch overwinters in moderate numbers along the lower Kern River at Hart Park and Lake Ming. It also overwinters in the College Heights residential area of Bakersfield.

126. *Danaus gilippus strigosus* (Bates).

Distribution: SJV (rare), KRV, Havilah, Caliente region, KV, MD. One record for SNM (Fay Creek, 6 miles north of Weldon; 14 VI 80). Flight: 14 VI to 7 X. Jim Brock has one record for April.

Freezing temperatures in the winter may make it impossible for this butterfly to overwinter in the county. Apparently, migrants regularly reach the area in the spring and establish breeding populations at various favorable locations. These localities are usually in lower mountain canyons or valleys where the narrow-leaved milkweed *Asclepias fascicularis* Dene. in A. DC. is locally common along streams or drainage ditches. Freshly emerged adults (including one which was deformed and unable to fly) and mature larvae of *strigosus* have been found near or on this plant, suggesting that this is the primary larval foodplant for the region.

Prior to 1981 rare strays had been collected in the southern San Joaquin Valley. These records included the following: Hart Park (? IV 68 leg. Jim Brock; 25 VII 70; 18 VIII 70; 27 IX 70); Bakersfield (11 IX 60; 13 IX 63); 6 miles south of Greenfield adjacent to Hwy. 99 and Union Ave. (21 IX 79; 18 IX 81).

Considering the fact that this species has been so rarely collected in the Valley it came as quite a surprise to find a breeding population on the Tule Elk State Reserve on 20 VIII 81. I observed no fewer than ten different individuals of *strigosus* on that afternoon. Five were captured. Two additional specimens were collected at the same locality on 5 IX 81. *Asclepias fascicularis* was very common along the wash bottoms and swampy region where *strigosus* was encountered. No other *Asclepias* species was seen on the Reserve.

Doubtful or Questionable Records

Nastra julia (Freeman).

I collected a single specimen from an alfalfa field in Bakersfield during the summer of 1962 (no specific date). The specimen was tentatively identified by John F. Emmel. We know of no additional records.

Poanes zabulon (Boisduval & LeConte).

Emmel & Emmel (1973) reported that there is a "female of this species in the Na-

tional Museum of Natural History (USNM) collection with the label 'Havilah, Calif./July/Barnes Collection.'" Like the Emmels, I doubt its authenticity.

Heraclides crespontes (Cramer).

Though recent publications (Emmel & Emmel, 1973; Tyler, 1975) have suggested that *crespontes* may have extended its range into Kern County and the Central Valley of California, we have no records for this species from Kern County. These statements have been made on the basis of larvae discovered in Fresno County. This infestation has since been eradicated.

Chalceria rubidus (Behr).

Emmel & Emmel (1973) report a possible record of this species from Monolith listed in the 1950 Field Season Summary. No populations of *rubidus* are known from this region today, and the record is considered doubtful.

Icaricia shasta (Edwards).

Emmel & Shields (1978(80)) report that there is a single male in the Los Angeles County Museum labelled "Tehachapi Mts., Kern Co., Calif." collected 22 VIII 37 by W. A. Evans. The record is doubtful since it has not been duplicated by others in this relatively well collected mountain range.

ACKNOWLEDGMENTS

Tule Elk Reserve is in the state park system; so, I am indebted to K. R. Morgan (the Area Manager) for providing the necessary collecting permit.

I would also like to thank all of the previously named individuals who directly or indirectly contributed data or information used in this paper. Dr. John M. Burns of the Smithsonian Institution clarified problems involving the genus *Erynnis*. Dr. William W. McGuire was consulted regarding the genus *Hesperia*.

Jim Brock was my co-worker on this project and has provided considerable information including foodplant records. He has also pointed out a number of taxonomic issues. Dr. John F. Emmel provided similar help through his numerous letters and helped clarify some of the taxonomic issues which were faced while writing this paper. Robert Langston first suggested I write and publish a Kern County checklist and provided considerable suggestions and encouragement which were most helpful. Not all of these suggestions from these contributors have been followed and the author takes full responsibility for any errors or criticisms of this paper. I would like to thank Dr. Emmel and Mr. Langston for reviewing this manuscript.

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BOOK REVIEW

BUTTERFLIES OF OMAN, by Torben Larsen. 1980. J. Bartholomew and Sons, Edinburgh. 80 pp., ill.

This book is part of a concerted effort by the Omani government to raise the consciousness and appreciation of that country's flora and fauna. It succeeds in its mission, both scientifically and artistically, the latter apparently largely through the efforts of Larsen's wife, Kiki.

It will surprise many that there is a significant butterfly fauna in this desert realm, but in fact, more species occur there than are found in the British Isles. Most of them occur in various *wadis*, around oases and in urban environments where the vegetation is relatively lush; many of the intervening arid areas are basically sterile. The Omani fauna is derived from three basic sources: the Palearctic, the Indian region, and arid eastern and southern Africa. Examples of each are given in the text. Whatever is known of the biology of all of the species is given, along with photographs of foodplants in many instances.

The nomenclature, though it will not please "traditionalists," is up-to-date and in conformity with that employed in the Palearctic literature. Thus, some "old friends" are in unfamiliar genera: *Stonehamia*, *Artogeia*, *Pontia*, *Epamera* and *Pseudophilotes* are used for species formerly placed in *Charaxes*, *Pieris*, *Pieris*, *Iolaus* and *Philotes*, respectively. These generic changes, though, are based on solid biological and morphological studies, so their acceptance is made easier, even though there will be the inevitable complaints.

One aspect of the nomenclature that I do question involves two "species pairs" recognized in the book. One of these is *Zizeeria knysna* (Trimen) and *Z. karsandra* (Moore), usually considered conspecific. These two entities are both in Oman but at opposite ends of the country, apparently not sympatric at all, even in Oman. Since *Z. knysna* is an African entity, and *Z. karsandra* is Oriental, and both occur about where one would expect to find African and Asian faunal elements, their allopatric occurrence in Oman does not make a convincing case for their specific identities. The same objections can be made for the Asian *Papilio demoleus* and the African *P. demodocus*. In both instances, the African elements are known only from near Dhofur.

Despite such nit-picking criticisms as the above, I can recommend the book for anyone interested in the butterflies of this area, or even for the reader who is interested in what butterflies might be hardy enough to withstand the vicissitudes of such a climate. Mr. Larsen, perhaps our premier authority on Middle East butterflies, is to be congratulated on another fine book, though perhaps with less scientific "meat" than his earlier *Butterflies of Lebanon*.

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ERBLICHIA ODORATA SEEM. (TURNERACEAE) IS A
LARVAL HOST PLANT OF *EUEIDES PROCULA VULGIFORMIS*
(NYMPHALIDAE: HELICONIINI) IN SANTA ROSA
NATIONAL PARK, COSTA RICA

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ABSTRACT. The larva of *Eueides procula vulgiformis* Butler & Druce feeds on the leaves of *Erblichia odorata*, a large turneraceous evergreen tree that occurs in relatively pristine evergreen forest patches among the deciduous forest patches of Santa Rosa National Park (300-350 m elevation) in the northwestern coastal plain of the Pacific side of Costa Rica. This is the only known case of a heliconiine caterpillar feeding on the foliage of a tree and the only known case of a heliconiine caterpillar feeding on a plant outside of the Passifloraceae. The larval and pupal stages are described and figured and are unexceptional for the genus *Eueides*.

Eueides procula vulgiformis Butler & Druce is a common butterfly (Fig. 1) in the small patch of evergreen forest ("Bosque Húmedo," "Bosque Siempre Verde") along the main entrance road in the north-east end of Santa Rosa National Park, northeastern Guanacaste Province, Costa Rica (350 m elevation). Its larval host and larval stages were unknown until now (K. Brown, 1981; P. J. DeVries, pers. comm.) and are described here.

Adults are present in the Bosque Húmedo throughout the year, but fluctuate strongly in density within and between years. From December 1979 through January 1982, they have been abundant in a forest where they were not encountered during intensive collecting in 1978 and early 1979 by P. J. DeVries, L. E. Gilbert and J. J. Smiley. In December 1979 and later, an adult could be located with a few minutes search. The most common and omnipresent heliconiine in this habitat is *Heliconius hecale zuleika* Hewitson, with which *E. p. vulgiformis* is a very good Müllerian co-mimic. Adult *E. p. vulgiformis* are encountered throughout the daylight hours, flying and soaring from ground level to the tops of the tallest trees (20 m); when 10-20 m tall *Licania arborea* (Chrysobalanaceae) are in flower in late December and early January, members of both sexes are common visiting the flowers, and males chasing other males are a commonplace.

The larval host of *E. p. vulgiformis* in the Bosque Húmedo is a large turneraceous tree, *Erblichia odorata* Seem. The tree is common in this habitat, attains a height of 15-20 m (DBH up to 50 cm), and is evergreen. *E. odorata* does not occur in the deciduous forests surrounding the Bosque Húmedo and *E. p. vulgiformis* is not encountered in these forests either. *E. odorata* has simple and glabrous lan-



FIG. 1. *Eueides procula vulgiformis* adults reared from larvae found on *Erblichia odorata* in Santa Rosa National Park, Guanacaste Province, Costa Rica: **Upper left**, female; **Lower left**, female underside; **Right**, male.

ceolate leaves 8–14 cm long and 1–3 cm wide (Fig. 2a), with a gently undulating and slightly toothed margin. The leaves are less stiff and leathery than those of most of the evergreen tree species in the Bosque Húmedo but somewhat more stiff and leathery than those of most of the deciduous trees in the area. While most of the individuals of *E. odorata* are adult or subadult trees, the forest is sprinkled with a small number of saplings and seedlings.

When the density of *E. p. vulgiformis* is high, females are often seen fluttering about the margins of the crowns of large *E. odorata*, both in sunlit margins of tree-falls and in moderately shady portions of a well-closed canopy. Males chase them at this time, and sometimes the advances of a male stops an ovipositing female from laying an egg and causes her to move on. If a female is ovipositing on leaves in a small *E. odorata* sapling intermingled with foliage of other trees, she often lands many times on leaves of other species before landing again on an *E. odorata* leaf. For example, during an hour of fluttering about in the foliage and avoiding advances by males, one female *E. p. vulgiformis* contacted eight *E. odorata* leaves and laid a single egg on each of four of them. She landed on 37 leaves of other species during this period (1000–1100 h, 2 July 1980; weather was sunny and breezy). She always landed on the upper surface of the *E. odorata* leaves, and the weight of her body caused the leaf to bend sharply downward. She then reached under the leaf with her abdomen and glued a single egg to the central portion of the blade, 1–2 mm to one side of the

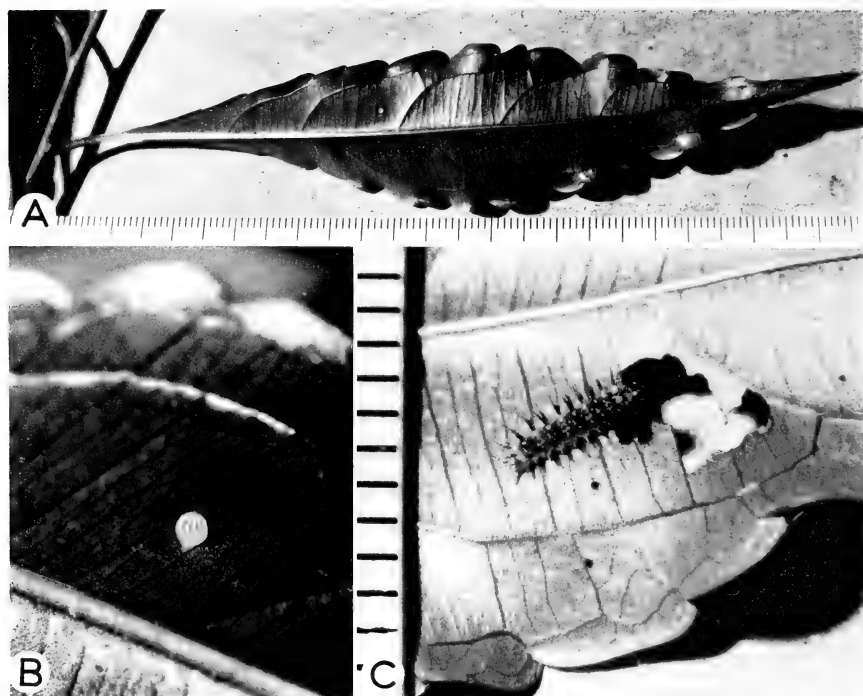


FIG. 2. **a**, normal-sized mature leaf of *Erblichia odorata* with a single egg of *Eueides procula vulgiformis* laid on its underside slightly to the left of center; **b**, egg of *E. p. vulgiformis*; **c**, second instar larva of *E. p. vulgiformis* feeding at the margin of the characteristic holes they cut in the leaf in the first and second instar. All scales in mm in this and later figures (all photos in this and later figures, Santa Rosa National Park, Guanacaste Province, Costa Rica, 350 m elevation).

midrib (Fig. 2a). Immediately after laying the egg she launched into a fluttering flight among the foliage; even if there was another *E. odorata* leaf nearby, she showed no directed flight toward it. After flying 1–3 m, she again alighted. If the landing site was not an *E. odorata* leaf, she launched into flight in a few seconds, and flew another few cm to a m or a bit more before landing again. Her general flight trajectory was neither straight nor strictly horizontal but rather wandering in both a vertical and horizontal plane. When chased by a male, she sometimes flew as much as 10 m before landing again. When the sun was obscured by a cloud for a few minutes, she landed on the upper surface of a leaf and sat motionless.

The eggs are pale greenish-yellow and have the appearance of domed squat cylinders (Fig. 2b). There are numerous ridges running from the base to top (portion away from the leaf), with horizontal

troughs breaking the ridges into a series of bumps. They look very similar to the eggs of *Eueides tales* figured by Brown (1981), except that where the *E. tales* egg has depressions on the surface, the *E. p. vulgiformis* egg has domes or bumps.

Eggs were laid on leaves of all ages, but in searching for eggs, I found more per leaf on vertical shoots off main trunks than on leaves on branches well out into the margins of the crown. For example, I watched one female lay three eggs in 12 minutes on a 30 cm long sucker shoot with 12 leaves at 4 m off the ground. Eggs were found on the leaves of plants as small as 1 m tall in heavily shaded understory and on leaves in the margins of the crowns of trees 15 m tall (obtained by climbing trees and cutting down branches). I saw females ovipositing in the foliage of the crowns of the tallest trees.

Of a set of four eggs laid by one female on 2 July, one hatched on 5 July and the other three on 6 July. The larvae were maintained at room temperature (not very different from that in the Bosque Húmedo 3 km away) in large plastic bags and pupated on 24–26 July. Throughout the 20 day larval period, the caterpillars were given freshly cut *E. odorata* leafy branches every other day. Still maintained at room temperature, each pupa produced a normal-sized adult (3 males, 1 female) eight days after pupation.

The first instar larva begins feeding in a very distinctive manner, and the second instar continues in the same manner. It eats a ragged-edged hole from 0.1 to 0.3 cm² in area (Fig. 2c), through the leaf blade within about 5 mm of where the egg was laid, and then moves on and eats other similar holes in the same or nearby leaves. After molting to the third instar, the larva begins eating at the margin of the leaf tip. It consumes the blade down to the midrib on one side and may continue until a quarter or more of the leaf blade is missing. Even when many caterpillars were confined in the same rearing container on a small amount of foliage, there was no sign of gregarious or side-by-side feeding.

The second instar larva (Fig. 2c) is semi-translucent light green with two rows of massive spines dorsally and along each side. The spines are as long as the body is thick and have spinelets projecting out of them. The spines are nearly black and their contact point with the body wall is in the center of a whitish-blue ring (dorsal rows of spines only). This gives the impression that the caterpillar has a light gray stripe down its back. The head capsule bears dorsally a pair of wide-spread massive spines like those of the body, but they are curved slightly backwards. The spines on the last two segments are paler in color than are those on the remainder of the body. The head capsule is grayish-brown in color.

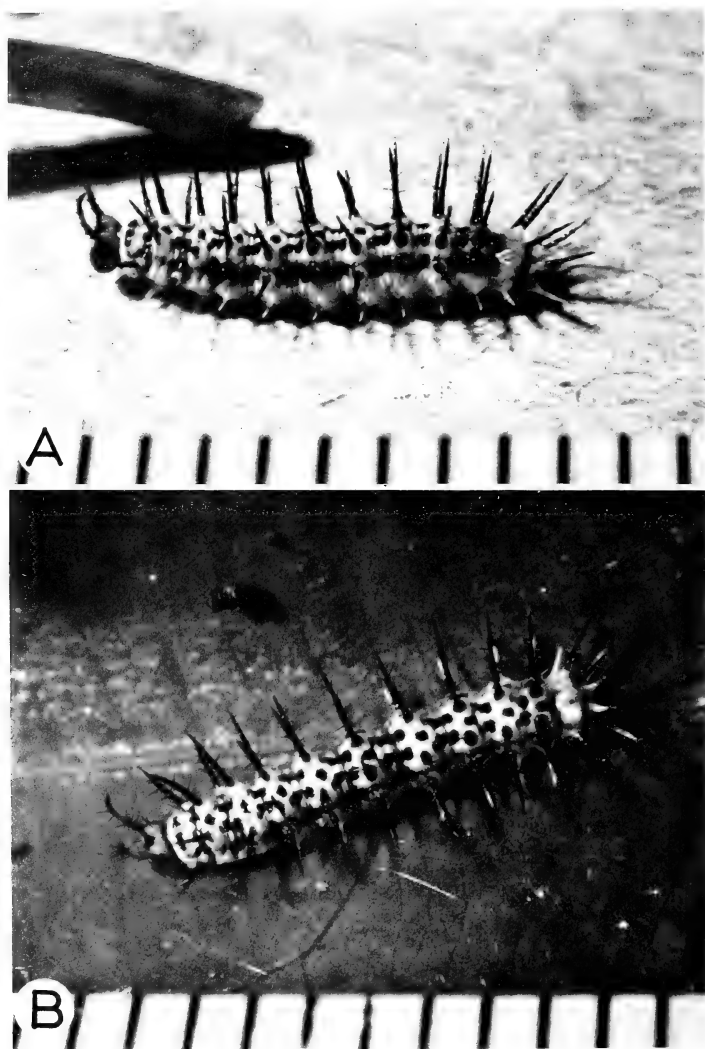


FIG. 3. a, third instar larva of *E. p. vulgiformis*, lateral view; b, third instar larva of *E. p. vulgiformis*, dorsal view.

The third instar larva gives the overall impression of being white with black spots and a yellow posterior (Fig. 3). The main body spines are black, as long as the body is wide, and bear conspicuous lateral spinelets. The spines do not urticate in this or any other instar. The head capsule spines are white, black-tipped, and curve backwards. The lateral spines on the posterior two segments are gray-white, and

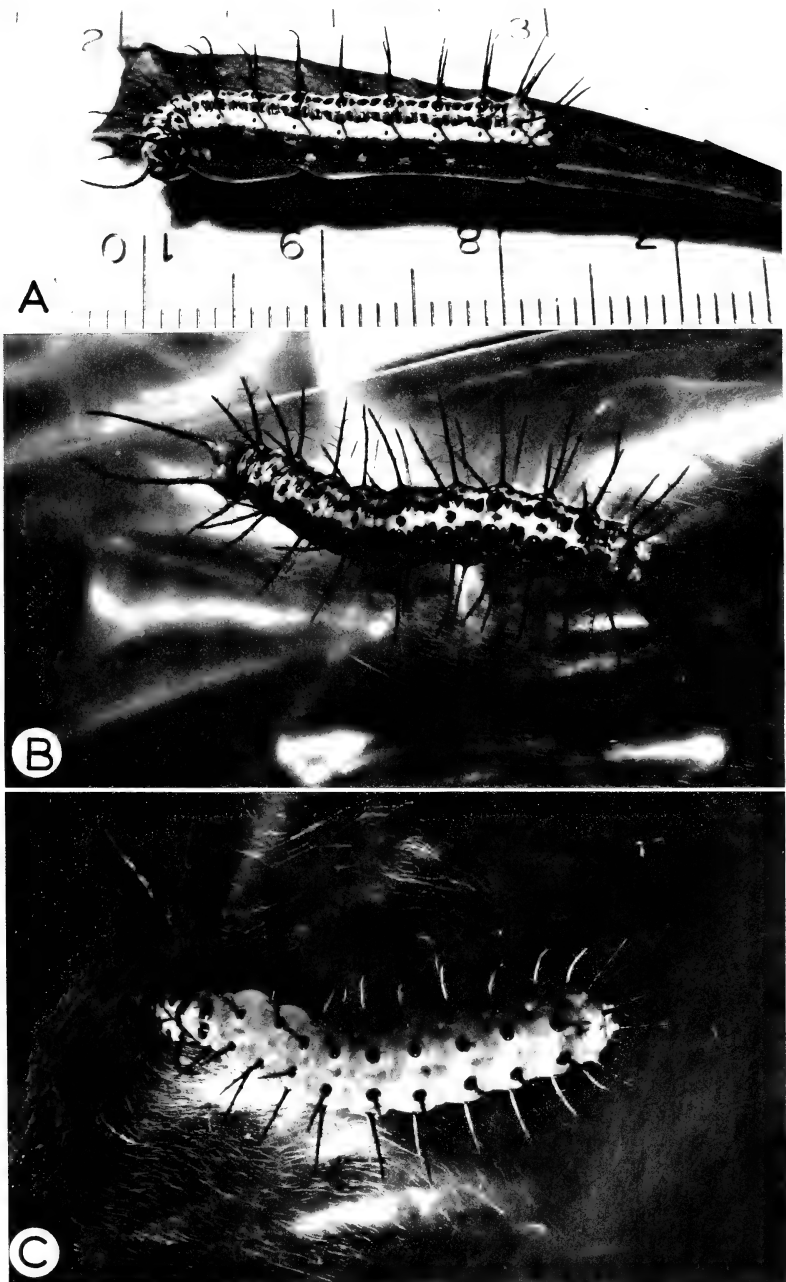


FIG. 4. a, fifth instar larva of *E. p. vulgiformis* shortly after molting from the fourth instar; b, fifth instar larva of *E. p. vulgiformis* after it has stopped feeding and begun spinning the pad on which it will pupate; c, pre-pupa of *E. p. vulgiformis*.



FIG. 5. Pupa of *E. p. vulgiformis*.

the ventral lateral spines along the entire body are more gray than black. The head capsule is black in color. Dorsally, each body segment is white with seven black dots, except that the penultimate segment is bright yellow dorsally. Laterally the caterpillar has a brownish-white stripe bordered by a white stripe ventrally.

The last (fifth) instar larva, while still feeding, is gray-white with a lateral pale yellow stripe (each spiracle covered by a black dot) and with a dorsal band of black dots (Figs. 4a, b). All spines are pure black, have lateral projections, and are as long as the body is thick.

The head capsule is black with white markings. The penultimate body segment is dorsally orange-yellow. Shortly before it becomes a non-feeding pre-pupa, the caterpillar is 22–25 mm in length.

The color change to the pre-pupa is dramatic. The pre-pupa has a bright yellow body with a white head capsule and black spines, except that the most lateral (ventral) set of body spines is white, and the base of each body spine is heavily ringed in black (Fig. 4c). The pre-pupa wanders for a few hours on the walls of the rearing container and then spins a silk pad as a pupation site, or it may change color after spinning the silk pad.

The pupa is white and sparsely flecked with small black specks, bears a pair of white but black-tipped spines ventrally on each of three abdominal segments, and bears a pair of long slightly hooked white spines with gray and yellow tips at the head end (Fig. 5).

In the forest I have found pupae on leaves of *E. odorata* and on leaves up to a few m from foliage of *E. odorata*.

In short, the immature stages of *E. p. vulgiformis* are in no morphological way exceptional in comparison with those of other heliconiines (Brown, 1981) but are distinguishable from those of other *Eueides* (K. Brown, pers. comm.). However, the larvae of *E. p. vulgiformis* are quite exceptional in their choice of food plants. This is the first unambiguous record of a heliconiine feeding on a plant outside of the Passifloraceae (K. Brown, pers. comm.). However, the species has not strayed far, since Turneraceae is closely related to Passifloraceae and Turneraceae is a well known host family for other Nymphalidae that are closely related to Heliconiinae (K. Brown, pers. comm.).

ACKNOWLEDGMENTS

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GENERAL NOTES

THE SUITABILITY OF *JUNIPERUS* (CUPRESSACEAE) FOR LARVAE OF *CALLOPHRYS HESSELI* (RAWSON AND ZIEGLER) (LYCAENIDAE)

Aside from the wing character differences and distinct male and female genitalia distinguishing *Callophrys hesseli* from other Nearctic Cupressaceae-utilizing *Callophrys* (*Mitoura*) (Rawson & Ziegler, 1950, J. N.Y. Entomol. Soc. 58:69-82; Johnson, 1978, J. Lepid. Soc. 32:3-19, and 1976, Bull. Allyn Mus. 38:1-30), its utilization of *Chamaecyparis thyoides* (L.) B.S.P. as the larval foodplant is a major taxonomic trait distinguishing it from its nearest spatial relative *C. (Mitoura) gryneus* Hübner. The latter is known to feed on four species of *Juniperus* L. (Johnson, 1978, loc. cit.). The two butterfly species are regionally sympatric but allopatric on the local level, except for occasional overlap in usage of nectar sources (Johnson, 1978, loc. cit.). No naturally occurring hybrids or instances of larvae feeding on the foodplant of the other species are presently known.

In laboratory studies, Remington & Pease (1955, Lepid. News 9:4-6) demonstrated larvae of *gryneus* could be raised to the imago stage on *C. thyoides* and not be nutritionally sterile. In their conclusions concerning suitability of *C. thyoides* for *gryneus* they stated the importance of knowing whether *Juniperus virginiana* L. (the foodplant of *gryneus* in eastern North America) was equally suitable in the laboratory for *hesseli*.

During studies of Nearctic *Callophrys (Mitoura)* (Johnson, 1984, Bull. Am. Mus. Nat. Hist., in press) this author received a number of second-hand reports of rearing of *hesseli* on *J. virginiana*; however, none could be verified with accurate data. The purpose of this note is to report the first verifiable rearing of *hesseli* on *Juniperus*.

Eric Quinter (American Museum of Natural History, New York) collected a series of live *hesseli* females on 17 May 1971, 3.6 mi. E of Chatsworth, Burlington Co., New Jersey. All were confined under incandescent light in mesh bags above sprigs of *C. thyoides* (in anticipation of rearing all larvae on this plant). Oviposition soon took place and over a hundred larvae were reared on *C. thyoides* until all larvae were in the second instar. When available foodplant supplies dwindled about 50 larvae in the second instar were transferred to *Juniperus virginiana* in hopes they might survive. All continued to feed readily and maintain normal growth. These larvae reached the last instar showing no difference from those on *C. thyoides*. Then a fungal infestation attacked the entire rearing apparatus, occurring just prior to expected pupation and resulting in a high mortality rate in larvae on both foodplants. In fact, of the healthy larvae on *J. virginiana*, only one last instar larva escaped infestation; however, it pupated readily and emerged on 10 July. Unfortunately, it was impossible to mate this male individual with a reared female from the same foodplant to test possible sterility.

This rearing demonstrates that *J. virginiana* is at least suitable for adult maturation in *Callophrys hesseli*. It is particularly impressive because the transference of larvae in middle or later instars is usually considered highly unfavorable to normal maturation or survival (Downey & Dunn, 1965, Ecology 45:172-178; Dethier, 1954, Evolution 8: 33-54). Usually in rearing experiments either ova or freshly emerged larvae are transferred to an alternative foodplant. Suitability of *J. virginiana* after the first instar, however, still does not prove full laboratory compatibility. Mortality might have occurred during the first instar itself. Also, with lack of testing for nutritional sterility, and more importantly, oviposition preference of reared females, this rearing can only provide limited conclusions. Any adequate test of ovipositional specificity in reared females would require larvae reared solely on one or the other plant. However, it is significant to record an instance of successful rearing to the adult stage on the alternative butterfly/foodplant combination used by Remington & Pease. Although suitability in the laboratory is no test of suitability in nature (Downey, 1962, System. Zool. 11:150-159; Downey & Dunn, loc. cit.; Dethier, loc. cit.), it is further evidence that specificity in the natural environment (which in the case of *C. hesseli* and *C. gryneus* seems just-

fably assumed by the abundant field data available on these species) is preserved by the oviposition habits of the female, according to Hopkins' Hostplant Principle.

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THE TYPE OF ARGYNNIS APACHEANA SKINNER

In 1954 (Trans. Amer. Entomol. Soc. 80:91-117) Gillham & Ehrlich published an excellent review of the butterfly names established by Henry Skinner. They questioned the statement in dos Passos & Grey (1947, Amer. Mus. Novitates, No. 1370, 30 pp.) that the type of *Argynnis apacheana* Skinner is from Arizona and in the Academy of Sciences, Philadelphia. The specimen referred to by dos Passos & Grey was in the collections of the Academy, but has been transferred to the Carnegie Museum of Natural History, Pittsburgh, Pennsylvania. It is designated ANSP No. 7031 and carries labels reading "holotype" and "Arizona, collector Skinner." This is contrary to Skinner's declaration of the type of *apacheana* in the original description, quoted by Gillham & Ehrlich.

Skinner (Entomol. News 29:67, 1st paragraph) wrote: "I propose the name *apacheana* for the species of *Argynnis* described and figured by Mr. W. H. Edwards in Volume I of his *Butterflies of North America*, plate IV of *Argynnis*, figures 1, 2, ♂, 3, 4, ♀, under the name *nokomis*." There is no other declaration of type in the article. The butterfly figured on this plate is not the type of the name *nokomis*. In fact, the plate in bound copies of the volume is not the original plate which was drawn from the type by Wiest. The plate referred to is the replacement for that plate. The new plate was drawn by Mrs. Mary Peart from specimens collected by the Wheeler Expedition in 1871, eight years after *nokomis* had originally been described.

Almost everyone has been misled by the locality designation "Arizona" for material sent east by the 1871 Wheeler Expedition. This designation is very much like the old one "Bogota" for Colombian butterflies; meaningless. A timetable and route for the expedition was published by Brown in 1957 (J. N.Y. Entomol. Soc. 65:219-234). The cases of specimens for the Smithsonian Institution were dispatched from Tucson, Arizona, the breakup point, in December 1871. These boxes contained material from most of the route. All that Baird told Edwards when he transmitted the material is that he had received it from Arizona (Brown, F. M., 1965, Trans. Amer. Entomol. Soc. 91: 233-350).

Some years ago I sent Scott Ellis and Samuel Johnson to Owens Valley, California to see if they could recover the species collected there by Bischoff and thus, narrow down type localities. They were successful in general but unsuccessful for *Cercyonis wheeleri* and *Speyeria "nokomis" (apacheana)*. Diversion of water from Owens Valley by the city of Los Angeles has destroyed the niches in which these sensitive species had lived. It is only in the vicinity of Round Lake, where the requisite *Viola* grows in the understory of the meadow and bog grasses, that *apacheana* is still found.

Dr. dos Passos is very ill, so I asked Mr. Paul Grey to correct the type statement, but he asked that I do it. Since the figure upon which Skinner based his name *apacheana* was drawn from material collected by Bischoff in 1871, that material must supply the type. The specimen that was used by Mrs. Mary Peart for the model of the male figure on plate *Argynnis* IV must be considered the type of *apacheana*. That specimen was

retained by W. H. Edwards and now is with his collection in the Carnegie Museum of Natural History, Pittsburgh, Pa. Its locality of capture at this time can be given no more closely than vicinity of Independence, Inyo Co., California, from a colony now extinct.

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A NEW FOOD PLANT RECORD FOR *CHLOSYNE GORGONE CARLOTA* (REAKIRT) (NYMPHALIDAE)

Host plants recorded for the larval stages of *Chlosyne gorgone carlota* (Reakirt) include a wide variety of genera in several families. While most authors (Klots, 1951, Field Guide to the Butterflies, Houghton Mifflin Co.; Forbes, 1960, Lepidoptera of New York and Neighboring States, Part IV, Cornell Univ. Agr. Expt. Sta. Memoir 371; Ehrlich & Ehrlich, 1961, How to Know the Butterflies, Wm. C. Brown Co.; Tietz, 1972, An Index to the Described Life Histories, Early Stages, and Hosts of the Macrolepidoptera of the Continental United States and Canada, Allyn Mus. Entomol., Sarasota, FL; Johnson, 1972 (1973), J. Res. Lepid. 11(1):1-64) list *Aster* spp. and *Helianthus* spp. (Compositae) as the primary food plants, *C. g. carlota* larvae have also been re-



FIGS. 1-4. Female specimens of *Chlosyne gorgone carlota* from Missouri: 1, 2, female showing typical markings of this species, dorsal and ventral views, respectively; 3, 4, female reared from *Ambrosia trifida*, dorsal and ventral views, respectively.

corded from *Lippia lanceolata* and *L. nodiflora* (Verbenaceae) (Kimball, 1965, Arthropods of Florida and Neighboring Land Areas, Vol. 1, Lepidoptera of Florida, Florida Dept. Ag.), *Lysimachia* sp. (Primulaceae) (Harris, 1972, Butterflies of Georgia, Univ. of Oklahoma Press), and *Eriogonum* sp. (Polygonaceae) (Tietz, *ibid.*).

In Missouri, *C. g. carlota* larvae have been recorded from *Helianthus annuus* L. (Compositae) (J. R. Heitzman, pers. comm.) and *Linaria vulgaris* Hill (Scrophulariaceae) (Masters, 1969, J. Kansas Entomol. Soc. 42(2):133-144). Here I report giant ragweed, *Ambrosia trifida* L. (Compositae), as a new food plant for *C. g. carlota*. *A. trifida* L. is an annual, monoecious weed common to fertile moist soils, bottom lands, alluvium, and waste places.

On 9 August 1977, while collecting along a roadside bank of State Rt. 10 (3.2 km west of Richmond, MO), I found thirteen larvae that were unfamiliar to me on the leaves of three separate giant ragweed plants. Due to the uniformity in larval size and the close proximity of the plants to each other (within 0.5 m of each other), the infestation was probably the result of a single oviposition. The thirteen larvae, along with an ample supply of the food plant, were collected and taken to my home to be reared. Six larvae were preserved on 9 August 1977; the remaining seven larvae were allowed to feed. On 10 August 1977 one larva pupated, emerging 11 days later. The single adult, identified as a female *C. g. carlota* by J. R. Heitzman, is slightly smaller and darker than the typical female of the species (Figs. 1-4), which may have resulted from the rearing. The six remaining larvae pupated on 11 August 1977 and were preserved.

I am especially grateful to J. Richard Heitzman for identifying the specimen and for reviewing this manuscript. Thanks are also extended to Dr. Charles V. Covell, Jr., Dr. Stephen Clement and to Ms. Candy Fogg for their critical reviews and to Mr. Glenn Berkey of the Ohio Agricultural Research and Development Center, Wooster, for the photographs.

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A NATURAL OCCURRENCE OF INTER-TRIBAL COPULATION IN THE PAPILIONIDAE

Among the Lepidoptera numerous prezygotic isolating mechanisms (Mayr, 1970, Population, Species and Evolution, Belknap Press, Cambridge, MA) operate to prevent interspecific mating. At times, however, these isolating mechanisms appear to break down. While breakdowns occur rarely between closely related species, breakdowns between distantly related and phenotypically distinct species are quite exceptional. A salient example of such a breakdown was observed on 15 April 1980 in the Kirby State Forest near Kountze, Tyler County, Texas.

Swallowtail diversity in Kirby Forest and throughout the upland savannah of southeast Texas is high; at least six different species are resident (Rausher, in preparation). *Eurytides marcellus* (Papilionidae: Graphiini) and *Battus philenor* (Papilionidae: Troidini) fly sympatrically in the open pine uplands. The two species are temporally synchronous, adults flying commonly between mid-March and mid-April. During this period females spend much of their time searching among the herbaceous vegetation for larval food plants. For *B. philenor*, these are *Aristolochia reticulata* and *A. serpentaria*, small erect perennial herbs in the family Aristolochiaceae (Rausher, 1978, Science 200: 1071-1073). The larval food plant of *E. marcellus*, in contrast, is *Asimina parviflora*, an annonaceous shrub that grows in east Texas to a maximum height of 2-3 ft. Males of each species fly through the pine uplands, approach females while they are ovipos-



FIG. 1. Female *Battus philenor* and male *Eurytides marcellus* photographed in copulo in Kirby Forest, southeast Texas.

iting or nectaring, and engage in precopulatory courtship flights. Although males of either species may approach heterospecific individuals, such encounters are usually brief in duration. In seven years of observation we have never seen a male engage in persistent courtship of a heterospecific female, although we have observed hundreds of conspecific courtships.

A female *B. philenor* and male *E. marcellus* (Fig. 1) were found resting in copulo among the forest herbs in Kirby Forest. After the pair had disengaged, the female was captured and offered foliage of both species of *Aristolochia* on which to oviposit. She failed to lay eggs on either species over a period of three days. Subsequent dissection of the female revealed no spermatophore in the bursa copulatrix, although many developed chorionated eggs were present. These observations suggest that, despite the fact that the two individuals remained in copulo for more than 30 minutes, no sperm transfer occurred.

Since little is known about the courtship and mating behavior of either butterfly species, it is difficult even to speculate about the events that gave rise to this unusual pairing. Nevertheless, despite the apparent breakdown of ethological isolating mechanisms in this instance, reproductive isolation was maintained by failure of the male to transfer sperm. Whether this failure was due to active interference by the female or simply to the absence of an appropriate cue necessary for triggering sperm transfer is not known.

We thank M. Nijhout for dissecting the female butterfly and Paul Feeny for bringing the east Texas habitat and swallowtails to our attention. This work was supported in part by N.S.F. grant DEB 8016414 to MDR.

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NOTES ON THE COURTSHIP OF *TROIDES OBLONGOMACULATUS PAPUENSIS* (PAPILIONIDAE) IN PAPUA NEW GUINEA

Straatman (1976, *Trans. Lepid. Soc. Japan* 27:156-162), gave an account of the courtship behavior exhibited during hybridization of *Troides oblongomaculatus papuensis* Wallace males with *Ornithoptera priamus poseidon* Doubleday females. However, there has been no detailed description of the courtship behavior of *T. o. papuensis*, particularly the use of the hindwing pouches of the male, although various authors have commented upon their highly specialized morphology and obvious androconial function. Similar pouches are found at the base of the costa of the forewings of *Chaetocneme* (Hesperiidae) males from the same region.

The cultivated *Aristolochia tagala* Chan. vines in the grounds of the Insect Farming and Trading Agency (I.F.T.A.) at Bulolo in Papua New Guinea have produced a thriving population of *T. o. papuensis* that can be observed readily throughout the year. These notes are a summary of observations of over fifty courtships and of a mark-recapture study over a period of one year (March '79-March '80).

Mark-recapture results by the author of ex-pupa specimens have shown that individual males can live up to two and one-half months and probably longer. They regularly patrol the grounds of the I.F.T.A. in search of freshly eclosed females by flying to inspect each vine in turn. Up to six males have been in sight at one time and often one or two females may be observed ovipositing at the same time. Marked females have been recaptured while ovipositing on the vines only up to about a week later, which suggests that they go much further afield in search of suitable vines on which to oviposit; thereby, maximizing the dispersal of the species.

Numbers of individuals in the I.F.T.A. grounds have always been too low to obtain an accurate estimate of population size using standard formulae, but a constantly renewed population of 15-25 individuals would be a fair estimate. The farthest distance from which a marked male has been recovered is 2 km, but they probably range farther and have been observed to revisit areas on a rotational basis to feed and search for females.

There are two distinct patterns of courtship by *Troides* males. In the first case, where a newly eclosed virgin female is encountered, pairing is abrupt with apparently no signal from the female that she is receptive. She merely does not prevent the male from coupling. The display by the male prior to pairing is, therefore, short and consists of a period of no more than 30 seconds, while he flutters with rapid wing beats close to, but not actually touching, the female. The male will settle near her on foliage and then turn to engage his open claspers to each side of her abdomen. The female opens her genital aperture by raising the ovipositor, and the union is effected within a matter of a few seconds. If the female flies off later the male is carried hanging inertly below with legs folded. When the female alights again the male will often remain in this posture. Based on ten observations, pairing lasts for about five hours.

The second category of courtship behavior is a sustained and repeated display initiated by the sighting of a previously paired, flying female. Males seem unable to recognize mated females, and prolonged courtship is only exhibited to such individuals. The author has never witnessed sustained aerial courtship of virgin females, probably because males in the grounds of the I.F.T.A. are always sufficiently numerous to locate most new females before they take to the air. Males may even be able to learn in advance the position of female larvae and pupae, because on many occasions *Troides* males have been observed to fly and investigate these early stages. Often they will hinder ovipositing females or (rarely) pursue other males in a briefly attempted courtship display.

The display to the female is a fluttering flight for the purpose of engaging her antennae with the androconial hair-scales of the scent pouches of the male. Therefore, if

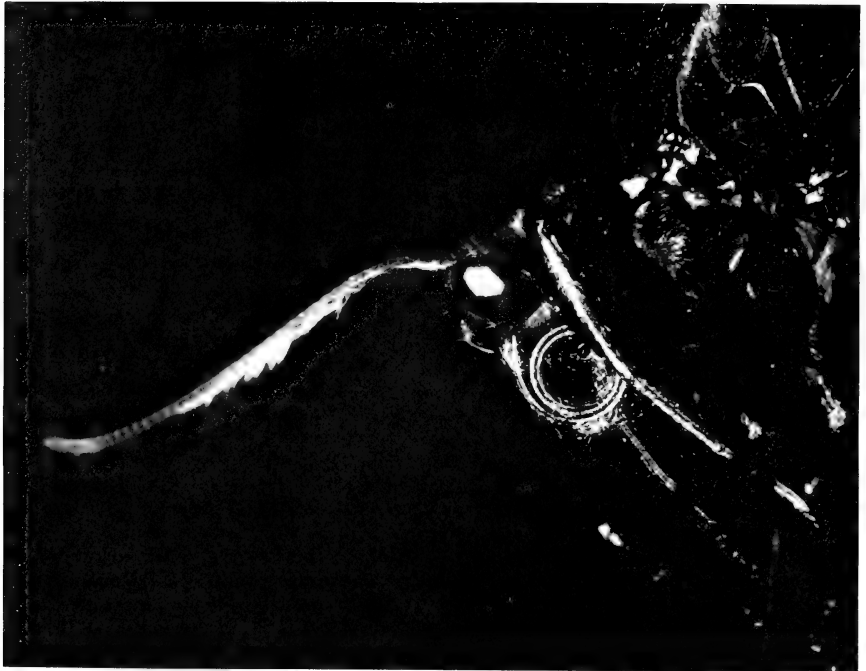


FIG. 1. Left side of head of female *Troides oblongomaculatus papuensis*, showing androconial scales from male adhering to her antenna.

the female is flying along in a straight line, the male will execute loops around her, coming quickly from behind and underneath so that the last wingbeat carries him upwards and backwards. The hindwing pouches are thereby timed to open as the female moves forward, so that her antennae then engage in the open slots of the male's pouches.

Sustained courtship by the male in this way elicits an avoidance reaction by the previously paired female, who then goes to ground with wings spread and abdomen pointing downwards. Often the male will continue this display and hover just above the head of the female, repeatedly backing his scent pouches in irregular sweeps onto the female's antennae by quick, downward strokes of the forewings. The male may fly off and return three or four more times but soon leaves the female at this stage. She may remain inert and prostrate on the ground for some minutes after the male has gone and then suddenly take to the air.

If the androconial pouch of the male is opened it can be seen to be full of vertically arranged, extremely close packed, white, hair-like scales. These are very easily dislodged and are so fine and light that they easily stick to a shiny needle point. Their function in courtship is to adhere to the antennae of the female (Fig. 1). Therefore, it appears that the male's courtship pheromone is not airborne but is physically transferred via the androconial hairs to the chemosensory surface of the female's antennae. The photograph shows the head of a female immediately after the repeated courtship display of a male. The hair-scales even adhere to the proboscis when the female has been subjected to a long courtship display.

Similar courtship has been observed in *Ornithoptera*, but it appears that the stiff fringe of brush-like hairs on the inner margin of the hindwing of *Ornithoptera* males

is a modification of the scent pouch of *Troides*. These long hairs are covered with a pheromone which is brushed by direct contact onto the antennae of the female during the courtship flight, but the hairs are not displaced. If the hindwings of a fresh male of *O. priamus poseidon*, for example, are placed on white card and stuck tightly beneath clear sticky-backed plastic, from the scent hairs only an orange compound, which presumably contains the pheromone, is slowly leached off through the glue reminiscent of a chromatogram.

During copulation a gelatinous substance is produced by the accessory glands of the male. This is soft and clear at first with a slight yellowish tinge and almost fills the genital cavity of the female once the male has parted. Later it dries hard and becomes opaque and dark brown. This is the sphragis, which is thought to act as a barrier to further insemination. However, as some ovipositing females have been found to have lost this, it appears more likely that it is the presence of the large spermatophore (which fills the bursa copulatrix) that produces a stimulus to reject further males. Nevertheless in *Cressida* and *Parnassius* (Papilionidae) and *Miyana* (Nymphalidae) the sphragis is external, very large, and is permanent and surely must physically prevent further pairing. Of the photographs in figure 65 (p. 87) of Haugum & Low (1979, A Monograph of the Birdwing Butterflies. Vol. 1, part 2, Scand. Sci. Press) of supposed sphragis in *O. priamus*, only the central picture shows this. The outer two merely figure the artificially distended genital plates of the female. Specimens killed by injection with ethyl acetate, for example, often die in this latter condition.

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ALBINIC VARIANTS OF *CHLOSYNE NYCTEIS* FROM CONNECTICUT (NYMPHALIDAE)

On 8 July 1979 two albinic males of *Chlosyne nycteis* (Dblidy.) were collected along a woodland trail on water company land near Lake Gaillard, North Branford, New Haven Co., Connecticut. One specimen has the usual orange-red ground color entirely replaced by white (Fig. 1). The other is only partially albinic, with creamy overlay in the hindwing medial and forewing subapical areas, and on wing bases. In both, the melanic border and markings are apparently unaltered. These specimens were taken in the company of typical orange-red *C. nycteis*. Some 10 to 15 adults were seen in the area on that day. A third specimen, also fully albinic, was collected 1 July 1979 at the same locality by William Martha. We are aware of no other wild-captured albinic *C. nycteis*.

The white color may represent the expression of an extremely rare allele akin to "whitish" and "blonde" of *Colias* (see Remington, 1954, *Lepid. News* 7:139-145). That the specimens were collected from within a small, local population of *C. nycteis* also suggests they may be the progeny of a single female. Oliver (1979, *J. Lepid. Soc.* 32: 309) and Shapiro (1966, *Butterflies of the Delaware Valley*, *Spec. Publ. Amer. Entomol. Soc.* 20) have reported albinos of *Phyciodes tharos* Drury from Pennsylvania. It is of interest to note the occurrence of similar white phenotypes in these two very closely related butterfly genera. Albinics have yet to segregate out of mass cultures of *C. nycteis*, *C. harrisii* (Scudder), and *Phyciodes* spp. (C. G. Oliver, pers. comm.). Our two



FIG. 1. Albinic variants of *Chlosyne nycteis*. **A**, Dorsal surfaces. From top: normal male, partial albinic, total albinic; **B**, Ventral surfaces of same specimens as in **A**. Specimens collected 8 July 1979, near Lake Gaillard, North Branford, New Haven Co., CT, leg. L. F. Gall & D. F. Schweitzer. Color filter used to enhance contrast between albinics and normal male.

specimens have been deposited in the entomological collections at the Peabody Museum of Natural History, Yale University.

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THYRIS MACULATA (THYRIDIDAE) AND THREE SPECIES OF
CLEARWING MOTHS (SESIIDAE) ATTRACTED TO
AN ARTIFICIAL CHEMICAL BAIT

Attraction of female sex pheromones for males of many members of the Sesiidae is well known (Sharp et al., 1978, *Florida Entomol.* 61(4):245-250; 1979, *Entomol. Soc. Amer. Symposium "Pheromones of Sesiidae."* ARR-NE-6:35-46; Reed et al., 1981, *Environ. Entomol.* 10(4):488-491), and it was interesting to discover that a moth representing another family is also attracted to at least one of these compounds. I spent most of July and August of 1980 collecting male clearwing moths with the aid of a sex attractant containing mostly the Z,Z isomer of 3,13-octadecadien-1-ol acetate (Z,Z-ODDA), a main component in the pheromone system of many sesiids. For a review of a sex attractant study see Duckworth and Eichlin (1977, *J. Lepid. Soc.* 31:191-196). The lure was kindly provided for my use by John Holyoada, whose interest in the Sesiidae induced me to participate in this study. The lure strip was enclosed in a piece of nylon netting material and pinned to the frame of my collecting net.

The study sites were mostly virgin prairie remnants in northeastern Illinois that have miraculously escaped the plow and the bulldozer, which years ago converted most of the Grand Prairie of Illinois to man's commercial uses. On 6 July I entered Harlem Hills Nature Preserve, a 53-acre dry upland prairie in Winnebago Co. Situated on the outskirts of Rockford, the prairie was dedicated as a Nature Preserve in 1973. Although surrounded by residential development it remains a relatively intact pathway into Illinois' past, when the State abounded with grasses and wildflowers of every description. About 0930 to 0940 CDT I observed several sesiids hovering around my net and zeroing in on the attractant. I netted specimens of two species, subsequently identified as *Carmenta anthracipennis* (Bdv.) and *Albuna fraxini* (Hy. Edw.), the former being the more common of the two. Individuals were so intent on locating the source of the lure that they paid scant attention to my efforts with the net.

While attending to some freshly captured specimens, I observed a very small moth near my net, hovering in much the same manner as the two sesiid species just encountered. After netting and examining the tiny specimen, I saw that it was not a sesiid but rather a moth of a different family. It was latter identified as *Thyris maculata* (Harris). Though apparently wide ranging from eastern United States through Texas into Mexico, this thyridid species is uncommon in collections (from unpublished data).

Before leaving the prairie site I collected one additional specimen of *T. maculata*, a few more *A. fraxini* specimens, and a long series of *C. anthracipennis*.

The day was intermittently sunny and overcast, but the changes in cloud cover did not seem to affect the activity of the male sesiids coming to the bait. Without the use of the attractant this would not have been the case, I'm certain; I have never observed clearwing moths nectaring on any but bright sunny days. Later on in the summer I collected specimens of *C. anthracipennis* in Lake, Cook and McHenry Counties in northeastern Illinois, all from similar prairie habitats and all captured when attracted to the same lure. This sex attractant also contributed to the capture of a third sesiid species, *Synthandon exitiosa* (Say), the species from which the Z,Z isomer had been extracted, identified and ultimately synthesized. Two specimens of the latter were collected on the three acre Cary Prairie, Cary, McHenry Co. on 7 August. This tiny parcel of natural prairie is situated in the middle of town, surrounded by homes and a Junior High School.

Specimens of *S. exitiosa* were also collected at Warren Dunes State Park, Berrien Co., Michigan on 26 August. These moths were encountered along the Lake Michigan bathing beach, having flown from some place farther inland.

One specimen of *T. maculata* has been placed in the collection of the Illinois Natural History Survey (INHS), Urbana, and the other has been retained in my own collection

temporarily. Specimens of all three sesiid species have been placed in the INHS collection, in the collection of John Holoyda, Chicago, and the remainder I have retained.

It is a pleasure to acknowledge with warm thanks the help given me by Dr. Thomas D. Eichlin, Insect Taxonomy Laboratory, Department of Food and Agriculture, Sacramento, California, in examining and determining the identity of *T. maculata* and the three sesiid species.

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EUCOSMOMORPHA ALBERSANA (HÜBNER), A PALAEARCTIC SPECIES,
COLLECTED IN NORTH AMERICA (TORTRICIDAE, GRAPHOLITINI)

Among undetermined olethreutine moth specimens in the Michigan State University Entomology Museum, I discovered a single male of *Eucosmomorpha albersana* (Hübner) (Figs. 1, 2). Label data include Midland Co., Mich., June 2, 1961, R. R. Dreisbach, genit prep PJ 163. The genus *Eucosmomorpha* has not previously been reported in North America.

Eucosmomorpha Obraztsov, 1951 is monobasic (Obraztsov, N. S., 1961, *Tijd. Entomol.* 104:51-70). Its structural distinctness makes it unlikely to be confused with any other genus. The Palaearctic distribution of the one described species, *E. albersana*, is extensive: from the United Kingdom and Scandinavia east into Asia (Bradley, J. D., W. G. Tremewan & A. Smith, 1979, *British Tortricoid Moths, Tortricidae: Olethreutinae*, London, 336 pp.; Benander, P., 1950, *Svensk Insektfauna* 10, Tortricina, 173 pp.; Bentinck, G. A., Graaf & A. Diakonoff, 1968, *Monogr. Nederl. Entomol. Ver.* 3, 201 pp.; Hannemann, H. J., 1961, *Die Tierwelt Deutschlands . . . 48 . . . Tortricidae*, 236 pp.; Kuznetsov, V. I., 1978, *Taxonomic Key to Insects of the European USSR*, 4, *Lepidoptera*, 21, *Tortricidae*, pp. 193-680 (Russian)).

The Michigan specimen has the forewing more intricately patterned than western European examples. It might be *E. albersana ussuriana* (Caradja, A., 1916, *Deut. Entom. Z. "Iris"* 30:1-88), but no authentic representatives of this taxon were available to me for comparison. With a forewing length of 5.5 mm, the specimen is slightly



FIGS. 1, 2. Michigan specimen of *Eucosmomorpha albersana*: 1, forewing pattern; 2, male genitalia.

smaller than Palaearctic examples, whose forewings are usually stated to range from 6.5 to 7.5 mm long. The male genitalia (Fig. 2) are indistinguishable from those of an example in the National Museum of Natural History collected in Kent, U.K.

Apparently, the Michigan specimen was captured flying or at a light, so its larval host plant is unknown. In Europe the larva feeds within tied leaves of *Lonicera* and *Symphoricarpos*, genera of the Caprifoliaceae or honeysuckle family (Swatschek, B., 1958, Die Larvalsystematik der Wickler, Berlin, 269 pp.).

Whether the specimen represents a population now extant or extinct, introduced or endemic, is thus far undetermined. There has been no confirmation in two decades, and, although far from traditional ports of entry, the collection area is near Great Lakes routes of international shipping through the St. Lawrence Seaway.

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MELIPOTES INDOMITA (WALKER) IN HAWAII

In this *Journal*, vol. 33(2):136, was a note concerning this species in Hawaii, which very easily could be understood as if it were a first report of it in the Islands. This, however, is not so. *Melipotés indomita* was reported for the first time on 8 June 1969 on a building wall in Manoa and then repeatedly at Hickam Air Force Base and Honolulu Airport. By 7 August the moth had been found already on Molokai and, shortly before that date on Kauai, and in September also on Maui. Now the moth is one of the most common noctuids in the Islands, which is understandable because of the abundance of the foodplant, the monkeypod tree (*Samanea saman* (Jacq.)). A very thorough description and the life cycle of the moth was published by Oda & Mau (1972, *Proc. Hawaiian Entomol. Soc.* 21(3):435-441).

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TMOLUS AZIA (LYCAENIDAE) AND ANTEOS CHLORINDE (PIERIDAE) IN THE DOMINICAN REPUBLIC

Tmolus azia (Hewitson) has recently been collected in Jamaica, the first record of its occurrence in the Caribbean (Vyhmeister, G., 1980, *J. Lepid. Soc.* 34(1):60). On 22 June 1981 at least three members of the Lepidopterists' Society Dominican Republic expedition collected single specimens of this butterfly in the "desert" region of Santiago Province, approximately 10 km NW of the city of Santiago and several hundred meters from the north bank of the Rio Yaque del Norte. This collection date followed approximately 40 days of rain, and the local vegetation was lush and dense. The collectors were Andrew F. Beck, S. S. Nicolay and Charles Zeiger; S. S. Nicolay identified the specimens. Mr. Nicolay returned to this site on 28 June 1981 and collected three

additional specimens, suggesting strongly that this insect is established at this locale and is not merely a visitor.

In addition, I collected a single, fresh male *Anteos chlorinde* (Godart) in Jarabacoa, La Vega Province, in the afternoon of 24 June 1981. It was captured on *Hibiscus* blossoms along a roadside in the vicinity of the Hotel Pinar Dorado. Riley (1975, A Field Guide to the Butterflies of the West Indies, Demeter Press) indicates that this butterfly is not recorded from Hispaniola.

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HAND-PAIRING OF *BATTUS PHILENOR* (PAPILIONIDAE)

Hand-pairing is a useful technique in the laboratory rearing of butterflies (Clarke & Sheppard, 1956, *Lepid. News* 10:47-53) and has been applied in several families, most extensively in the Papilionidae. I have successfully used it for most eastern North American swallowtails but had been unable to hand-pair *Battus philenor* (L.) Recent observations of mating of caged *B. philenor* revealed the probable reason for my failure and suggested how I might be able to hand-pair the species, which has now been accomplished.

B. philenor males and females were released within a day of eclosion in a large outdoor flight cage (7.6 m × 4.6 m × 4.6 m high). Within a few minutes the following behavioral sequence was observed for two pairs: A motionless female sitting upright on a honeysuckle stem about 3 m from the ground was approached by a male, which quickly landed upside down on the stem beneath the female and in a few seconds had curved his abdomen up and locked *in copula*. He immediately hung free with folded wings in the usual way. Two aspects of this sequence were unexpected: There was no fluttering of wings by either individual; and the male approached from below with his body initially parallel to that of the female in a frontal position.

The usual technique in hand-pairing is to bring the tips of the abdomens together at about 180°, squeeze the male to open his claspers and join the two. If this technique is tried with *B. philenor*, both individuals curve the tips of their abdomens under, and the two cannot be joined. The observations in the flight cage suggested that the curvature facilitates copulation in the natural position. I, therefore, brought together a male and female in the frontal position, pressed the male's abdomen to open his claspers, and the two immediately joined. Several pairs were so mated and dissection revealed a spermatophore in each female. *B. philenor* seems to remain *in copula* somewhat longer than most other swallowtails, but, as in other species (Clarke & Sheppard, 1956, *op. cit.*), about 20 minutes is sufficient for the passage of a spermatophore.

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SPECIES OF *EUCALYPTUS* AS FOOD PLANTS
FOR LEPIDOPTERA IN EAST AFRICA

Dr. I. F. B. Common's paper, "Some factors responsible for imbalances in the Australian fauna of Lepidoptera" (1981, *J. Lepid. Soc.* 34:286-294), and his remarks on the role of *Eucalyptus* as a lepidopterous food plant suggest that a list of the Lepidoptera feeding on the introduced *Eucalyptus* spp. in East Africa might be of interest.

Various species of *Eucalyptus* are grown in many parts of East Africa, primarily as sources of firewood but also as useful agents in the reclamation of swampy land. *E. citriodora* is grown as a plantation crop in Zaire and elsewhere for its oil, used in the perfumery trade.

The following is a list of species recorded as feeding on species of *Eucalyptus*: **Lymantriidae**—*Euproctis molunduana* Auriv., *Dasychira georgiana* Fawcett, *D. basalis* Wlk., *Argyrotagma niobe* Weymer; **Lasiocampidae**—*Lechriolepis nigrivenis* Strand, *Bombycopsis bipars* Wlk., *Nadiasa cuneata* Distant, *Pachypasa subfascia* Wlk., *P. papyri* Tams, *Eucaera salambo* Vuillot; **Saturniidae**—*Bunaea alcinoe* Stoll, *Nudaurelia conradsii* Rebel, *N. cytherea* F., *N. dione* F., *N. krucki* Hering, *N. gueinzii* Karsch, *Lobobunaea phaedusa* Drury, *Urota sinope* Westwood, *Athletes ethra* Westwood; **Notodontidae**—*Desmeocraera varia* Janse; **Limacodidae**—*Latoia chapmanni* Kirby; **Psychidae**—*Eumeta rougeoti* Bourgogne, *Kotochalia junodi* Hylaerts; **Noctuidae**—*Euxoa longidentifera* Hampson, *Spodoptera littoralis* Bdv., *Heliothis armigera* (Hbn.), *Anua mejanesi* Gn., *A. tirhaca* Cramer, *Achaea lienardi* Bdv., *A. catella* Gn., *A. faber* Holland, *Plusia limbirena* Gn.; **Geometridae**—*Orthonama obstipata* F., *Colocleora divisaria* Wlk., *Ascotis selenaria* Schiff., *A. reciprocaria* Wlk., *Cleora nigrisparsalis* Janse, *C. herbuloti* Fletcher, *C. dargei* Herbulot, *C. scobina* Fletcher, *C. rothkirchi* Strand, *Luxiaria curvivena* Warren; **Pyralidae**—*Herculia tenuis* Butler, *Sylepta balteata* F. As shown for Australia no African butterfly larva have been known to feed on *Eucalyptus*.

The two indigenous genera of the Myrtaceae, *Eugenia* and *Syzigium*, serve as host plants for relatively few lepidopterous larvae: five *Charaxes* spp., one lycaenid, two lymantriids, one each lasiocampid, thaumetopoid and metarbelid, three limacodids and two noctuids; however, another introduced genus, *Psidium*, originally from tropical America, is eaten by two lycaenids, one lymantriid, one lasiocampid, six saturniids, three notodontids, one limacodid, one metarbelid, one noctuid and two geometrids.

It is most unusual for introduced species to be eaten by more species than the indigenous plants. In the Mimosaceae, for example, there are no records of lepidopterous larvae feeding on the introduced *Leucaena glauca* and *Acacia decurrens*, nor are the flowers visited by imagines; yet, the indigenous species of *Acacia* are eaten by numerous species of lepidopterous larvae, and their flowers are highly attractive to butterflies and moths.

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SUMMER BUTTERFLIES IN DINOSAUR NATIONAL MONUMENT

The canyons of the Green River in Dinosaur National Monument are in large part accessible only by raft. They are in a most interesting area biogeographically, however,

lying just off the eastern end of the Uinta Mountains, the most southern outpost of the northern Rocky Mountains. To the north and east of Dinosaur lies the Wyoming Basin, which separates the northern and southern Rockies and forms a gap that has not been crossed by such butterflies as *Euphydryas gillettii* (Barnes) and *Parnassius clodius* Ménétriés.

A raft trip down the Green River in mid-July of 1981 provided an opportunity for a quick survey of the butterfly fauna of the canyons. Although during the trip (12–17 July) the river was cold, the desert floor of the canyons was hot, and few wildflowers were in bloom. In general the butterfly fauna was unexciting. *Asclepias* was abundant, and *Danaus plexippus* L. was the most prominent butterfly. Occasional individuals of *Vanessa cardui* (L.) and *Pieris rapae* (L.) were seen, and once or twice a day a *Papilio multicaudatus* Kirby would fly by. In dry grassy areas *Cercyonis oetus* (Bdv.) was frequent, second only to monarchs in abundance. Occasionally an *Erynnis afraninus* (Lintner) was seen. A single *Colias* flew by, possibly *alexandra* Edw.

Near Upper Disaster Falls in the Lodore Canyon, Colorado (mile 237) some thistles were in bloom. While our party was reconnoitering the rapids I took a couple of *Speyeria coronis* Behr and then was attracted by the unusual silhouette of a backlit "monarch" nectaring. A second look told me it was no monarch—indeed it was *Speyeria nokomis* (Edw.), a species I had not seen before. Two males were taken of this scarce and strangely distributed fritillary—previously unknown in northwestern Colorado but present in adjacent northeastern Utah (Uintah County—Callaghan and Tidwell, 1972, J. Res. Lepid. 10:191–202; Ferris & Fisher, 1971, J. Lepid. Soc. 25:44–52).

Since mineral development is rampant in Uintah County, it is a pleasure to report this minor range extension, because it means that *S. nokomis* is established in a national monument where its habitat will be protected. It is clear that further exploration of the canyons of Dinosaur National Monument would be useful, to establish both the nature of the butterfly fauna earlier in the season and the extent of the *S. nokomis* colony.

L. P. Grey kindly identified the *Speyeria coronis*; John M. Burns the *Erynnis*.

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NEW BUTTERFLY DISTRIBUTION RECORDS FOR NORTHERN NEW YORK STATE

In general, the Adirondack and St. Lawrence valley regions of New York are poorly represented in entomological collections owing, in part, to a dearth of resident collectors in these regions. This is especially evident in the lack of records of many species of Lepidoptera from these areas. The following annotated list of Rhopalocera supplements Shapiro's list of the butterflies and skippers of New York (1974, Search: Agriculture, Cornell Univ. Agric. Exp. Sta. No. 12, Ithaca, N.Y., 60 pp.).

Most specimens were collected or observed at White's Hill (elev. 438 m), Parishville, in St. Lawrence County. White's Hill lies just within the northwestern boundary of the Adirondack Park and overlooks the St. Lawrence valley to the north. This area is, therefore, intermediate between the lower, very flat plain extending to the St. Lawrence River and the much higher Adirondack Mountains. Some areas of White's Hill are old fields in succession, but much of the land is second-growth deciduous forest, with pockets of hemlock and spruce.

Additional records within St. Lawrence Co. are presented from the Cranberry Lake Biological Station (CLBS), owned by the State University of New York College of Environmental Science and Forestry; and Sterling Pond, located about 13 km SE of

White's Hill. Other records are given for Onondaga Co. and Dutchess Co. New county records are designated by an asterisk (*). The format follows Shapiro (1974, op. cit.). The specimens are in the author's collection.

Satyridae

Lethe anhedon (Clark)—St. Lawrence Co.*, Parishville, 12–28 July. In 1974–75, this species was semi-abundant in rocky, sunlit deciduous woods.

Lethe eurydice (Johansson)—Dutchess Co.*, Amenia, July 1977. St. Lawrence Co., Parishville, 8–20 July. Very common locally in wet meadows, sighted frequently at CLBS in old beaver meadows.

Coenonympha tullia inornata Edwards—St. Lawrence Co.*, Parishville, 23 June 1973; 11–17 June 1975; 23–24 Aug. 1973, 75. Most often encountered in wet meadows, and two broods per year are apparent.

Euptychia cymela (Cramer)—St. Lawrence Co.*, Parishville, Sterling Pond, and CLBS, 9–25 June. Collected along margins of open deciduous woods.

Cercyonis pegala nephele (Kirby)—St. Lawrence Co.*, Parishville, 26 July 1974. In dry sloping, abandoned field. Only occasional specimens have been seen in the area. This specimen does not appear to represent an intergrade between *C. pegala alope* Fabr. and *C. pegala nephele*.

Nymphalidae

Speyeria cybele (Fabricius)—This common and widespread species has been collected frequently at Parishville and CLBS during July.

Speyeria atlantis (Edwards)—St. Lawrence Co., CLBS, 26 July–15 Aug. Not a particularly common species.

Speyeria aphrodite (Fabricius)—St. Lawrence Co., Parishville, August. Common in dry, brushy fields feeding at composites.

Boloria selene myrina (Cramer)—St. Lawrence Co., Parishville, 22 June 1974. In open marshy area with exposed patches of flat rock surrounded by small spruces and red maples.

Euphydryas phaeton (Drury)—St. Lawrence Co., Parishville, late June to mid-July. Not particularly abundant, even where its foodplant (*Chelone glabra* L.) is found.

Chlosyne harrisii (Scudder)—St. Lawrence Co., Parishville, 11–22 June, in boggy meadows. Collected further northward than previously recorded in New York.

Polygonia interrogationis (Fabricius)—St. Lawrence Co.*, Parishville, 9 Sept.; CLBS, 2 Aug. Onondaga Co., Lafayette Experiment Station, 20 June. The St. Lawrence Co. records extend the range more northward than previously recorded for the state. It seems doubtful that the adults overwinter in St. Lawrence Co.

Polygonia comma (Harris)—St. Lawrence Co.*, Parishville, 23 May 1975. In open woods near a long-abandoned farm. Wild hops (*Humulus* sp.) growing nearby may have been the foodplant.

Polygonia faunus (Edwards)—St. Lawrence Co., Parishville, 7 Sept. Collected along wooded margins of a dirt road. Other records are mostly from the central Adirondacks (Shapiro, 1974 op. cit.).

Nymphalis j-album (Boisduval & LeConte)—St. Lawrence Co., Parishville. The 17 April is earliest, 25 Oct., the latest date of collection.

Nymphalis milberti (Godart)—In Aug. 1977, I saw dozens of individuals flying about, sunning themselves, and feeding at flowers and spots of moisture on the summit of Algonquin Peak (elev. 1558 m) in Essex Co. Shapiro (1974, op. cit.) described this as a lowland species.

Nymphalis antiopa (Linnaeus)—In Syracuse (Onondaga Co.), larvae have caused mild defoliation of Hackberry trees (*Celtis occidentalis* L.) in ornamental plantings. Earliest sighting was 23 April in Parishville.

Vanessa atalanta (Linnaeus)—Not seen during spring months at Parishville, but only from mid- to late summer.

Vanessa cardui (Linnaeus)—St. Lawrence Co., Parishville, 24 May–6 June. I have seen this species only three times at White's Hill. The specimen captured on May 24 was feeding at Dandelion flowers (*Taraxacum officinale* Weber).

Vanessa virginiensis (Drury)—St. Lawrence Co., Parishville. Locally abundant in open meadows, from mid- to late summer.

Asterocampa celtis (Boisduval & LeConte)—Onondaga Co.*, Lafayette Experiment Station, and Clark Reservation State Park, 15–30 June 1978, 79. Common along Hackberry-lined woodland roads. Previously reported from a few southern-most counties bordering Pennsylvania and on Long Island (Shapiro, 1974, op. cit.).

Lycaenidae

Harkenclenus titus (Fabricius)—St. Lawrence Co.*, Parishville, CLBS, late June to early July. Commonly collected at *Asclepias* sp. flowers in open brushy fields.

Satyrium liparops (Boisduval & LeConte)—St. Lawrence Co., Parishville, 19 July. Collected along fencerow in an old field.

Callophrys niphon (Hübner)—St. Lawrence Co.*, Parishville, 18–24 May; Oneida Co., Boonville, 25 May. *Pinus strobus* L. was the only pine in the areas where specimens were taken. Shapiro (1974, op. cit.) suspected that *C. niphon* may utilize white pine where hard pines (*P. rigida* Mill.) do not occur.

Lycaena thoe (Guérin-Méneville)—St. Lawrence Co., Parishville, CLBS, mid-July. These captures confirm its presence in the western Adirondacks.

Celastrina argiolus pseudargiolus (Boisduval & LeConte)—Very common in May at Parishville, especially along margins of dirt roads. May 11 is the earliest date of capture for ♂♂ and ♀♀.

Papilionidae

Papilio polyxenes asterias Stoll—St. Lawrence Co., Parishville, 15 Aug. Not commonly seen in this area. There are few records from the northern-most counties.

Papilio glaucus Linnaeus—The small *canadensis* form is found in St. Lawrence Co.*, Parishville, and CLBS, with May 22 as the earliest capture date. On June 12, 1978, I observed large numbers (over 20/min) at White's Hill. Many individuals were feeding at Orange Hawkweed blossoms (*Hieracium aurantiacum* L.).

Pieridae

Pieris napi oleracea Harris—Onondaga Co.*, Manlius, 3 May 1977, in open deciduous woods. St. Lawrence Co., Parishville, 17 May–27 June. Commonly collected along wooded roads.

Colias eurytheme Boisduval—St. Lawrence Co., Parishville, 17 Aug.–26 Sept. Not very common around the Parishville area (1973–78), and there are few reported localities for northern New York.

Hesperiidae

Erynnis icelus (Scudder & Burgess)—St. Lawrence Co., Parishville, 20 May–21 June. Common along wooded dirt roads. It is doubtful that *E. brizo* Boisduval & LeConte occurs in this area, as there are no oaks upon which to feed.

Erynnis baptisiae (Forbes)—Onondaga Co.*, Syracuse, 20 May.

Carterocephalus palaemon mesapano (Scudder)—St. Lawrence Co., CLBS, 4 June, in a grassy beaver meadow near a spruce bog.

Ancyloxipha numitor (Fabricius)—St. Lawrence Co.*, CLBS, July. In wet grassy areas.

Polites mystic (Scudder)—St. Lawrence Co., Parishville, 18 July. In a wet meadow.

Poanes hobomok (Harris)—St. Lawrence Co., Parishville, CLBS, 26 May–18 June. A very common skipper in the county.

Amblyscirtes hegon (Scudder)—St. Lawrence Co.*, Parishville, 29 May.

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BOOK REVIEWS

THE BUTTERFLIES OF THE MALAY PENINSULA, by A. Steven Corbet and H. M. Pendlebury, 3rd ed., revised by J. N. Eliot. 1978. Malayan Natural History Society, Kuala Lumpur, Malaysia. v-xiv + 578 pp., ill.

Col. Eliot has done a magnificent job of revising "the" standard reference to Malaysian butterflies, which was no easy task, inasmuch as the original Corbet and Pendlebury treatment produced perhaps the finest regional text available anywhere. Eliot has thoroughly modernized the treatments of all groups of butterflies, save most of the HesperIIDae which are left nearly as Evans had classified them in 1949. Among the new taxa proposed by Eliot in this book (a practice that I do not like, because such descriptions are better made available in journals) are five hesperiid genera, and since most new taxa add to clarity, the book is helped by them.

Introductory treatments of the morphology of various stages (could have been a bit more detailed), nomenclature and classification, geographical distribution of butterflies, wing patterns, duplex species, sex ratios and the history of collecting on the peninsula lead off the book. All sections are well done and the information presented is sound.

The discussions of species and higher categories are competent and comprehensive. As is the case with so many modern books, the nomenclature is not so conservative as that in the earlier literature; but in this case, the reasons behind these nomenclatorial changes are well elucidated. No reviewer can be expected to wholeheartedly agree with everything in a book; this book and this reviewer are not exceptions. On page 128, Eliot mentions my 1968 higher classification of the Satyridae, stating that it "... ignores the male genitalia, takes little account of secondary sexual characters and is not adopted here." Male genitalia were not considered in the revision chiefly because the genitalia of Satyridae are so simplified that they offer very few good characters for higher classification; for generic and specific determination, they are very appropriate. The use of male secondary sexual characters, so abused by Moore and others around the turn of the century as the basis of new genera, were not used mainly because geneticists tell us that a characteristic can be shifted in position on a wing through the action of a single gene, hardly enough to warrant a change in tribal status, the lowest point to which my classification went.

The larvae of some Neotropical Morphidae feed on monocots (others on dicots), which characteristic makes that family a pivotal one in the evolution of the nymphalid complex. At this time, though, I am inclined to consider at least part of the Morphidae (*Taenaris*, etc.) to perhaps be satyrids, and were I doing the revision today, I should consider the genus *Penthema* to be a satyrid in the Elymniinae, as suggested by Japanese correspondents.

I am pleased to see that *Cethosia* is unequivocally placed in the otherwise Neotropical Heliconiinae. This genus sits in the Heliconiinae in about the same position (that of an outlier of a Neotropical group) as does *Tellervo* in the Ithomiidae.

Lycaenid classification has benefitted in this book by Eliot's use of his own superb higher classification of that family. Classification of members of that family has always been a problem with traditional treatments, and the original Corbet and Pendlebury handling of the group was no exception. The success Eliot has had with his classification should send a signal to the rest of us that it *works*, better than any other. It should be expected to treat the Malaysian fauna well (it was based chiefly on Malaysian examples), but it is certainly adaptable to lycaenids from other regions.

A brief word about other features of the book must include mention of the very useful keys scattered throughout the text. Many amateurs do not like keys, preferring to rely instead on illustrations, preferably colored, but keys are the most economical way of presenting differences (and similarities) between taxa. These keys are much expanded over the original Corbet-Pendlebury ones, thus adding to the utility of the volume for both professional and amateur alike.

For those who admittedly refuse to use keys, there are high quality illustrations as well. Not all of the species are figured (nor are their genitalia in the plates of those),

but the illustrations are of good quality and clarity. In conjunction with the keys, the reader should be able to identify any Malaysian butterfly from the species illustrated on the plates.

In short, this book should be on the shelves of anyone with an interest in the butterflies of this region, even if he has another edition of Corbet and Pendlebury. Eliot has done a fine revision that would make both Corbet and Pendlebury happy to have their names associated with, and nothing finer can be said about a revision of an older book.

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THE CUTWORM MOTHS OF ONTARIO AND QUEBEC by Eric W. Rockburne and J. Donald Lafontaine, with photographs by Thomas H. Stovell. 1976. Agriculture Canada, Research Branch, Publication 1593. 164 pp., 613 col. figs. Obtainable from Canadian Government Publication Centre, Supply and Services Canada, Hull, Quebec K1A 0S9. \$US 10.50, \$CAN 8.50.

This hard-bound, lavishly illustrated little book is primarily a collection of life-size colored illustrations of noctuid moths from the Agaristinae to the Catocalinae (in the sequence of the McDunnough, 1938, check list), intended as an identification guide for the amateur. It has a brief text of usually three or four lines per species, giving distribution within the two provinces, food plants, and flight period, and a 5-page introduction consisting of elementary information on classification, life history, adult structure, and collecting. It treats all Noctuidae represented by specimens from Ontario or Quebec in the Canadian National Collection with the exception of the Hypeninae, Rivulinae, and Herminiinae (in the sense of McDunnough). My only complaint about the book is that these latter three also could have been covered with the addition of only two and one-half pages to the 41 pages of illustrations already included, making it a nearly complete guide to the Noctuidae of that region. The term "cutworm moths" is construed as encompassing such a large part of the Noctuidae that it might just as well have been applied to them all.

This book is essentially without errors, and the nomenclature is current as of the time of publication. The colored illustrations are not perfect, but they would have to be regarded as adequate to excellent when one considers the modest price. The original photographs, made against the traditional pale-blue background by the same photographer who did the illustrations for the *Butterflies and Moths of Newfoundland and Labrador*, were obviously very well done. As in the work just cited, the legends give no locality data, but the stated purpose of Rockburne and Lafontaine was only to produce "a handbook intended for amateurs." Also, I could see nothing in the illustrations to reveal that the figured specimens were from anywhere other than Ontario or Quebec.

I do not hesitate to recommend this book as a useful aid to the identification of noctuid moths of the Northeast and suspect that it will find an important place on the bookshelves of many entomologists who do not think of themselves as amateurs.

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Cover illustration: Adult of the squash vine borer, *Melittia cucurbitae* (Harris) (Sesiidae), which occurs in the eastern half of the United States and along the Gulf Coast into Vera Cruz, Mexico. The larvae are destructive borers in the vines of various cultivars of *Cucurbita* spp. (squash, pumpkins and gourds). Original drawing by Dr. Charles S. Papp, Sierra Graphics & Typography, 1722 J Street #19, Sacramento, CA 95814, USA.

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NATURAL HISTORY OF SEVEN HAIRSTREAKS IN COASTAL NORTH CAROLINA

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ABSTRACT. Seven species of hairstreaks were observed in their natural habitats along coastal North Carolina. Also, larvae of each were reared in the laboratory from eggs. Various aspects of the butterflies' natural history are discussed. The species studied are: *Satyrium calanus falacer* (Godart), *S. liparops* (Leconte), *S. kingi* (Klots & Clench), *Calycopis cecrops* (Fabricius), *Mitoura hesseli* Rawson & Ziegler, *Incisalia henrici* (Grote & Robinson), and *Fixsenia ontario* (Edwards).

For the last six years (1974-1980), the senior author has observed hairstreak behavior in the field on Hatteras Island and Roanoke Island, Dare County, North Carolina. In addition, larvae were reared in captivity from eggs found in nature or obtained from caged females. The seven species considered in the present paper are *Satyrium calanus falacer* (Godart), *S. liparops* (Leconte), *S. kingi* (Klots & Clench), *Calycopis cecrops* (Fabricius), *Mitoura hesseli* Rawson & Ziegler, *Incisalia henrici* (Grote and Robinson), and *Fixsenia ontario* (Edwards). The junior author has provided comparative notes in the discussion of each species based upon prior literature reports. Each species is discussed individually and information for each species is also presented on Table 1.

METHODS

If possible, females were observed in the field in order to gain some idea of their host preferences, and in some cases, e.g., *I. henrici*, eggs were collected in the field. In most instances wild caught females

TABLE 1. Life-cycle data obtained in North Carolina on five species of hairstreaks.

Species	Hatched	1st molt	2nd molt	3rd molt	Pupated	Emerged	Food plant
<i>S. c. falacer</i>	6-IV-80	16-IV	21-IV	27-IV	4-V	25-V	blue jack oak (<i>Q. incana</i>)
<i>S. kingi</i>	6-IV-80	14-IV	26-IV	2-V	11-V	31-V	sweetleaf (<i>Symplocos tinctoria</i>)
<i>S. l. strigosum</i>	24-III-78	4-IV	14-IV	23-IV	15-V	4-VI	blueberry (<i>V. corymbosum</i>)
<i>I. henrici</i>	11-IV-80	22-IV	28-IV	3-V	11-V	19-VI-81	American holly (<i>Ilex opaca</i>)
<i>F. ontario</i>	4-IV-80	10-IV	16-IV	23-IV	29-IV	22-V	live oak (<i>Q. virginiana</i>)

were caged with appropriate host plant material and nectar sources if available. Larvae resulting from eggs obtained by either method were kept in individual containers and fresh host material was provided each day. The date of each molt, pupation and adult eclosion were recorded on each container. Larvae were kept on an outside porch under natural temperature conditions. Examples of eggs, larvae, and pupae of each species were preserved. Reared adults were deposited in the Carnegie Museum of Natural History and the Smithsonian Institution.

RESULTS

Satyrium calanus falacer

Eggs were obtained from females collected on Roanoke Island and caged with twigs of bluejack oak (*Quercus incana*). The egg-bearing twigs were inserted into a styrofoam block within a square cage, which was hung from a branch in the senior author's yard. They were separated to prevent mold. In general, the developmental behavior was similar to that of *Fixsenia ontario*. The *falacer* eggs hatched a few days later than those of *F. ontario*; concomitantly, the former's host (*Q. incana*) flowered and leafed out a few days later than did *Quercus virginiana*. The larvae fed on catkins at first and then switched over to young leaves when they appeared.

The larvae were dark green and marked with white. The body setae were brown. The larvae looked brownish and were accented by the white markings. The mature larvae crawled a good deal and ended up pupating on the lids or sides of the containers. Pupae were never found in the field. Typical developmental times are shown on Table 1. Adults emerged from 25 May to 4 June.

S. calanus utilizes only members of the oak (Fagaceae) and walnut (Juglandaceae) families as hosts, although Smith (1797) reports hawthorne (*Crataegus*: Rosaceae) based on a painting by John Abbot. In any one area usually only one host genus is utilized. In most situations these are various oaks (present paper; Shapiro, 1966, 1974), but hickory (*Carya*) or walnuts (*Juglans*) are utilized in Texas and some portions of Florida (Kendall, 1964; D. Baggett, pers. comm.).

It is possible that there are two or more unrecognized sibling species currently going under the name *calanus*, and that these might be host-limited (D. Baggett, pers. comm.).

Satyrium liparops

On both Hatteras and Roanoke Islands, the larvae of *S. liparops* were the first to hatch from their eggs in the spring. Their host, high

blueberry (*Vaccinium corymbosum*), was also the first shrub in the area to put out new spring growth. It may be that the same weather conditions govern both events. Eggs and larvae were collected on *Vaccinium* in the field at both localities. Eggs were laid on host twigs the previous summer. Female *S. liparops* lay eggs both on reproductive and non-reproductive hosts, but seem to preferentially select portions of the shrub which will produce the most rapid growth. Eggs must be kept under natural moisture conditions outside or they will desiccate, and the young larvae will be unable to chew a hole through the egg. The remainder of the egg was not eaten. The young larva crawled to the nearest bud and bored into it. It fed within the bud until the leaves began to unfurl, after which time it fed on the leaves. In some instances the larvae bored into flower buds, open flowers and developing fruits, all of which were fed upon. The larvae were dark green when mature with transverse white markings. The body setae were dark brown. Typical developmental times are indicated on Table 1. Adults emerged between 30 May and 6 June.

This hairstreak is the most catholic *Satyrium* in its choice of larval hosts, although only one or a few may be used in any one region. Brown (1976) reported a Florida population to utilize blueberry as its host, while Knudsen (1955) reported rhododendron as a host in Georgia. Thus, southeastern populations may oviposit only on members of the heath family (Ericaceae). In contrast, more northern populations are known to utilize a wide array of woody hosts, including hawthorne (*Crataegus*), wild plum and cherry (*Prunus*), shadbush (*Amelanchier*), blackberry (*Rubus*), oak (*Quercus*), willow (*Salix*), and hornbeam (*Carpinus*) (Klots, 1951; Shapiro, 1974).

Satyrium kingi

Found on Roanoke Island, adult females and larvae of *S. kingi* were found in close association or upon sweetleaf or horse-sugar tree (*Symplocos tinctoria*: Symplocaceae). This plant occurs in isolated patches scattered through the woods on Roanoke Island, where adults were also seen nectaring on flowers of chinquapin (*Castanea pumila*). Eggs were placed near twig tips by captive females. The larvae did not eat the egg shells after chewing their way out, but bored directly into leaf buds and fed there until after the first molt when the leaves began to unfurl. Larvae presented with host flowers or fruits refused to feed. Two larvae found in nature, when collected with host material for captive stock, completed their development at the same time, and the resultant adults eclosed on about the same dates.

The larvae were lighter green than those of *S. liparops* and were a

little larger when mature. Typical developmental times are shown on Table 1. Adults emerged between 31 May and 6 June.

King's hairstreak is probably limited to *Symplocos tinctoria* throughout its range, as it was also reported on this plant in Georgia (Floyd, 1974), and its distribution agrees well with that of the plant. The report by Harris (1972) that flame azalea (*Rhododendron calendulaceum*) is a host for this butterfly may have resulted from a misidentified *S. liparops*.

Calycopis cecrops

The habits of *Calycopis cecrops* are bizarre. Found on both Hatteras and Roanoke Islands, the butterfly has two full broods and a partial third (April, July, September). Robert Cavanaugh of North Carolina observed female *C. cecrops* ovipositing on dead leaves on the ground under plants (pers. comm.). With this cue the senior author began to watch females in the field and eventually saw the act repeated. The eggs are laid on the underside of dead leaves and are hidden from view. The one found by Gifford was laid on a dead leaf three inches from the base of the nearest plant, a wax myrtle (*Myrica cerifera*). The larvae were dull blackish brown and densely setate in all their instars.

On 8 August 1980, several female *Calycopis* were placed in a cage with sprigs of wax myrtle and staghorn sumac (*Rhus typhina*), as well as some fall flowers. Small dead dry leaves were scattered on the bottom of the cage. The females laid a number of eggs, all under the dead leaves hidden from view. When the eggs hatched, the young larvae had their choice between wax myrtle and sumac. Wax myrtle was selected by 36 larvae (59%) and sumac by 25 (41%).

Fresh leaves of the plant selected were provided daily, and all larvae survived until hibernation in late fall. Larvae on sumac grew at a normal rate, although their growth slowed after the third molt. The molting process normally required about three days, but was lengthened to five or six days for the third molt. After this molt the larvae each rested under a sumac leaf until the following March when they pupated. Sixteen larvae (64%) survived until spring.

The larvae on wax myrtle grew more slowly but molted at the same time as the sumac group. They were relatively smaller and spent more time resting. The three larvae (8%) which successfully overwintered began moving about with the first warm weather in February. The larvae were then provided wax myrtle sprigs with overwintered leaves and male flower buds. The larvae fed on the flower buds and ignored

the leaves. They completed development and pupated about the time the flowers opened in nature.

Wax myrtle is the primary natural host in coastal North Carolina, although sumac and oak may be selected on occasion. The fact that different hosts may be used results in different developmental times and, therefore, extended flight periods. For example, spring generation adults may be found from 10 April to 15 May.

The life stages of this species were previously described by Rawson & Hessel (1951). They associated the butterfly with dwarf sumac (*Rhus copallina*) in New Jersey, and obtained eggs by enclosing females in paper bags with suspected host material. They reported the larvae to prefer leaves and to show strong negative phototropism.

Mitoura hesseli

On 20 July 1980, three female *M. hesseli* were collected near East Lake, Dare County, North Carolina, visiting flowers of sweet pepperbush (*Clethra alnifolia*). In the vicinity grew white cedar (*Chamaecyparis thyoides*), the only host of *C. hesseli*. The females were taken back to Roanoke Island where they were confined with branches of white cedar and flowering branches of sweet pepperbush. One female died the first day, but the other two lived until about 25 July by which time 20 eggs had been laid.

The larvae were transferred to red cedar (*Juniperus virginiana*), since white cedar was not readily available. Two larvae would not accept the alternate host and died without feeding. The remaining larvae accepted red cedar and developed normally. The young larvae were bright green. At the third molt the white transverse markings began to appear, but were not fully developed until the last instar. Larvae in the third instar would hang by a silk thread when accidentally dislodged. Some larvae molted five times prior to pupation and others molted only four times. *M. hesseli* larvae required two days to molt before feeding was reinitiated. Larvae always ate the shed exuviae.

The life history of *Mitoura hesseli* was described previously by Rawson et al. (1951), and the observations reported herein are generally confirmatory. This hairstreak is well known to be closely associated with its host white cedar throughout its range from New Hampshire to Florida.

Previously, Remington and Pease (1955) found that *Mitoura gryneus* larvae, whose normal host is red cedar (*Juniperus virginiana*), will readily feed and develop normally on white cedar. Thus, results of the reverse experiment reported here are of more than passing interest.

Incisalia henrici

On Hatteras Island, *I. henrici* fed only upon yaupon (*Ilex vomitoria*), but on Roanoke Island, only American holly (*Ilex opaca*) was utilized. Individuals of the Hatteras Island population had a greenish cast ventrally, and might eventually be described as a separate subspecies (L. D. Miller, pers. comm.).

Female *I. henrici* oviposited when the hollies were beginning to leaf out. Females circled about investigating expanding buds. If a bud seemed suitable a female would fly to a nearby leaf (the previous year's—holly being an evergreen) and laid an egg on the upper surface adjacent to the midrib. Eggs were laid indiscriminately with regard to sex of the host (*Ilex opaca* being dioecious). Eggs hatched seven to 11 days after oviposition. Upon hatching the young larvae crawled to the expanding leaf buds and bored in. As the leaves expanded, the larvae skeletonized them; then as they became larger, they fed on entire leaves. Fruits or flowers were not fed upon. Older larvae fed at night and rested under year-old leaves by day.

I. henrici larvae were green, molted three times, and required about a month for development to pupation.

On Hatteras Island, adult *I. henrici* fed at willow flowers. Typical developmental times are shown on Table 1. Adults emerged from 10 to 16 April.

The geographic distribution of *I. henrici*'s host associations are unusual. The butterfly, which uses a single host in any one area, feeds on quite different hosts in different portions of its range. In much of its inland range, the insect selects redbud (*Cercis canadensis*) with its larvae feeding on flowers and young fruits (many reports). Apparently, Atlantic coastal plain populations are associated with various hollies, as there are also reports from Florida (Baggett, 1980) and New Jersey (W. Wright, pers. comm.). In Texas, *henrici* feeds on persimmon (*Diospyros texana*) (Kendall, 1964), while the larva feeds on huckleberry (*Gaylussacia*) or blueberry (*Vaccinium*) on the southeastern Piedmont and in the upper Great Lakes States (Harris, 1972; Baggett, 1980; Nielsen, 1970). Shapiro (1966) reports it on wild plum (*Prunus*) and possibly blueberry in western Pennsylvania.

Fixsenia ontario

In nature, females must usually oviposit on high branches of their host plants, since larvae were never found on low branches. In addition, females accepted as oviposition substrata only twigs which would produce male catkins the following spring. On Hatteras Island, a female was observed depositing an egg on laurel oak (*Quercus laurifolia*). She was taken alive and caged with branches of both laurel

oak and live oak, the only oaks found at that locality. The *ontario* female laid six eggs on the former and eight on the latter. On Hatteras, the host leaves began to expand before the eggs hatched, and larvae always ate host leaves. There was no difference in rate of growth, size or timing of adult emergence for larvae raised on the two hosts.

On Roanoke Island, matters were quite different; two females caged with branches from non-reproductive individuals of *Q. laurifolia* laid only two or three eggs before dying. The following spring the larvae hatched before the hosts had begun to leaf out. At that time both oaks were in flower, so the larvae were provided with male catkins, which they fed upon until young leaves were available. The following year females were caged with branches of reproductive-aged trees of the hosts mentioned above, as well as black jack oak (*Quercus marilandica*), blue jack oak, and Spanish oak (*Q. falcata*). All five occurred naturally on that island. All females were caged together, and quite a lot of eggs were laid but only on *Q. virginiana*. Subsequent attempts to obtain oviposition on black jack, blue jack and Spanish oaks were also unsuccessful. A few larvae obtained from eggs laid on live oak were fed catkins and leaves of black jack oak. They developed normally and adults eclosed at the same time as those raised on live oak.

Young larvae bored into individual flowers and fed on pollen leaving the outer portion uneaten. The catkins were available until the third larval molt by which time the young leaves appeared. The larvae finished their feeding on young leaves. The larvae were always pale green, about the shade of the lower surface of a live oak leaf. In nature, they must pupate on the leaves or branches. In captivity, they usually pupated on leaves on the bottom of the container. Developmental times for a typical individual are given on Table 1. Adults emerged from 22 May to 6 June.

Little has been published previously on the life history of this insect, save for a few reports of host associations. Kendall (1964) reared the butterfly from larvae found on live and laurel oaks in Texas, while Shapiro (1974) reported white oak (*Quercus alba*) as the host in New Jersey. Clench (1971) found this hairstreak on shale barrens in Virginia and Pennsylvania where bear oak (*Quercus ilicifolia*) is prevalent.

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NOTES ON THE SATYRID BUTTERFLY POPULATIONS OF CORCOVADO NATIONAL PARK, COSTA RICA

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ABSTRACT. Results of a mark-release recapture study of satyrid butterflies at Corcovado National Park, Costa Rica are reported. Seven species were captured in undisturbed primary forest along the Olla Trail. Eleven species, including all but one of the species from the undisturbed habitat, were found in the more heterogeneous habitat along the Rio Claro Trail. Two of the principal forest species, *Pierella luna* Fabricius and *Euptychia arnaea* Fabricius, occur in "viscous" populations (repeated recaptures within a relatively small area), with a predominance of males among captured individuals. The population structure of *Cithaerias* (*Callitaera*) *menander* Drury was extremely "fluid" (no recaptures), with mostly females captured and no behavioral preference for local high points. The other major understory species, *Pierella helvetia incanescens* Godman & Salvin, was not captured often enough to make any significant biological inferences. Results are discussed with reference to theories of competition, character displacement and ecological disturbance.

The butterfly families Satyridae, Morphidae and Brassolidae have been called a "family cluster" by Young & Muysmond (1975). They are characterized by monocotyledonous larval food plants (although many morphos feed on legumes), use of non-floral resources (fallen fruit, dung, etc.) as adults (many north-temperate satyrids do feed on flowers) and cryptic, brown to ochre coloration (iridescent blue on the upper wing surface is fairly common among tropical species). Monocots have relatively few secondary compounds, and the generally cryptic color patterns of adults may result from inability to sequester toxic compounds. Larval food preference among monocot feeders does not appear to have "coevolved" along with plant defenses as it has in other groups (Ehrlich & Raven, 1964; Gilbert, 1975). Tropical *Euptychia* species (used here and afterwards in the sense of Weymer, 1924) commonly accept several species of grasses as larval hosts (M. C. Singer, pers. comm.). Young & Muysmond (1975) report two congeneric species of brassolids which use larval hosts in different families, and in another paper (Young & Muysmond, 1972) emphasize the importance of factors such as habitat selection in explaining radiations within the genus *Morpho*.

Satyrids, like many groups of new world organisms, reach their greatest diversity in the tropics. Ecology of tropical satyrids has received little attention to date, with the exception of work by Young (1972) and Singer (unpublished). Young (1972) marked individuals of twelve species (including satyrids, brassolids and morphids) at four *Coumarouna oleifera* (Leguminosae) fruit drops at La Selva, Costa Rica. He found little day to day variation in numbers, with the same

butterflies returning repeatedly to the same feeding sites. Adult mortality and recruitment were low, and the species composition at the four fruit drops was essentially homogeneous. Most of the species used artificial food when it was offered, but introduction of artificial food did not result in separation of feeding preferences, as would be expected if competition for adult resources were a limiting factor. This study presents basic data on satyrid distributions over a variety of habitats and behavioral comparisons of several species which occupy the same habitat and use the same adult food resources.

METHODS

Corcovado National Park is located on the Osa Peninsula of Costa Rica on the southern Pacific coast. The park headquarters is located in a valley about 1 km from the ocean. The lowlands near headquarters have been used for agriculture in the past, and several habitat types are found, including pasture, second growth and disturbed forest. The surrounding hills are covered with tropical wet forest. This study was carried out in July, which is early in the wet season. Two censusing routes were used, one (the Rio Claro Trail) to sample disturbed habitats and another (the Olla Trail) to sample primary forest. A map of the Sirena (headquarters) area of Corcovado National Park is included in Gilbert et al. (in prep.). The Rio Claro Trail starts just north of headquarters, goes southward up a steep ridge through disturbed primary forest, bears to the north and forks about 0.8 km (one-half mile) from its beginning. The left fork goes to a small landslide clearing and then ends. The right fork goes south along a long ridge, with the Rio Claro to the north. Vegetation along the ridge is very heterogeneous, with *Heliconia* (Musaceae) and *Cecropia* (Moraceae) intermixed with the primary forest species. The trail descends the ridge through an extensive stand of *Heliconia*, goes past a ruined shack in a small clearing, then turns and goes west along the Rio Claro until it reaches the ocean. The forest along the river contains a higher proportion of mesophytic species because of the level topography and consequently increased soil moisture. Total walking distance is about 3.5 km. The Olla Trail goes northeast through slightly disturbed to undisturbed upland forest, after crossing the Rio Camaronal near headquarters. The first 2.5 km were used for study. Both trails were marked with metal tags on tree trunks at intervals of about 50 m.

Censusing was done by walking along the trail and catching as many satyrids as possible. Routes were usually run in the morning between 0730 h and noon. Afternoon rain was very common, and butterfly activity along the trails was somewhat less during the after-

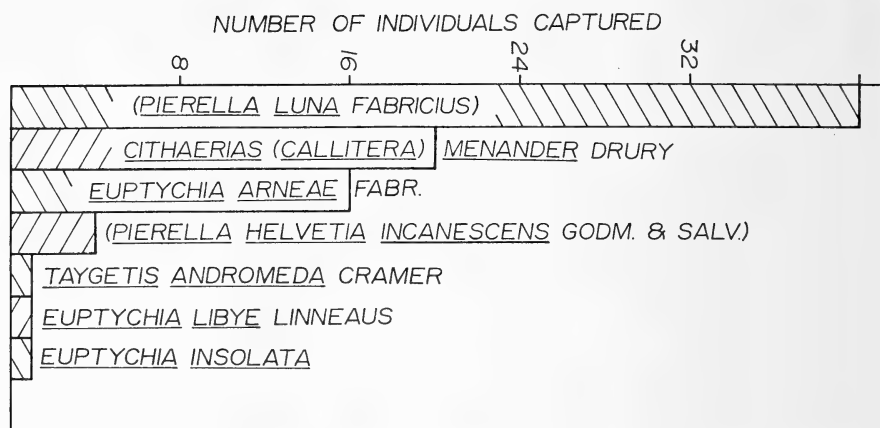


FIG. 1. Total number of butterfly individuals captured along the Olla Trail.

noon. The Rio Claro Trail was sampled on 6, 7, 8, 9, 10, 14, 19, 21, 27 (afternoon) and 28 July 1979, usually starting at the mouth of the river. The Olla Trail was sampled on 11, 12, 13, 15, 18, 20, 25, 27 and 29 July. Capture success was about 60% for most species and somewhat lower for *Pierella helvetia incanescens* Godman & Salvin.

Captured butterflies were marked with a red PILOT ultrafine point pen and then released. (A few butterflies were retained for voucher specimens.) All butterflies were numbered sequentially, regardless of species. The number was written on the undersurface of one hindwing and opposite forewing. Number, sex, species, condition (fresh, worn or intermediate), date, time and location (measured by pacing to the nearest metal marker) were recorded for each capture. Recaptures were released promptly after noting the number and condition.

Horizontal distance between markers was estimated by pacing along the trail, using a compass to determine direction. Capture points were marked on a map, and distances between consecutive capture points for recaptured butterflies were estimated from the map distances. These estimates do not include vertical displacement. Each marker station was rated for local topography ("0" for level ground or local depression, "+" for a slope, "++" for a ridge or hilltop). Abundance of fallen fruit in the vicinity of the marker ("0", none visible; "1", scarce; "2", moderately abundant; "3", abundant) was recorded on 20 July. There was some fluctuation in the abundance of fallen fruit over the course of the study, and no attempt was made to identify fallen fruit to species. Chi-square tests were used to evaluate the significance of observed trends.

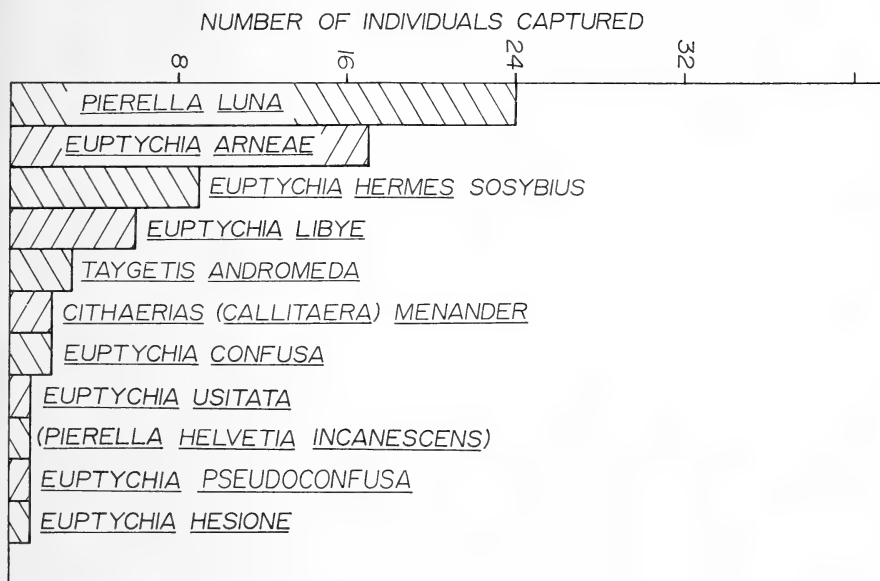


FIG. 2. Total captures along the Rio Claro Trail.

RESULTS

Figs. 1 and 2 show the number of different butterflies of each species captured in each of the two study areas, ranked in order of the number of individuals captured. The Rio Claro Trail fauna is more diverse (11 species, $1/(\sum p_i^2) = 4.40$) than that of the Olla Trail (7 species, $1/(\sum p_i^2) = 3.03$), in spite of the smaller sample size. Members of the related genera *Euptychia* (Weymer) and *Taygetis* comprise 59% (39 out of 66) of the Rio Claro sample and only 22% (18 out of 82) of the Olla Trail sample. Several species usually found in open or second growth habitat (*Taygetis andromeda* Cramer, *Euptychia hermes* Linnaeus, *Euptychia usitata* Butler, *Euptychia hesione* Sulzer, *Euptychia libye* Linnaeus) were captured in or near the clearing on the Rio Claro Trail. *Cithaerias menander* Drury was much less abundant in the Rio Claro area ($n = 2$ vs. $n = 20$).

Table 1 shows basic capture data for the four most common Olla Trail satyrids. *Pierella luna* Fabricius and *Euptychia arnaea* Fabricius were predominantly males. Recaptures were common in both species. One *P. luna* was captured six times within a 5 m radius, while another moved at least 1268 m between four capture points. The longest movement between captures by any *E. arnaea* was 30 m. Most of

TABLE 1. Capture-recapture data on major Olla Trail satyrid species.

		No. of but- terflies	No. sampled	No. re- captured	No. of re- captures	Mean recapture distance (S.D.) (m)
<i>Pierella luna</i>	♂	35	0	22	48	73.2 (107.2)
	♀	5	2	0	0	—
<i>Cithaerias menander</i>	♂	6	0	0	0	—
	♀	14	2	0	0	—
<i>Euptychia arnaea</i>	♂	14	0	5	8	7.6 (12.6)
	♀	1	0	0	0	—
<i>Pierella h. incanescens</i>	♂	1	0	0	0	—
	♀	3	1	0	0	—

the *C. menander* captures were females, and there were no recaptures of this species. The biased sex ratios are probably a result of behavioral differences between the sexes. The absence of *C. menander* recaptures indicates a large effective population size, although the density per unit area for *C. menander* and *P. luna* may be roughly comparable.

Table 2 gives the number of male *P. luna* captured (Olla Trail), the number recaptured (second and subsequent captures of the same butterfly on the same day are omitted), and a simple Lincoln index ($N = n(C + R)/R$, where n is the number of individuals previously marked, N is the estimated population density, C is the number of new captures on that day and R is the number of recaptures) estimate of population number for each day of the study. The mean estimated population size is 41.85, with standard deviation 13.96. By sampling along the trail, I believe I effectively covered an area of about one hectare.

Table 3 shows the number of captures in relation to topography. There were six level stations ("0") covering 367 m of trail, 21 stations on slopes ("+", 1201 m) and 17 stations on ridges or hilltops ("++", 914 m). Expected values were calculated by multiplying the number of total captures (including recaptures) for each species by the pro-

TABLE 2. Number of new captures (C), recaptures (R) and Lincoln-index estimates of population density (N) of *P. luna* males on the Olla Trail.

	Date (July)								
	11	12	13	15	18	20	25	27	29
C	9	6	3	4	7	3	1	1	1
R	0	2	4	3	3	5	7	11	8
N		36.0	26.25	42.0	73.3	46.4	36.6	36.0	38.25

TABLE 3. Total captures (Olla Trail), by topographic position of nearest marker. Expected values in parentheses. See text for further explanation.

	0	+	++	
<i>P. luna</i>	2 (9.31)	41 (42.58)	45 (32.41)	$\chi^2 = 14.26$, df = 2, P < 0.005
<i>C. menander</i>	0 (2.96)	11 (9.68)	9 (7.37)	$\chi^2 = 3.50$, df = 2, P > 0.10
<i>E. arnaea</i>	0 (3.40)	7 (11.13)	16 (8.47)	$\chi^2 = 11.62$, df = 2, P < 0.005
<i>P. h. incanescens</i>	0	0	4	P = 0.0184

portion of trail belonging to that given topographic category. For example, the expected number of *P. luna* captures at level stations is $(88)[367/(367 + 1201 + 914)]$. *P. luna* and *E. arnaea* both had a significant preference for local high points. *C. menander* captures showed no significant trend. *P. h. incanescens* also seemed to prefer high points, although the number of captures was very small.

Table 4 shows total captures for each species, according to local abundance of fallen fruit on 20 July. Two stations (122 m of trail) had no fruit visible nearby, 26 stations (1378 m) were rated as "1", 11 stations (655 m) were rated as "2" (moderately abundant) and five stations (327 m) were rated as "3". Expected values were calculated by multiplying the total number of captures by the proportion of trail assigned to that rating group. Capture distributions were significantly non-random for all species except *P. h. incanescens*. For the other three species, there was a trend toward higher capture frequencies around high densities of fallen fruit. The trend is less pronounced for *P. luna* than for *C. menander* or *E. arnaea*. Eighteen of the 23 *E. arnaea* captures were within 100 m of a single large fruit drop. The

TABLE 4. Total captures (expected values in parentheses) by abundance of fallen fruit around the nearest marker (Olla Trail).

	Fruit abundance				
	0	1	2	3	
<i>P. luna</i>	2 (4.31)	39 (48.89)	34 (23.21)	13 (11.59)	$\chi^2 = 8.42$, df = 3, P < 0.05
<i>C. menander</i>	0 (0.98)	7 (11.11)	3 (5.28)	10 (2.63)	$\chi^2 = 20.08$, df = 3, P < 0.005
<i>E. arnaea</i>	0 (1.13)	12 (12.78)	1 (6.07)	10 (3.03)	$\chi^2 = 21.45$, df = 3, P < 0.005
<i>P. h. incanescens</i>	0	2	1	1	

TABLE 5. Total captures (Olla Trail) by time of day.

	Time					
	0730- 0830	0830- 0930	0930- 1030	1030- 1130	1130- 1230	After 1230
<i>P. luna</i>	14	24	26	18	4	2
<i>C. menander</i>	8	5	3	2	1	1
<i>E. arnaea</i>	1	13	5	3	1	0
<i>P. h. incanescens</i>	0	1	1	1	1	0

C. menander captures were distributed among several widely separated sites. There was no significant association between topography and abundance of fallen fruit.

Table 5 shows the number of captures by time of day for *P. luna*, *C. menander*, *E. arnaea* and *P. h. incanescens*. *C. menander* were most active early in the morning. *E. arnaea* were most active around 0900 h, and *P. luna* showed a slight peak around 1000 h. Very little time was spent collecting after 1200 h, so the picture presented in Table 5 is incomplete. Wet weather usually depressed activity in late morning or early afternoon, but all four species were seen flying on sunny afternoons.

DISCUSSION AND SUMMARY

Cutting along the Rio Claro Trail has created openings and allowed invasions by successional plant species, such as *Heliconia*. The greater habitat diversity results in greater satyrid diversity, with several *Euptychia* species occurring which are not found in the forest. This result supports recent suggestions of Gilbert (1980) and Huston (1979) that ecological disturbance may increase species diversity.

The behavior of *C. menander* reported here is markedly different from that described by Young (1972). Young reported small, closed demes, with the same individuals returning to the same place day after day. The opposite seems to be true at Corcovado: Different individuals were captured at the same place and time on different days. Young (1972) also found a mid-day peak in activity, with no sightings before 0830 h. Several hypotheses may be proposed as explanations. The habitat at Corcovado is more hilly, so fruit drops might be smaller and less persistent through time. This would generate a more fluid population structure. Repeated movements in the same area might increase chances of predation, although there is no reason to believe this should be more important at Corcovado. A more scattered, ephemeral distribution of larval resources at Corcovado might also result in a more mobile population. Interference competition with *P.*

luna may also play a role. *P. luna* (which is not present at Young's study site) is an aggressively territorial species and often chases conspecifics. The early morning activity peak and mobile flight behavior of *C. menander* would both reduce the chances of being chased by a *P. luna*. Young (1973) reports aggressive patrolling behavior in one of his La Selva species (*Morpho amathonte* Deyrolle). According to Young (1972), *M. amathonte* flies early in the morning at La Selva before *C. menander* becomes active there.

P. luna usually flies low to the ground, often following the contour of the trail for 20 or 30 m. They are extremely cryptic against the background of forest litter: Young individuals resemble wet leaves when at rest, and older butterflies resemble dry leaves. Males will patrol the same area repeatedly, and encounters often result in chasing behavior. Positioning on ridges and hilltops may confer some advantage in mating, as Shields (1967) has reported in several temperate species. According to Scott (1968), "hilltopping" is usually an adaptation to low population densities, but densities of *P. luna* were not especially low during the study. Access to food may also be important. Occasional long flights may reflect searching for a territory with adequate food and few competitors.

E. arnaea is usually encountered in small sunny areas within the forest, with several males present in the same place. Scott (1974) lists several situations which should favor "perching" (as opposed to patrolling) as a mate location strategy, including low population density and patchy resource distribution. *E. arnaea* is less common and more patchily distributed than *P. luna* at Corcovado, so either one could be responsible for the observed behavior. Both predominantly male species (*P. luna* and *E. arnaea*) prefer local high points, while *C. menander*, which flies singly (usually female) or in pairs at Corcovado, doesn't. *Cithaeris* and *Pierella* are placed close together in most classification schemes (Weymer, 1924), even though their behavior in this situation is very dissimilar. Both *C. menander* and *E. arnaea* show slight sexual dimorphism with respect to size (males are smaller) and wing color. *P. luna* males have conspicuous scent patches (androconia) near the upper rear edge of the hindwings.

Previous work by Gilber & Singer (1973) has demonstrated that spatial distribution of resources may affect flight and mating behavior in butterflies. Results presented here indicate that interspecific competition may also have a significant impact. Comparison of behavior of related species in the same area and of single species in different areas, combined with accurate measurement of niche parameters such as food preference and flight time, will be needed to clarify this issue. Detailed descriptions of courtship, mating, oviposition behavior and larval life histories are also necessary.

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I thank L. E. Gilbert and J. Mallet for their interest and encouragement, and the staff of Corcovado National Park for their hospitality during my stay. P. J. DeVries and M. C. Singer helped identify specimens. This research was supported in part by a graduate student research grant from the University of Texas at Austin.

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A NEW SUBSPECIES OF *SPEYERIA EGLEIS*
(NYMPHALIDAE) FROM THE PUMICE REGION
OF CENTRAL OREGON

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ABSTRACT. A small-sized *Speyeria egleis* of central Oregon, delimited in its distribution to an area of some 4026 km² (2500 square mi.) extending northeasterly of Crater Lake, is described as a new subspecies, *S. e. moecki*. This region is geologically characterized as one of heavy ash and pumice outfall from the eruption of Mt. Mazama. The new subspecies is distinguished from the more southerly and larger *S. e. oweni* and from the sympatric and superficially similar *S. mormonia erinna*.

Lepidopterists of the Pacific Northwest have long been aware of a distinctive population of *Speyeria egleis* (Behr) in the pumice region of central Oregon (Deschutes and Klamath Counties). This was first noted by Arthur H. Moeck (1957), who took specimens in the Sand Creek region just east of Crater Lake at about 1524 m (5000 ft) elevation. Unofficially known as the Sand Creek type, this small-sized *egleis* was recently illustrated by Dornfeld (1980, Pl. 30, Figs. 3 and 4). Remarkably uniform in phenotype, it is geographically confined to an area of some 4026 km² (2500 square mi.), as shown in the distribution map (Fig. 1). This region is geologically characterized by heavy ash and pumice outfall from the eruption of Mt. Mazama (Crater Lake) about 6600 years ago. Tilden (1963) has given an account of the geological history and ecology of the Sand Creek Basin, but with respect to *Argynnis* (= *Speyeria*) he believed that "no equilibrium in phenotype has been reached by any of the several species." The evidence as it affects *S. egleis* does not sustain this view. Both with respect to the relative uniformity of its distinctive phenotype and the circumscription of its distribution, the "Sand Creek" *egleis* can be readily separated from the *egleis* populations that occur in southern Jackson and Klamath Counties. Those populations are composed of consistently larger butterflies that show affinities with *S. e. oweni* (Edwards) of the Mt. Shasta region. The Sand Creek *egleis* is here recognized as a distinct subspecies. Several hundred specimens have been examined.

***Speyeria egleis moecki*, new subspecies**

Male. Length of forewing (n = 71) 21 to 25 mm (\bar{x} = 23 mm). Dorsal wing surfaces medium orange with the usual pattern of black spots and bars. Moderate basal suffusion and veins of forewing slightly thickened with dark scales. Dorsal hindwing with yellowish patches between the black median band and black postmedian spots. Ventral forewing with yellowish or yellow-orange ground color; brown patches around the

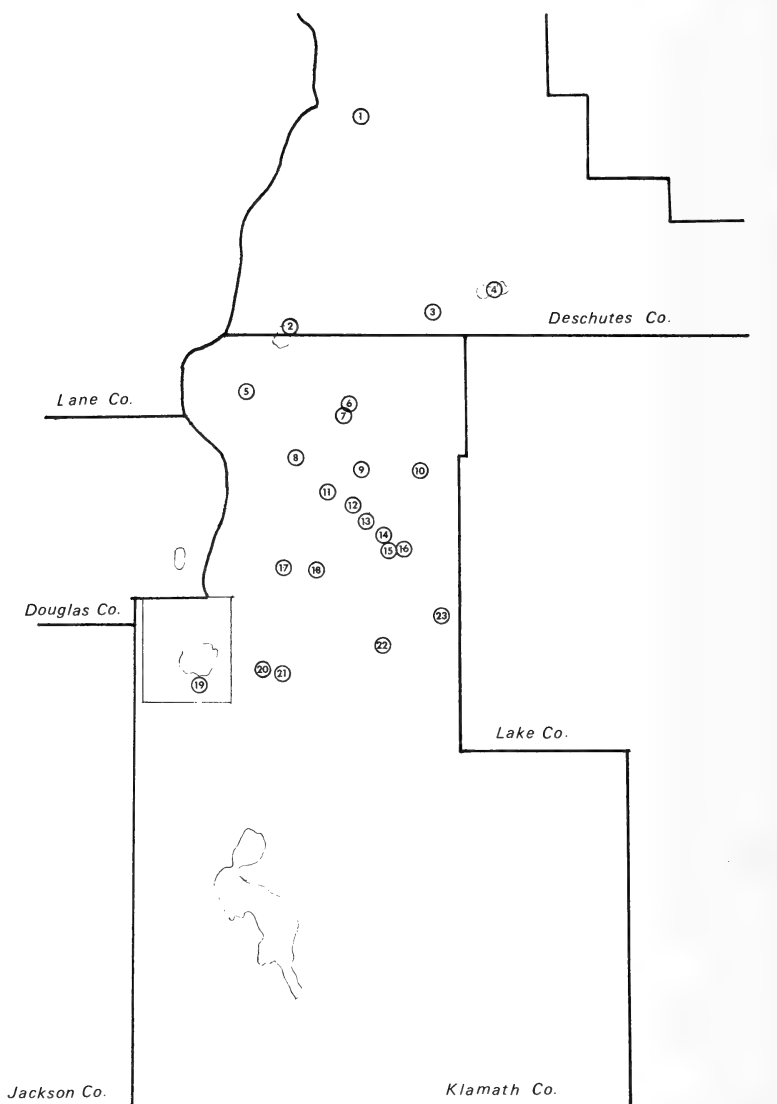


FIG. 1. Distribution of *Speyeria egleis moecki*, n. ssp. Figures in circles identify collection sites.

postmedian spots of the apical region. Ventral hindwing with dark reddish brown or umber-brown disc and a narrow yellowish tan or pale brown submarginal band. Spots usually brightly silvered and narrowly outlined basally with black scales. Median spots usually small, rounded or pointed, and the submarginal spots rounded to flattened. Brown or reddish brown marginal border.

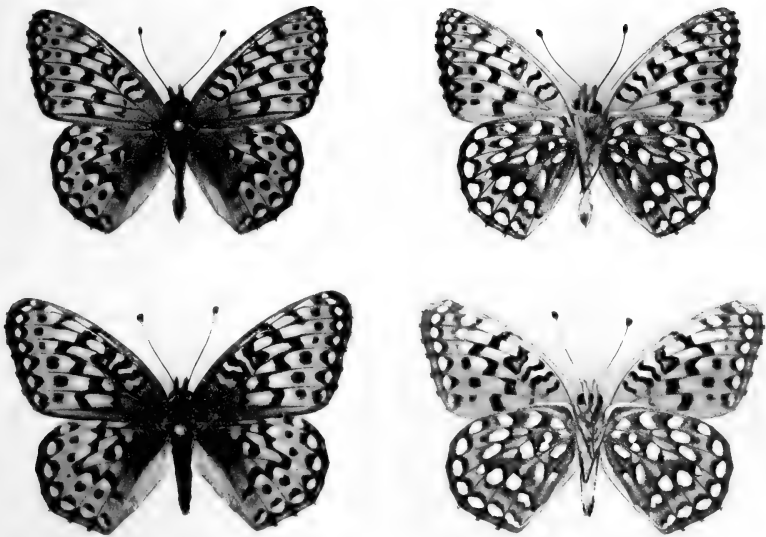


FIG. 2. *Speyeria egleis moeckii*, n. ssp. **Above:** dorsal and ventral sides of holotype, male. **Below:** dorsal and ventral sides of allotype, female.

Female. Length of forewing ($n = 54$) 22 to 27 mm ($\bar{x} = 25$ mm). Similar to the male, but veins of forewing not thickened; dark basal suffusion usually more extensive. Ventral forewing strongly flushed with reddish orange toward base of wings, but pale yellow along costal margin (as in male).

The name chosen for this race of *Speyeria egleis* honors the memory of the late Arthur H. Moeck of Milwaukee, Wisconsin. Over a period of thirty summers he and his wife Dorothy systematically covered the North American Continent in search of Fritillaries and, thereby, contributed greatly to our knowledge of these butterflies.

Types. HOLOTYPE: male (Fig. 2), Skookum Mdw., Walker Rim, Klamath Co., Ore., 25 July 81 (P. C. Hammond). ALLOTYPE: female (Fig. 2), same data. Types deposited in the American Museum of Natural History. PARATYPES: 48 males and 33 females. Disposition as follows: one pair each to the U.S. National Museum of Natural History, the California Academy of Sciences, and the Systematic Entomology Laboratory of Oregon State University; 8 males and 4 females to the collection of L. Paul Grey; 17 males and 10 females retained by Paul C. Hammond; 20 males and 16 females retained by Ernst J. Dornfeld.

Records. Figures in parentheses identify numbered loci on map (Fig. 1). DESCHUTES CO.: (1) Three Creeks Mdw., 6/viii/81 (Hammond); (2) Davis Lake, 24/vii/34 (Jewett); (3) 6 mi. E La Pine, 16/vii/61 (Shields); (4) Paulina/East Lakes, 15/vii/59 (Moeck), 16/vii/61 (Shields), 27/vii/75 (Hammond). KLAMATH CO.: (5) Crescent Lake, 23/vii/60 (Newcomer); (6, 7) Gilchrist, Crescent, 29/vii/45, 10/vii/54, 4/vii/56, 28/vii/57, 4/vii/59, 10/vii/60, 2/vii/67 (Dornfeld); (8) Mowich, 11/vii/54 (Dornfeld); (9) Round Mdw., 22/vii/68 (Hinchliff); (10) Cannon Well, 30/vii/61 (Newcomer); (11) South Walker Spg., 22/vii/68 (Hinchliff); (12) Skookum Spg., 23/vii/61 (Newcomer); (13) Skookum Mdw., 23/vii/61 (Newcomer), 17/viii/62, 13/viii/64, 18/vii/66 (Dornfeld), 24/vii/66, 18/vii/69 (Hinchliff), 17/vii/79 (Lattin), 26/vii/75, 25/vii/81 (Hammond); (14) Dempsey Spg., 18/

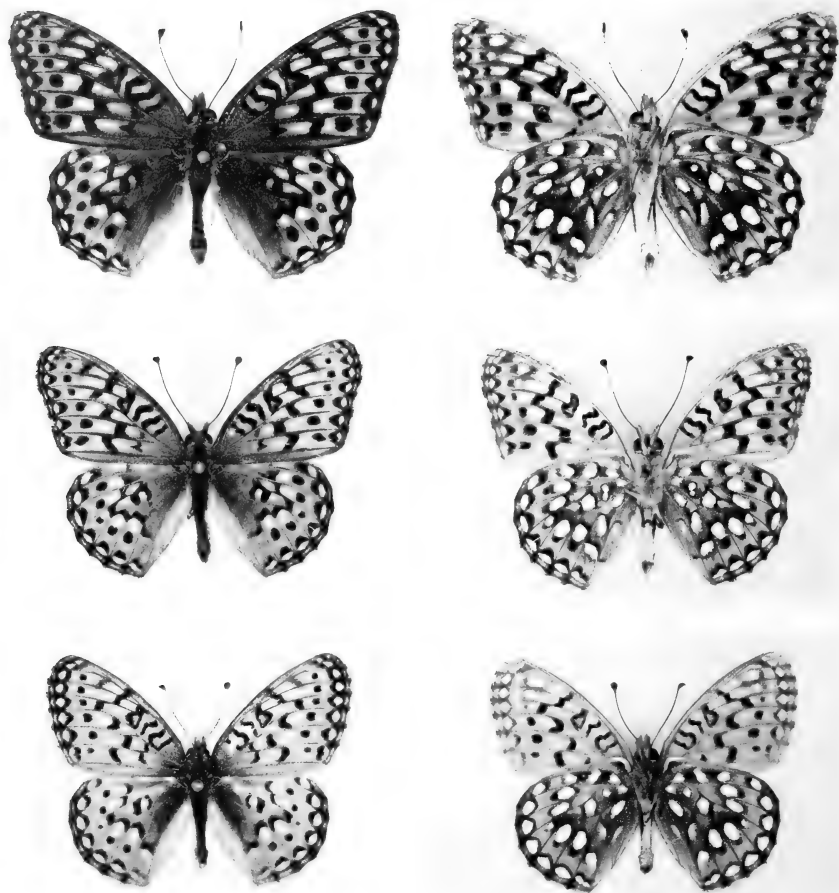


FIG. 3. **Top:** *Speyeria egleis oweni*, male, dorsal and ventral sides; Mt. Shasta, Siskiyou Co., Calif., 23 July 81 (PCH). **Middle:** *S. egleis moeckii*, male, dorsal and ventral sides; Sand Cr. at Hwy. 232, Klamath Co., Ore., 3 July 68 (EJD). **Bottom:** *S. mormonia erinna*, male, dorsal and ventral sides; Skookum Mdw., Walker Rim, Klamath Co., Ore., 24 Aug 72 (EJD).

vii/66 (Dornfeld), 25/vii/81 (Hammond); (15) Huckleberry Spg., 24/vii/66 (Hinchliff), 25/vii/81 (Hammond); (16) Davis Flat, 17/viii/62 (Newcomer), 25/vii/81 (Hammond); (17) Beaver Marsh, 17/viii/62 (Newcomer); (18) 5 mi. E Beaver Marsh, 14/vii/61 (Shields), 13/viii/64 (Dornfeld), 24/vii/66 (Hinchliff); (19) Crater Lake, 8/viii/30, 14/viii/30 (Sculen); (20) Sand Cr. at Hwy. 232, 16/vii/55 (Moeck), 10/vii/62, 25/vii/62, 12/viii/64, 3/vii/68, 20/vi/78 (Dornfeld); (21) Sand Cr. nr. Chinchalo, 22/vii/68 (Hinchliff); (22) 3 mi. E Klamath Fst. Nat. Wlf. Refuge, 25/vii/81 (Hammond); (23) N of Little Yamsay Mt., 27/vii/64 (Perkins).

DISCUSSION

The only race of *Speyeria egleis* that comes geographically close to the newly described subspecies is *S. e. oweni* (Edwards), whose type locality is Mt. Shasta in Siskiyou County, California (Fig. 3). Populations of the *oweni* phenotype extend northward into the Cascades of southern Jackson and Klamath Counties, Oregon, but lie south of the region occupied by *S. e. moecki*. Those populations that extend between Lake-of-the-Woods in southern Klamath County and the south edge of Crater Lake National Park exhibit clinal intergradation between *oweni* and *moecki* with respect to size and coloration. However, the *oweni* phenotype is almost completely excluded from the *moecki* populations of northern Klamath and Deschutes Counties, the region of the heavy Mazama ash fall (Fig. 1).

Speyeria egleis moecki can be readily distinguished from the race *oweni* by its uniformly small size, reduced dark basal suffusion, relatively thinner veins of the male dorsal forewing, and the high frequency of a reddish brown disc color on the ventral hindwing. For comparison, a sample of Mt. Shasta *oweni* included 85 males with a forewing length of 24 to 28 mm (\bar{x} = 26 mm) and 34 females with a forewing length of 26 to 30 mm (\bar{x} = 28 mm). The sympatric *S. mormonia erinna* (Edwards) is superficially similar to *S. e. moecki* in size and coloration (Fig. 3), but the latter tends to be darker orange above, shows a moderate amount of basal suffusion, and the veins of the male are distinctly thickened with dark scales. *Speyeria m. erinna*, in contrast, is usually pale yellow-orange above, shows almost no basal suffusion, and the veins of the male forewing are completely thin as in the female. In addition, *S. m. erinna* almost always exhibits a greenish tinge along the anal margin of the ventral hindwing that is never present in *S. e. moecki*. Although the adult butterflies of both species fly together, the peak flight period of *S. egleis* usually precedes that of *S. mormonia* by a week or two.

Speyeria egleis is absent from the Oregon Cascade Range north of Deschutes County, but populations of this species do occur eastward in the Ochoco Mountains of Crook County. The latter, however, belong to the Rocky Mountain race *macdunnoughi* (Gunder), which is highly divergent from *moecki* in both size and coloration. The dorsal wing surfaces show a very extensive dark basal suffusion, the ventral disc color is dark black-brown to greenish brown, and the forewing length is 27 to 31 mm in males, 29 to 33 mm in females. Virtually no trace of such *macdunnoughi* influence has been observed in Cascadian *moecki* populations, which suggests that *moecki* is largely derived from the adjacent *oweni* populations of northern California.

The distribution of *S. e. moecki* corresponds very closely with the ash-pumice fields deposited by the eruptions of Mt. Mazama, Mt. Newberry, and the volcanoes of the Three Sisters system. This ash-pumice habitat represents an extremely xeric environment since the volcanic material fails to retain moisture during the summer growing season. As a result the vegetation is dominated by a shrubby forest of lodgepole pine (*Pinus contorta*), with scattered bitterbrush (*Purshia tridentata*) and small tufts of grasses on the forest floor. However, in some areas ground water does come to the surface and produces small creeks, seepages, and wet boggy meadows. A great diversity of herbaceous plants and butterflies are found in these wet areas. *Speyeria egleis* and its larval foodplant, *Viola purpurea* (oviposition observed), are largely confined to the pine forests adjacent to these habitats. Around the upper rim of Crater Lake, however, *S. egleis* and *V. purpurea* occupy open, dry, rocky pumice slopes. *Speyeria mormonia erinna*, by contrast, flies in the wet boggy meadows that support *Viola palustris* and *V. adunca* var. *bellidifolia*, the larval foodplants of this species (oviposition observed).

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For specimens and data we are obligated to the lepidopterists cited in the distribution records. Besides the late Arthur H. Moeck, E. J. Newcomer, and Herman Scullen, these include John Hinchliff, Stan Jewett, John D. Lattin, Edwin and Stephen Perkins, and Oakley Shields.

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CAUSAL ANALYSIS OF A MIGRATION OF THE
SNOUT BUTTERFLY, *LIBYTHEANA BACHMANII LARVATA*
(STRECKER) (LIBYTHEIDAE)

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ABSTRACT. Observation of a massive migration of the snout butterfly, *Libytheana bachmanii larvata* (Strecker), in central Texas in 1971 is described. An association of peak migration periods and periodic precipitation episodes is believed to be causal in nature.

One of the many migratory species of Lepidoptera is the snout butterfly, *Libytheana bachmanii larvata* (Strecker). At irregular intervals great numbers of this species migrate in various directions in south and central Texas. The latest of these large migrations occurred during July-September 1971. One previous report exists for this migration (Helfert, 1972) in which only a portion of the migration is discussed. Helfert initiates his remarks with observations on 22 August 1971 and concludes them on 2 September. Migratory activity was at a peak during this period but occurred both before and after this time.

The purpose of this communication is to supplement the data available on this particular migration and to discuss possible environmental triggers involved in this phenomenon. A hypothetical relationship between snout butterfly population recruitment and periods of substantial rainfall is presented. Personal observations of the 1971 flight will be presented chronologically before analysis.

In order to critically analyze a mass migration of snout butterflies as the one observed in 1971, one must be aware of normal conditions. In central Texas, i.e., the Austin area, snout butterflies are present in low numbers, with adults being active on warm winter days (H. G. Lacey in Kendall & Kendall, 1971). Despite its constant presence, snouts are not apparent to non-lepidopterists, particularly those living in urban areas. In south Texas (area south of San Antonio) snout butterflies are often abundant (though highly scattered spatially and temporally) and quite regularly migrate in large numbers.

Butterflies of the genus *Libytheana* are variable in phenotype; species relationships are still unclear. The populations of central and southern Texas are referred to *Libytheana bachmanii larvata* (Strecker). Howe (1975) indicated that the taxon of the snout butterflies in the Kansas flight (see discussion below) was *Libytheana carinenta mexicana* Michener. This taxon rarely occurs in the United States. Clench (1968) was "not certain that this entity is really distinct from

L. bachmanii larvata (Strecker)." These forms, whatever their true relationship, have been taken flying together (Heitzman & Heitzman, 1972). However, W. D. Field (in litt., 11 May 1976) reports that specimens from the migration collected by Howe in Kansas are not *cari-nenta*. Examination of personal color transparencies taken during the 1971 migration in central Texas reveal that the taxon involved was *larvata*. Ferris (1976) reports that all snout butterflies figured in Howe (1975) are *larvata* and that the verbal descriptions of these two species are reversed.

1971 Observations

As early as 20 July 1971 snout butterflies were very common in Austin. Butterflies were moving individually (similar to migration of 22–25 August reported by Helfert). On 25 July snout butterflies were seen "by the thousands." Many were noted on leaflets of a chinaberry tree (Meliaceae: *Melia azedarach* L.) growing on the bank of Waller Creek on the campus of the University of Texas at Austin. Adults landed on leaflets and appeared to feed from the surface as they unrolled their probosces and moved them over the leaflet surface. On 26 July numerous adults were observed in similar feeding behavior on leaves and stem nodes of bean plants at the Brackenridge Field Laboratory (BFL) of University of Texas at Austin. Possibly nutrients and water (Austin area was still suffering from year-long drought) were obtained by these butterflies. Many snout butterflies were seen as late as 28 July, after which time numbers of snout butterflies declined.

A number of mature larvae of *larvata* were observed at BFL as early as 18 August on Texas sugarberry (Ulmaceae: *Celtis laevigata* Willd.) (see Neck, 1976). On 23 August adults were again noted as abundant (Helfert reports 22–25 August). At this point butterflies were traveling individually (as reported by Helfert) and were most abundantly found feeding at flowers of kidneywood (Leguminosae: *Eysenhardtia texana* Scheele).

An incredibly dense concentration of migrating snout butterflies moving NNE peaked on 27 August. Densities over central urban areas were not as high as observed outlying urban or rural areas. Peak numbers dropped off after 30 August. Helfert reports peak on 26–28 August with last large numbers seen on 2 September. Helfert records no further observations after 2 September, but my notes record "many, many snout butterflies" migrating together on 20 September after an intervening period of low abundance.

Indications are that this flight of snout butterflies traveled north-

TABLE 1. Drought severity in Austin, Texas, 1970-1971.

	Recorded rainfall	Normal rainfall	Accumulated deficiency since November 1970
November 1970	T	2.12	2.12
December	0.11	2.53	4.54
January 1971	0.04	2.35	6.85
February	0.69	2.58	8.74
March	0.79	2.13	10.08
April	1.07	3.55	12.56
May	1.37	2.71	13.90
June	1.68	3.22	15.44
July	1.23	2.18	16.39
August	5.69	1.94	12.64
September	2.13	3.44	13.95
Total	14.80	28.75	—

ward at least to east central Kansas, as Howe (1975:258) reported that "hundreds" of snout butterflies appeared in Franklin County, Kansas, in September and early October 1971 still "flying in a due north-northeast (N22.5°E) direction." Franklin County is about 1100 km north of the Austin area at an approximate direction of N12°E. If one assumes that these were butterflies from the peak migration of late August-early September in central Texas, these butterflies traveled the distance in approximately thirty days for an average daily distance of about 35 km. Daylength at that season is decreasing but is about 12 h. Allowing for low flight activity during the cool crepuscular period, one can assume an 8 h flight day (Helfert, 1972), yielding 4.4 km/h. This speed is certainly exceeded by these butterflies, allowing for sufficient time for energy source location and utilization. Previous reports of speed of migrating snouts have varied from 7.2 to 24 km/h (Gable & Baker, 1922; Parman, 1926; Fletcher, 1926; Clench, 1965).

Associated Weather System and Biotic Responses

In summer 1971, central and southern areas of Texas were experiencing a drought which had begun in late 1970 (see Table 1). Plant growth and insect populations were greatly depressed. Substantial rains occurred in the Border Country (Fig. 1) as early as 1 June (Table 2). However, at this time the central Texas area was still suffering from drought conditions, although rain would soon begin. The entire July rainfall (1.23 inches vs. average 2.18) occurred on and after 24 July. The first six days of August brought 5.23 inches of rain (average for entire month is only 1.94 inches).



FIG. 1. Base map of Texas, showing localities discussed in text. Solid line is Balcones Escarpment Zone; arrow indicates general direction of snout butterfly migration; names refer to weather station locations.

Central Texas was transformed from drought to lush conditions in a very short period of time. Plants put on new growth (up to 1 m branch growth in *C. laevigata*); insect populations increased dramatically. Various bird species, whose nesting had been curtailed by the dry spring and early summer, responded with late nesting attempts (Webster, 1972). Impact of the 1971 drought and heavy rain conditions affected the population dynamics of various lizards (Clark, 1976; Martin, 1977), snakes (Clark, 1974; Clark & Fleet, 1976) and small mammals (Beasom & Moore, 1977).

Rainfall in Austin for the remainder of August totaled 0.45 inches, while September rainfall was sporadic and subnormal (2.13 inches vs. average 3.44). Therefore, plant growth occurred profusely for a brief

TABLE 2. Extensive rainfall (and associated cool temperatures) in central and south Texas in summer 1971 which broke drought of 1970-1971.

Station	Ave. temp.	Departure from normal	Precipitation	Departure from normal	Greatest daily rain total
June 1971					
Central Texas					
Austin	83.7	+1.8	1.68	-1.54	1.40
San Antonio	83.6	+1.7	2.74	-0.21	1.07
Border Country					
Carrizo Springs	84.2	-0.5	13.52	+10.98	3.81
Del Rio	80.1	-4.3	4.87	+2.58	1.03
Eagle Pass	82.0	-3.8	14.71	+12.28	4.85
Encinal 3NW	83.2	-1.4	10.80	+8.42	4.00
July 1971					
Central Texas					
Austin	85.9	+1.4	1.23	-0.95	0.94
San Antonio	85.9	+1.9	1.05	-1.04	1.03
Border Country					
Carrizo Springs	84.2	-2.4	0.17	-1.66	0.13
Del Rio	82.0	-4.2	0.45	-0.86	0.33
Eagle Pass	83.0	-4.6	0.32	-1.72	0.32
Encinal 3NW	83.8	-2.7	0.17	-1.40	0.17
August 1971					
Central Texas					
Austin	81.2	-3.5	5.69	+3.75	1.72
San Antonio	81.2	-2.6	9.42	+7.06	2.38
Border Country					
Carrizo Springs	80.4	-6.1	12.46	+10.15	6.00
Del Rio	78.6	-7.2	6.10	+4.58	2.76
Eagle Pass	79.2	-8.1	7.16	+4.82	1.77
Encinal 3NW	79.8	-6.5	3.62	+1.72	0.95
September 1971					
Central Texas					
Austin	79.3	+0.2	2.13	-1.31	0.74
San Antonio	80.1	-1.5	4.57	+1.08	1.86
Border Country					
Carrizo Springs	80.1	-1.4	—	—	1.21
Del Rio	78.5	-1.4	0.50	-2.11	0.25
Eagle Pass	78.6	-2.8	1.19	-1.31	0.31
Encinal 3NW	77.4	-3.9	9.90	+7.09	4.50

period in early August but was terminated by a return to dry conditions.

DISCUSSION

Study of published reports of previous snout migrations and contemporary weather systemics reveals that climatic conditions of cen-

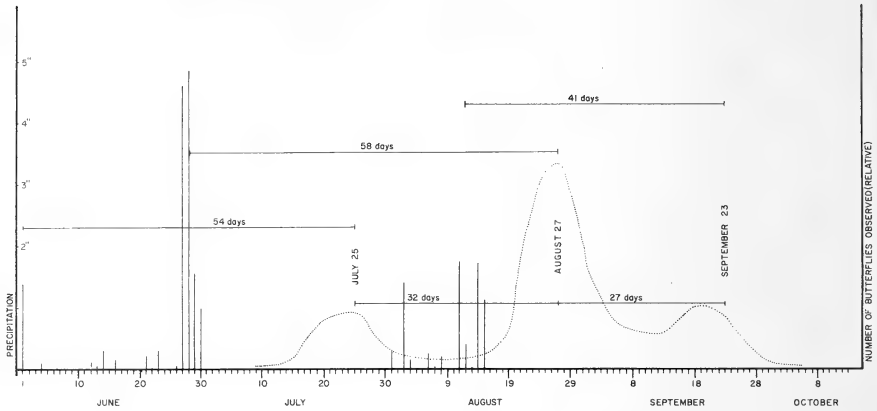


FIG. 2. Time relationship between rainfall at Eagle Pass and snout butterfly migration at Austin. Abscissa = relative butterfly numbers; Ordinate = calendar.

tral and south Texas are the key to snout butterfly migrations (Neck, unpubl.). The initial low-density migration in late July (not observed by Helfert) probably involved adults from south Texas which developed subsequent to the initial rains in the Border Country. Upon migrating to central Texas (under drought conditions) flights of these first generation butterflies were not joined by central Texas snout butterflies (which occurred in very low numbers at that time). Additionally, stimuli which evoke massive synchronized migration were lacking; adults moved more or less individually. Eggs were laid by these south Texas butterflies on central Texas *Celtis*; larvae from these eggs faced conditions favoring rapid population growth (abundant new plant growth and depressed populations of natural control agents). Adults of this second generation formed the massive migrations seen in late August in Austin (note mature larvae found in mid-August at Austin). The smaller-scale migration seen in mid-September apparently involved adults of a third generation. The reason for its smaller size was probably two-fold: 1) reduced amount of new plant growth; and 2) increased population levels of natural control agents.

Helfert (1972) suggests that central Texas is a major breeding ground of *larvata*. Breeding occurred in moderate numbers in 1971 in central Texas, but such conditions are unusual. Normally, *larvata* occurs at low population levels in central Texas. The largest breeding ground for this species is south Texas and adjacent parts of northeastern Mexico where its favored larval foodplant (Kendall and Glick, 1972), spiny

hackberry (*Celtis pallida* Ten.), is very abundant. Dorothy Yeager (pers. comm., 20 Feb. 1976) reported that during September and October hackberry trees within a 4-km radius of Pearsall, Frio County, were "almost completely denuded of leaves." This observation also indicates that the Border Country area is the breeding grounds for a great number of the snout butterflies of this migration.

Occurrence of associated major and minor migrations of the snout butterfly has apparently not been reported previously. Temporal separation of occurrence of drought-breaking rains in south and central Texas may have caused the occurrence of these major and minor migrations. Normally, such drought-breaking rains occur in these areas concurrently. The temporal relationship between the drought-breaking rains and the snout butterfly migrations is shown in Fig. 2.

QUESTIONS RAISED

A series of questions has been raised by analysis of this snout butterfly migration. Tentative answers are here given to these questions. Study of future migrations will shed light on the validity of these answers.

1) Would the late July (first minor) migration have been a larger migration if rains had occurred in central Texas in late June?

Not likely; two generations of favorable breeding conditions are probably required to produce such a tremendous build-up of numbers of individuals. The central Texas area was not the source of these butterflies except for a contribution of unknown importance to the late August (major) migration.

2) Would the migration of late August (major) have occurred if rains had not returned to the Border Country area in late July and early August?

Yes, although possibly on a smaller scale; these butterflies originated as the second generation from the Border Country of Texas and Mexico as a result of the June rains. Rainfall in late July in the Border Country was relatively minor. One possible result of the absence of these later rains would have been the diminution of this major migration.

3) Would the late September (second minor) migration have been a major migration if rain had continued through September?

Probably not; by this time natural control agents had presumably increased in population size sufficiently to have a dampening effect upon population levels of the snout butterfly. One should also consider the possibility that many of these butterflies may have originated in central Texas.

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LEPIDOPTERA ASSOCIATED WITH WESTERN SPRUCE BUDWORM IN THE SOUTHWESTERN UNITED STATES

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ABSTRACT. Western spruce budworm, *Choristoneura occidentalis* Freeman (Tortricidae), is an important pest of Douglas-fir and white fir in the southwestern United States. A variety of other Lepidoptera, several previously unrecognized from this part of the country, commonly occupy similar feeding niches as larvae. Included are species of Geometridae, Gelechiidae, Noctuidae, Plutellidae, Pyralidae, and Tortricidae. Notes are presented on species' life history, and field identifying features in late larval and adult stages.

Western spruce budworm, *Choristoneura occidentalis* Freeman, is an important defoliator of Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, and true firs, *Abies* spp., throughout western North America. It also feeds on spruces, *Picea* spp., and western larch, *Larix occidentalis* Nutt. (Furniss & Carolin, 1977). The budworm is a common pest of Douglas-fir and white fir, *A. concolor* (Gord. & Glend.) Lindl. ex Hildebr., and is currently in outbreak status in northern Arizona (Kaibab Plateau, Coconino County), in northern New Mexico (Jemez and Sangre de Cristo Mountains, Sandoval and Taos Counties, respectively), and in Colorado (mainly in the Front Range of the Rocky Mountains—Larimer, Boulder, Jefferson, Teller, Fremont and Custer Counties).

A variety of other Lepidoptera coexist with the budworm, occupying similar feeding niches in the larval stage. These associates have been little known in this part of the country. The main objective here is to summarize this information for other workers, so that with already available keys to larvae (Carolin & Stevens, 1979, 1981), they can identify common budworm associates and have information about each species' life history and habits.

Other Lepidoptera may sometimes occur in sufficient numbers to also qualify as budworm associates. However, the ones discussed here are present more or less regularly, and are considered to be the

¹ Headquarters is in Fort Collins, in cooperation with Colorado State University.

common set of associates in the area. Table 1 lists these species. All probably have the ability to colonize both main budworm hosts, *Abies* and *Pseudotsuga*.

Larvae of other insect groups, including Xyelidae, Diprionidae, and Pamphiliidae (Hymenoptera), are sometimes found feeding on foliage along with budworms. These are readily separable from Lepidoptera larvae, however, and are not considered here. Also excluded is the Douglas-fir tussock moth, *Orgyia pseudotsugata* (McDunnough); although sometimes common on the same hosts, the tussock moth occupies a different feeding niche and is not usually a budworm associate.

Some of the species discussed here are well-known forest insects and have been studied elsewhere in North America. For these, pertinent information is summarized to help in field identification and an understanding of life histories as the insects relate to western spruce budworm. In several cases little is known about the species' life history and habits, and in some of these new information is presented. Incorporated also are pertinent and previously unpublished observations made by Carolin in the Pacific Northwest.

Voucher specimens are kept in the insect museum at the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Gelechiidae

Chionodes abella (Bsk.)

C. abella (Fig. 1a) is a rare species reared from white fir in the Jemez Mountains. A small (wingspan 15 mm), strikingly-patterned moth, *C. abella* is not likely to be confused with any of the other common budworm associates. The larva is mostly greenish-brown, with a tan head capsule. The thoracic legs and posterior part of the first thoracic segment are black. Details of its life history and habits are unknown.

Coleotechnites sp.

The genus *Coleotechnites* includes several well-known forest pests (e.g., the needle miners *C. milleri* (Busck) and *C. starki* (Freeman)), (Furniss & Carolin, 1978), as well as several undescribed species (R. W. Hodges, pers. comm., 1981). One or more of the latter are budworm associates, found extensively throughout the western United States. The moths (Fig. 1b) are small (wingspan 10–12 mm), and mostly black and white. We have a few specimens from the Jemez Mountains.

TABLE 1. Lepidoptera associated with western spruce budworm in the southwestern United States.

Family	Species
Gelechiidae	<i>Chionodes abella</i> (Busck) <i>Coleotechnites</i> sp.
Geometridae	<i>Enypia griseata</i> Grossbeck <i>Eupithecia catalinata</i> McDunnough
Noctuidae	<i>Achytonix epipaschia</i> (Grote) <i>Syngrapha angulidens</i> Smith <i>Egira</i> (= <i>Xylomyges</i>) <i>simplex</i> (Walker)
Plutellidae	<i>Ypsolophus nella</i> (Busck)
Pyralidae	<i>Dioryctria</i> spp.
Tortricidae	<i>Acleris gloverana</i> (Walsingham) <i>Argyrotaenia dorsalana</i> (Dyar) <i>Argyrotaenia klotsi</i> Obraztsov <i>Argyrotaenia provana</i> Kearfott <i>Clepsis persicana</i> (Fitch) <i>Griselda radicana</i> (Heinrich) <i>Zeiraphera hesperiana</i> Mutuura & Freeman

Geometridae

Enypia spp.

Although they never appear to occur in large numbers, loopers of the genus *Enypia* are widely distributed budworm associates on both *Abies* and *Pseudotsuga*. Evans (1960) indicates that *E. griseata* Grossbeck and *E. venata* (Grote) are found in the Southwest; we have occasionally reared *griseata*. Adults of both species are large (wing-span 35–39 mm) gray moths, and are difficult to tell apart by non-specialists. *E. griseata* is shown in Fig. 1c. Eggs of both species are ivory colored when first laid. They are laid on needles, singly or occasionally in pairs. According to Evans (1960), the larvae are solitary and constitute the overwintering stage, and fully-developed larvae of the two species differ as follows:

E. griseata

Head pale green-brown.
Body green dorsally; venter paler green.
Narrow pale-green dorsal line; wide near-white sub-dorsal stripes.

E. venata

Head brown, irregularly patterned.
Body pale golden brown dorsally; overall pattern of broken dark irregular lines; posterior parts of segments darker than anterior portions, darker reddish-brown irregular dorsal stripe.

Pupation is on the foliage, in a loosely-constructed cocoon.

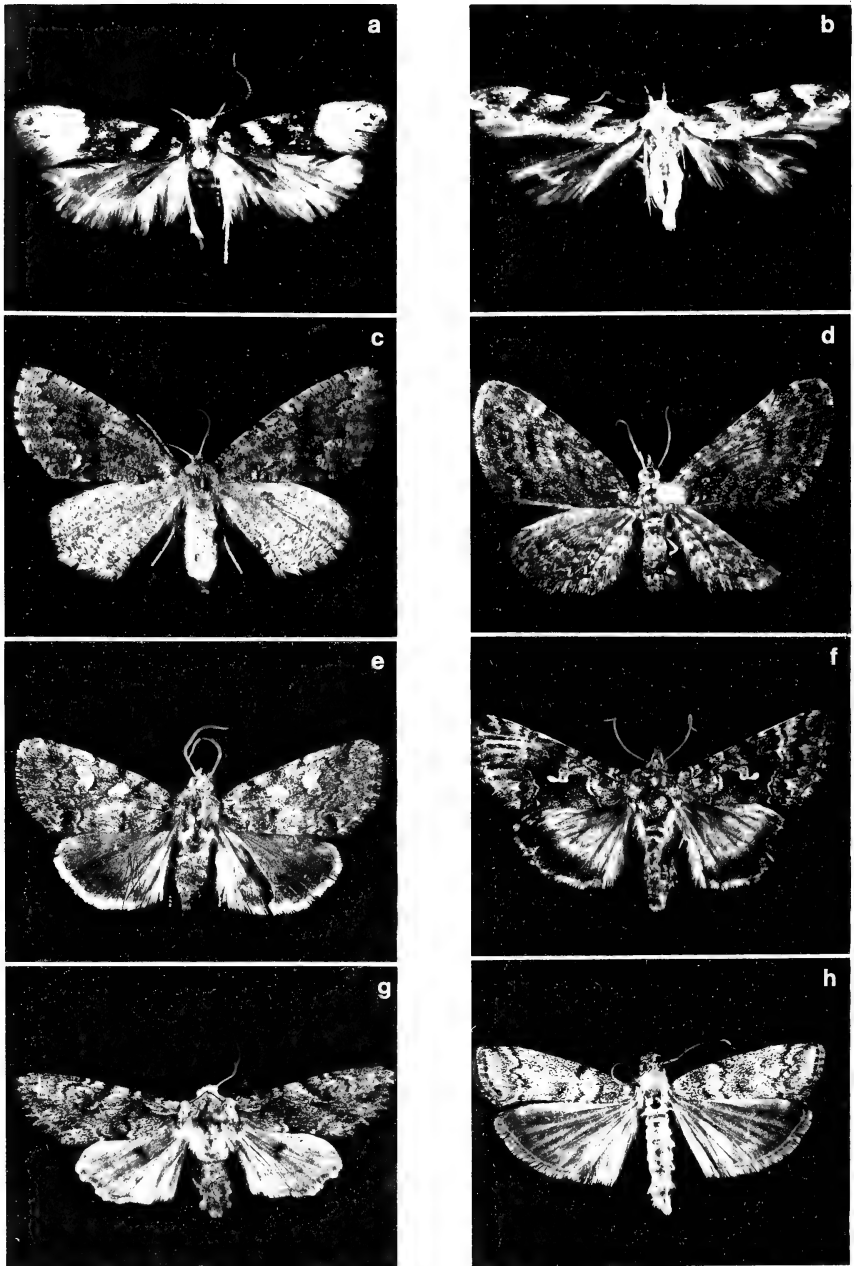
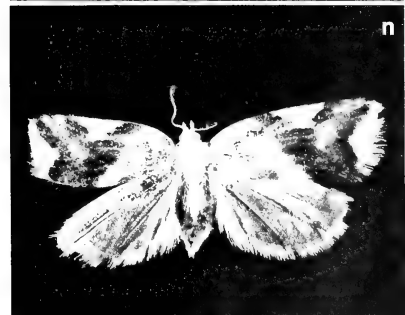
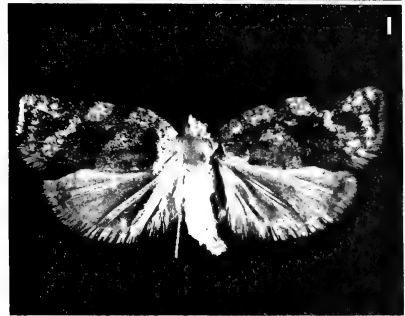
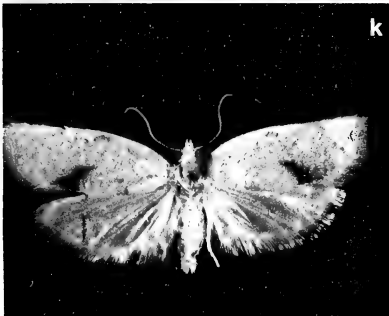


FIG. 1. Budworm associate adults: **a**, *Chionodes abella*; **b**, *Coleotechnites* sp.; **c**, *Enypia griseata*; **d**, *Eupithecia catalinata*; **e**, *Achytonix epipaschia*; **f**, *Syngrapha angulidens*; **g**, *Egira simplex*; **h**, *Dioryctria* sp.; **i**, **j**, *Ypsolophus nella*; **k**, *Argyro-*



taenia dorsilana; **l**, *A. klotsi*; **m**, *A. provana*; **n**, *Clepsis persicana*; **o**, *Griselda radicans*; **p**, *Zeiraphera hesperiana*.

Eupithecia catalinata McD.

E. catalinata is a little-known species of looper not previously recognized as a budworm associate. However, many members of the genus feed on coniferous foliage (McGuffin, 1958), and one, *E. annulata* (Hulst), is a recognized budworm associate on the West Coast (Carolin, 1980). The adults (Fig. 1d) are small (wingspan 20–22 mm) gray moths with indistinctly marked wings.

Noctuidae

Achytonix epipaschia (Grote)

A. epipaschia has been reared in small numbers from the Jemez Mountains. Carolin (1980) considers it a "sporadic" and "occasional" budworm associate in the Pacific Northwest. The distinctively marked gray moths (Fig. 1e) have a wingspan of 25–30 mm. They fly about the same time as does the budworm, and the two species have somewhat similar life histories; both overwinter as small larvae and pupate on the shoots where they have been feeding. Early instars of *Achytonix* also resemble those of budworm. However, in late instars, the green abdomen, conspicuous black setal bases, and three broad longitudinal lines on the dorsum make *Achytonix* readily identifiable.

Syngrapha angulidens (Smith)

S. angulidens (Fig. 1f), a large (32–34 mm wingspan), distinctively-marked noctuid, is another relatively uncommon budworm associate in the Southwest. Little is known of its life history and habits, but Eichlin & Cunningham (1978) indicate that eggs are deposited singly and larvae overwinter. Larvae of Noctuidae possess varying numbers (3–5 pairs) of abdominal prolegs. Some with three pairs move like geometrids; *S. angulidens* is one of these.

Egira simplex (Wlk.)

E. simplex is widely distributed throughout the West (Furniss & Carolin, 1977) and is an occasional budworm associate in the Southwest. Its life history is much like that of the budworm, except that *E. simplex* overwinters as a pupa in the soil. The adult (Fig. 1g) is a large (38–40 mm wingspan) gray moth. Fully developed larvae are up to 35 mm long, green with white longitudinal dorsal and sub-dorsal lines, and shiny black head capsules and dorsal and anal shields.

Plutellidae

Ypsolophus nella (Bsk.)

The life history and habits of *Y.* (= *Abebaea*) *nella* have not previously been described. However, records on file in the insect museum



FIG. 2. White fir needles tied into "tents" by larvae of *Ypsolophus nella*.

at the Rocky Mountain Forest and Range Experiment Station indicate that the species is common on *Abies concolor* throughout Colorado and New Mexico. It has been a consistent budworm associate on white fir in our recent collections. Carolin (1980) reported *Y. prob. cervella* (Walsingham) as a rarely collected associate on Douglas-fir in western Oregon in the 1950's.

Adults and larvae of *Y. nella* are highly distinctive. The adult (Figs. 1i, j) is a small (wingspan 20–21 mm) moth, with gray abdomen and hindwings, and narrow brown forewings ornamented by longitudinal lines made up of black and white scales. The amount of black on the wings varies and may be totally lacking in some individuals.

Fully developed larvae, about 15 mm long, are generally purplish to pale green, with two narrow and one broad yellowish-green longitudinal lines on each side of the dorsal midline. Black setae and

setal bases also constitute distinctive recognition characters. The larvae are particularly active and capable of unusually rapid movement when disturbed.

The character of larval feeding is also distinctive. The ends of the needles are webbed together soon after their emergence from the bud. As the needles elongate, their central parts diverge, creating an expanding "tent" (Fig. 2) within which the larva feeds. Pupation occurs in the foliage in a loosely constructed cocoon. Summer larval and pupal periods approximate that of the budworm; eggs have not been seen nor is the overwintering stage known.

Pyralidae

Dioryctria spp.

The spruce coneworm, *D. reniculelloides* Mutuura & Munroe, has long been recognized as a budworm associate, sometimes occurring in great numbers. Carolin (1980) reported as many as 158 *Dioryctria* larvae per 100 buds in a 1957 sample plot in central Oregon. Both it and insects identified as *D. pseudotsugella* Munroe are commonly reared along with budworms in the Southwest. The two *Dioryctria* species are difficult for the non-specialist to separate either as larvae or adults; for the purposes of this article *Dioryctria* associates are considered a single entity.

Moths have gray forewings with distinctive transverse bands (Fig. 1h), and are not likely to be confused with any of the other budworm associates. Although we have reared adults with wingspans as small as about 15 mm, most specimens are larger, 20–25 mm. Larvae are also distinctive; the dorsum of well-developed individuals is generally pinkish to reddish-brown, with broad, irregular white and black lines on either side of the dorsal midline. The pupa is dark brown to black and is found in the foliage. In general, the life history parallels that of the budworm; however, *Dioryctria* may pupate slightly later.

Tortricidae

Acleris gloverana (Wlshm.)

A. gloverana, the western blackheaded budworm, has not previously been known from the southwestern United States; however, it has been fairly common in Jemez Mountains rearings of budworm associates. *A. gloverana* is a serious forest pest in British Columbia and southeast Alaska (Furniss & Carolin, 1977), and its life history and habits have been thoroughly studied in that region. Also, Powell (1962) provides a detailed discussion of it.

Adults, wingspan 18–22 mm, display a bewildering variety of fore-

wing markings, making identification difficult for the inexperienced observer. Furniss & Carolin (1977) show three of the more common morphs. In general, the moth is dark colored; the forewings are variously marked with brown, white, yellow, and orange. Small larvae have black head capsules and prothoracic shields, and lemon-yellow bodies. The latter instars have chestnut-brown head capsules and grass-green bodies.

The life cycle and habits are similar to those of the western spruce budworm; however, *A. gloverana* eggs are laid singly on needles, and the egg overwinters. On the West Coast, *Acleris* adults emerge 2–3 weeks later than spruce budworms.

Argyrotaenia spp.

According to Hodges (in litt.), the genus *Argyrotaenia* includes 34 North American species. Of these, *A. dorsalana* (Dyar), *A. klotsi* Obr., and *A. provana* Kearf. are budworm associates. All are found regularly in the Southwest. These species are sufficiently similar in most respects to justify treating them together.

Except for *A. dorsalana*, details of their life histories are essentially unknown; however, they are probably all similar. Eggs of *A. dorsalana* are laid in overlapping rows on needles, much as in the case of the budworm. The eggs are slightly smaller and are finer-textured than those of budworm, and the egg mass usually has an orange-pink tint. The small larva overwinters. Larval feeding is also similar to that of budworm; pupation is in the foliage, slightly earlier than budworm.

Larvae of all species are generally green. The moths, while differently marked, are all about the same size, wingspan 20–25 mm. *A. dorsalana* is generally the most common member of the genus as a budworm associate in the Southwest. Forewings of the adult (Fig. 1k) are largely straw-yellow but exhibit a variety of brown markings. The most common form is nearly pure yellow with a small marking on the posterior margin. Some have no marks at all; others are heavily patterned.

The forewings of *A. klotsi* and *A. provana* (Figs. 1l, m) are gray-black, with distinctive white (*provana*) or yellow (*klotsi*) bands and patches. Adults of these species appear to show much less morphological variation than do those of *A. dorsalana*.

Clepsis persicana (Fitch)

C. persicana (Fig. 1n) is a striking species we reared only once from the Jemez Mountains. The forewings (wingspan 18 mm) of the adult are orange to ochreous-orange basally, having a dark gray "V"-shaped section distally and white patches on the anterior margin and apex of

the wingtip. The hindwings are gray dorsally and white ventrally. Fully developed larvae are about 12–15 mm long and generally green; the head capsule is green with a brownish tint; prothoracic and anal shields are emerald-green; the dorsum is dark olive-green with two whitish longitudinal lines and whitish setal areas. The venter is lighter green. Feeding habits are similar to that of budworm.

Powell (1964) indicates that *C. persicana* utilizes a variety of food plants other than conifers; however, he also has more recently reared it as a budworm associate in California (J. A. Powell, unpublished data). Carolin reared it once from the Blue Mountains in northeastern Oregon and several times from *Abies balsamea* L. in Maine.

Griselda radicana (Heinr.)

G. radicana, the spruce tip moth, is another common budworm associate not previously known to occur in the Southwest. We reared several specimens from the Jemez Mountains, and presumably the species occurs much more generally. *G. radicana* is a small moth, wingspan 12–16 mm, having gray forewings with distinctive rusty-colored basal sections (Fig. 1o). Young larvae are pale yellow overall. Later instars have the dorsum marked with three orange-brown to orange-red lines; fully developed larvae undergo a quiescent prepupal period, during which the abdomen becomes whitish and the lines disappear. Adult emergence is in late summer. Eggs, laid singly at the bases of needles, overwinter. Larval feeding is similar to that of budworm.

Zeiraphera hesperiana M. & F.

Z. hesperiana, commonly known as the Douglas-fir bud moth, is well known as a budworm associate. However, it has not previously been reported from the Southwest, and the only published information on its life history is a brief mention by Carolin (1980). Mutuura & Freeman (1966) described the species from British Columbia; Furniss & Carolin (1977) also record it from Oregon. We have specimens from Idaho and Montana, and from the Jemez and Sangre de Cristo ranges in New Mexico. Thus the species appears to have a wide distribution. The following notes on life history and habits are largely from Carolin's observations in Oregon. Stein and Stevens have noted similar habits in New Mexico.

The adult (Fig. 1p) is a distinctly marked, generally dark moth, wingspan 15–20 mm. At rest it is readily separable from moths of other common budworm associates by the presence of a prominent saddle-like white to brownish-white patch located centrally on the forewings. The forewings are otherwise marked with characteristic patches made

up of black, cream, brown, and orange-brown scales. Eggs overwinter. They are yellow, spiny, and laid singly on bark of limbs, 50 cm or more back from branch tips. In spring, new larvae enter buds and feed therein, concealed until the buds open. Feeding becomes visible as shoots develop. Fully developed larvae are 12–15 mm long and generally stout in form. The head capsule and prothoracic shield are golden to chestnut-brown; the abdomen is generally yellowish, with a broad, olive-brown to chocolate-brown dorsal stripe. The prothoracic shield usually has a characteristic black posterior margin. Larvae leave the feeding area to pupate in the soil or duff layer, well before the time of budworm pupation.

ACKNOWLEDGMENTS

The authors thank Pamela Farrar for assistance in the field in 1979, and S. A. Mata for taking the photos. J. A. Powell, University of California, Berkeley, T. D. Eichlin, California Department of Food and Agriculture, Sacramento, D. C. Ferguson and R. W. Hodges, Systematic Entomology Laboratory, USDA, Washington, D.C., and A. Mutuura, Canada Department of Agriculture, Ottawa, kindly identified specimens. W. E. Waters, and W. J. A. Volney and associates, University of California, Berkeley, and M. J. Stelzer, Pacific Northwest Forest Experiment Station, Corvallis, Oregon provided very helpful study material from their rearings in New Mexico and Arizona, respectively. The material reported here was developed with partial support from the Canada–United States Spruce Budworms Program (CANUSA).

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TWO NEW SPECIES OF THE TRIBE EUCOSMINI
(TORTRICIDAE) CLOSELY RELATED TO
PHANETA GRANULATANA (KEARFOTT)

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ABSTRACT. *Phaneta linitipunctana* and *Phaneta argutipunctana* are described and imagines and male and female genitalia are figured. *Phaneta granulata* imagines and genitalia are also figured.

***Phaneta linitipunctana*, new species**

(Figs. 1-7)

Head. Front and vertex light ochreous. Labial palpi exceeding front by $2\frac{1}{2}$ eye diameters, light ochreous, with brushlike 2nd segment obscuring blackish 3rd segment. Antennae simple, light ochreous.

Thorax. Light ochreous with fulvous spots on patagia and mesonotum.

Forewing (Figs. 1-4). Ground color light ochreous with extensive fulvous maculation, which, in well marked examples shows a tendency to form vertical rows. On the basal third, extending from dorsum to $\frac{2}{3}$ the distance to costa, the fulvous markings are heavier, forming an ill-defined patch, the outer margin of which is angled slightly outward from dorsum. A narrow streak of ground color extends along the fold, interrupting the fulvous maculation. Ocelloid patch with central area lighter than ground, with a pearly luster, and bearing a weak scattering of black scales, tending to form three horizontal dashes. Along upper margin of ocelloid patch is a small elongate patch composed of small flat, white tipped brown scales. Fringe consists of two bands, the inner band fairly broad and composed of scales having a whitish base and tip with a dark brown center; the outer band is ochreous.

Hindwing. Light fuscous. Fringe with fuscous inner band and ochreous outer band.

Length of forewing. Males ($n = 12$): 6.6-8.3 mm, average 7.3 mm. Females ($n = 9$): 7.3-8.7 mm, average 8.0 mm.

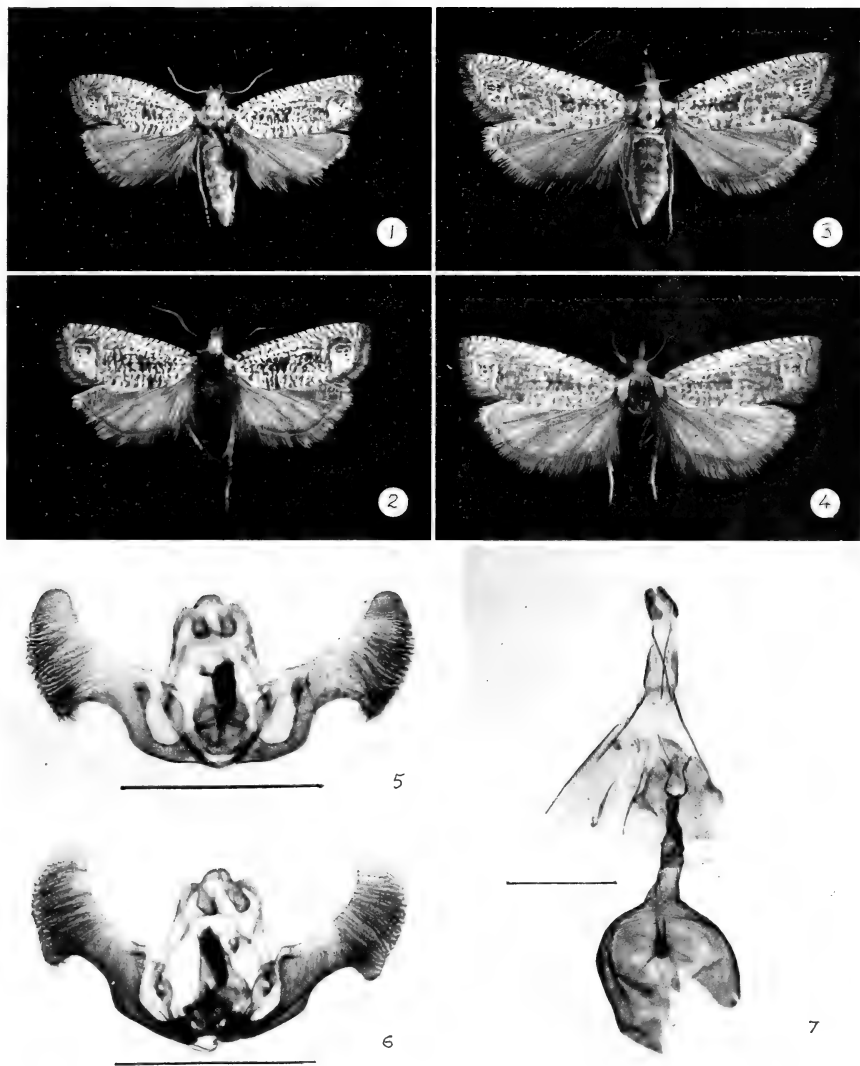
Venation. Hindwing: M3 and Cu1 stalked for $\frac{1}{3}$ the length of Cu1. Rs and M1 approximate for $\frac{1}{4}$ the length of M1.

Male genitalia. As in Figs. 5 and 6.

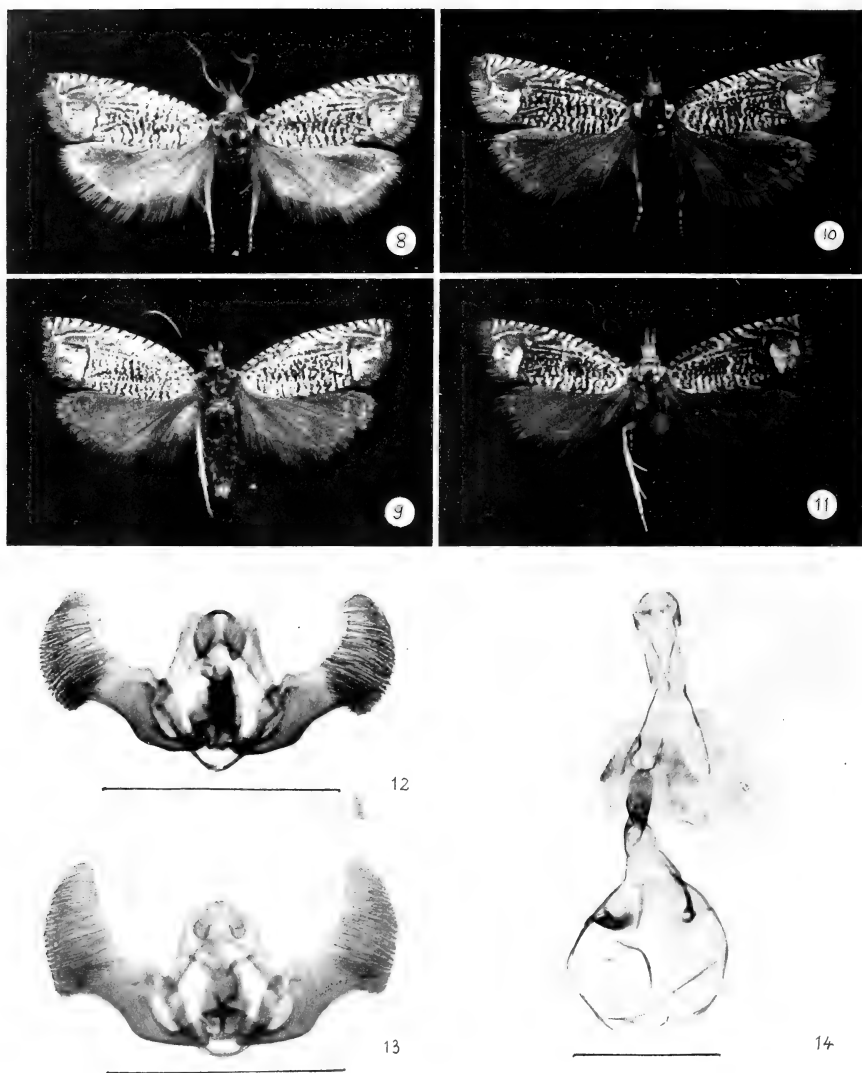
Female genitalia. As in Fig. 7.

Holotype. Male, Nueces Co., Texas, North Padre Island, 9-IX-74, slide A.B. 4342, collected by A. & M. E. Blanchard and deposited in the National Museum of Natural History.

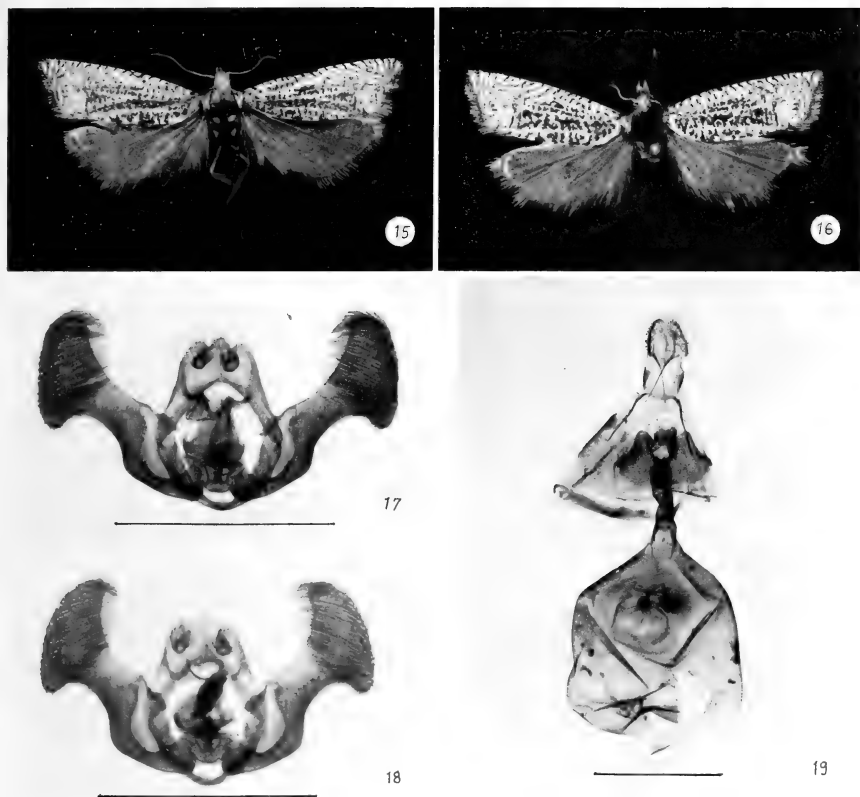
Paratypes. Hemphill Co., Texas, Canadian, 13-VIII-71, 2 males (slides A.B. 2905, 2844), 2 females (slide A.B. 4999), 15-VIII-71, 3 females (slides A.B. 2845, 4344, 5053); Nueces Co., Texas, North Padre Island, 9-IX-74, 3 males (slide A.B. 4343), 29-IX-75, 1 male, 17-VIII-76, 1 male (slide A.B. 4306), 24-IX-79, 2 males (slide A.B. 5028), all collected by A. & M. E. Blanchard; Nueces Co., Texas, North Padre Island, 12-X-79, 2 males (slides ECK 197, 199), 1 female; Cameron Co., Texas, 10 miles west of Brownsville, 13-X-79, 1 female, all collected by E. C. Knudson.



FIGS. 1-7. *Phaneta linitipunctana*: **1**, paratype male, North Padre Island, Nueces Co., Texas, 9-IX-74; **2**, holotype male, same data, slide A.B. 4342; **3**, paratype female, Canadian, Hemphill Co., Texas, 13-VIII-71; **4**, paratype female, same locality, 15-VIII-71, slide A.B. 4344 (all four adults same scale); **5**, male genitalia of holotype, slide A.B. 4342; **6**, male genitalia of paratype, slide A.B. 4306, North Padre Island, Nueces Co., Texas, 17-VIII-76; **7**, female genitalia of paratype, slide A.B. 5053, Canadian, Hemphill Co., Texas, 15-VIII-71. The segments in Figs. 5-7 equal 1 mm.



FIGS. 8-14. *Phaneta argutipunctana*: **8**, holotype male, Canadian, Hemphill Co., Texas, 15-VIII-71, slide A.B. 2846; **9**, paratype male, Padre Island Nat. Seashore, Kleberg Co., Texas, 13-X-79; **10**, paratype female, same data as holotype, slide A.B. 5000; **11**, paratype female, Camp Strake, Montgomery Co., Texas, 14-IX-77, slide A.B. 4997 (all four adults same scale); **12**, male genitalia of holotype, slide A.B. 2846; **13**, male genitalia of paratype, slide ECK 198, North Padre Island, Nueces Co., Texas, 12-X-79; **14**, female genitalia of paratype, slide A.B. 4997, same data as Fig. 11. The segments in Figs. 12-14 equal 1 mm.



FIGS. 15-19. *Phaneta granulata*: **15**, cotype male, Oslar, Denver, Colo., slide USNM 25200; **16**, cotype female, Colo., 2298, slide USNM 25201; **17**, male genitalia of cotype, slide USNM 25200, same data as Fig. 15; **18**, male genitalia of cotype, slide USNM 25202, Oslar, Denver, Colo.; **19**, female genitalia of cotype, slide USNM 25203, Oslar, Platte Canon, Colo. The segments in Figs. 17-19 equal 1 mm.

Phaneta argutipunctana, new species

(Figs. 8-14)

Head. Front and vertex whitish with some brownish tipped scales on vertex. Labial palpi exceeding front by three eye diameters, whitish ochreous with some grayish scales on 2nd segment. 3rd segment blackish, usually hidden by 2nd. Antennae simple, whitish, with prominent black scaling on inner surface of scape.

Thorax. Patagia and mesonotum whitish with dark brown central patches.

Forewing (Figs. 8-11). Ground color whitish with pearly luster. Maculation consists of strongly contrasted black to dark brown scales generally arranged in evenly spaced, interrupted, vertical rows, except on outer third, where there is a tendency to form longitudinal rows which extend basad from the upper and lower outer margins of the ocelloid patch. Ocelloid patch ochreous with three weak black dashes near center. Along inner margin of ocelloid patch is a short vertical black line. Above ocelloid patch

and indenting it along the lower portion of the outer margin are patches of small, flat, white tipped brown scales. Fringe consists of two bands; the inner band composed of dark brown scales with whitish base and tips, the outer band ochreous. The outer band stops short of the extreme apex, where it is replaced by the bicolored scales of the inner band. Termen is slightly concave.

Hindwing. Light fuscous. Fringe darker fuscous inwardly, whitish outwardly.

Length of forewing. Males ($n = 18$): 4.7–6.4 mm, average 5.7 mm. Females ($n = 14$): 5.2–7.0 mm, average 6.1 mm.

Venation. Hindwing: M3 and Cu1 stalked for $\frac{1}{3}$ the length of Cu1. Rs and M1 approximate for $\frac{1}{4}$ the length of M1.

Male genitalia. As in Figs. 12 and 13.

Female genitalia. As in Fig. 14.

Holotype. Male, Hemphill Co., Texas, Canadian, 15-VIII-71, slide A.B. 2846, collected by A. & M. E. Blanchard and deposited in the National Museum of Natural History.

Paratypes. Hemphill Co., Texas, Canadian, 15-VIII-71, 2 females (slides A.B. 4998, 5000); Nueces Co., Texas, North Padre Island, 30-IX-75, 2 males; Kleberg Co., Texas, Padre Island National Seashore, 13-X-79, 3 males, 2 females (slide A.B. 4996); Montgomery Co., Texas, Camp Strake, Conroe, 7-IX-77, 1 male, 1 female, 14-X-77, 5 males (slides A.B. 4257, 5026), 3 females (slide A.B. 4997); Anderson Co., Texas, Tennessee Colony, 27-VIII-78, 1 male (slide A.B. 5027), all collected by A. & M. E. Blanchard; Nueces Co., Texas, North Padre Island, 1-X-77, 1 female, 12-X-79, 6 males (slide ECK 198), 4 females (slides ECK 196, 200); Cameron Co., Texas, Laguna Atascosa NWR, 13-X-79, 1 female, all collected by E. C. Knudson.

Discussion

These two new species are extremely close to *Phaneta granulata* (Kearfott) (Figs. 15–19) but are separable by characteristics of the imagines and male genitalia. *P. argutipunctana* can be easily diagnosed by the presence of black scaling on the scape, lacking in the other two species. In *granulata* the ground color of the forewing is whitish yellow with maculation consisting of patches of dark brown scales, which tend to be more irregular and not arranged in vertical rows as in *argutipunctana*. The heavier maculation on the basal third of the forewing of *linitipunctana*, which tends to form an angulate basal patch, is lacking in the other two species. In *granulata* the ocelloid patch is poorly defined, due mainly to the absence of the patch of small, flat, white tipped, brown scales above the ocelloid patch, which is found in the other two species. *P. granulata* and *linitipunctana* are the same in average length of forewing; whereas, *argutipunctana* is significantly smaller. The male genitalia of all three species are very similar, but in *argutipunctana* the neck of the valva is broader with a shallower ventral excavation. In *granulata* the uncus tends to be narrower and more compact than in the other two species.

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GENERAL NOTE

OVERWINTERING AGGREGATIONS OF HACKBERRY CATERPILLARS (*ASTEROCAMPA CLYTON*: NYMPHALIDAE)

Hackberry caterpillars (*Asterocampa* spp. Roeder: Nymphalidae) overwinter as mid-instars, presumably in fallen leaves and crevices of bark (Scudder, 1893, Guide to the Commoner Butterflies, Holt, New York). In the fall of 1981 in Gainesville (Alachua Co.), Florida, the preparatory overwintering behavior of *Asterocampa clyton* Boisduval and Leconte was observed. After molting in mid- to late October, the greenish caterpillars moved up to several meters from the molting site to the ends of branches of their host plant, hackberry (*Celtis laevigata* Willdenow). Each group of caterpillars effectively tied a leaf to its branch by repeatedly laying silk over the junction of the branch and leaf petiole. Some groups tied the sides of the leaf together. Eventually the leaf curled and dried around the caterpillars. By late fall most of the leaves still on the trees were those tied by the caterpillars. Occasionally, the aggregation of caterpillars split and, consequently, two or more leaves at the end of a branch were tied, each leaf sheltering some caterpillars. By this time the caterpillars were pinkish-brown, blending with the dead leaves.

To determine the mean number of larvae per overwintering group, 20 groups were collected in December (just after leaf abscission) and 21 groups in late February (just prior to budbreak). Group size was not significantly different ($\bar{x} = 8.7$ larvae ± 1.9 S.E. in December and $\bar{x} = 10.1 \pm 2.7$ S.E. in February; Mann-Whitney *U* test, $P > 0.20$). Similar group size early and late in the overwintering period suggests that probably few individuals were lost from an aggregation during that period.

To determine the effectiveness of tying leaves to the trees for overwintering sites, larval groups were marked in December by attaching numbered, plastic bird bands to the branches. Of 71 groups, 16% were recovered in late February, each with more than half of the leaf and caterpillars present. Fourteen percent of the markers had less than half of a leaf and 70% of the markers had no leaf. None of these had caterpillars. This supports the idea that disappearance from the branches was a larval group event rather than an individual event.

Thus, it appears that hackberry caterpillars overwintered within leaves tied to branch tips on their host plants when more than half of the leaf remained intact and tied to the branch. Tied leaves and aggregations of caterpillars missing from the trees may be a result of avian predation or weather, causing deterioration or detachment of the leaves.

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THE IDENTITY OF TWO MONOTYPIC GEOMETRID GENERA WRONGLY ATTRIBUTED TO THE NEARCTIC FAUNA (GEOMETRIDAE)

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ABSTRACT. *Apolema carata* (Hulst) and *Nyctiphanta laetula* Hulst were described from North America in error. *A. carata* is a synonym of *Pseudopanthera ennomosaria* (Walker) [Asia], and *N. laetula* is a synonym of *Aspitates ochrearia* (Rossi) [Europe]. *Apolema* Hulst and *Nyctiphanta* Hulst are monotypic genera and junior synonyms of *Pseudopanthera* Hübner and *Aspitates* Treitschke respectively.

Apolema carata (Hulst), described from Florida, and *Nyctiphanta laetula* Hulst, described from Arizona, have been consecutively listed in all check lists covering North American Geometridae from the time the two generic names were proposed (Hulst, 1896:336) to the McDunnough check list (1938:168). *Apolema carata* was listed for Florida by Kimball (1965:186); both genera were listed most recently by Fletcher (1979:18, 142). I identified *A. carata* in time to eliminate it from the new Check List of the Lepidoptera of America North of Mexico (Hodges et al., in press), but not so with *N. laetula*, which was left at the end of the tribe Lithinini, following earlier authors. No previous author satisfactorily associated the unique type of either species with any known North American geometrid, not surprisingly inasmuch as both have proven to be exotic. Through the kind cooperation of Dr. Frederick H. Rindge of the American Museum of Natural History, I was able to borrow the types and identify them.

The holotype of *Apolema carata* is a specimen of *Pseudopanthera ennomosaria* (Walker, 1862) or something very close to it, probably from India or Pakistan. Thus *Apolema* Hulst, 1896, is a junior synonym of *Pseudopanthera* Hübner, 1823, and its type by original designation and monotypy, *Aspilates carata* Hulst, 1887, should be listed as a junior synonym of *P. ennomosaria* (Walker).

The holotype of *Nyctiphanta laetula* is a specimen of the European *Aspitates* (*Aspilates* Auct.) *ochrearia* (Rossi, 1794). Thus *Nyctiphanta* Hulst, 1896, is a junior synonym of *Aspitates* Treitschke, 1825, and its type by original designation and monotypy, *Nyctiphanta laetula* Hulst, 1896, is a junior synonym of *Aspitates ochrearia* (Rossi).

These names should therefore be referred to the synonymy under *Pseudopanthera* and *Aspitates* as follows:

Pseudopanthera Hübner, 1823

Apolema Hulst, 1896:336. Type-species: *Aspilates carata* Hulst, 1887: 211, by original designation and monotypy. Not new synonymy here because it was mentioned in my introductory comments in the check list (Hodges et al., in press).

Pseudopanthera ennomosaria (Walker, 1862)

Aspilates (sic) carata Hulst, 1887:211 (new species based on "1 ♂, Fla. Coll. Franck," now in the American Museum of Natural History). Hulst, 1891:71.

Apolema carata, Hulst, 1896:336 (new genus proposed for *carata*). Dyar, 1903:315. Smith, 1903:75. Barnes and McDunnough, 1917: 114. McDunnough, 1938:168. Kimball, 1965:186. Fletcher, 1979: 18.

Aspilates Treitschke, 1825

Nyctiphanta Hulst, 1896:336. Type-species: *Nyctiphanta laetula* Hulst, 1896:336, by original designation and monotypy. NEW SYNONYMY.

Aspilates ochrearia (Rossi, 1794)

Nyctiphanta laetula Hulst, 1896:336 (new genus, new species, described from "Arizona, one male," now in the American Museum of Natural History). Dyar, 1903:315. Smith, 1903:75. Barnes and McDunnough, 1917:114. McDunnough, 1938:168. Fletcher, 1979: 142. NEW SYNONYMY.

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A NEW SPECIES OF *SCHINIA* (NOCTUIDAE)
FROM CENTRAL FLORIDA, WITH DESCRIPTION
OF ITS LIFE HISTORY

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ABSTRACT. *Schinia rufipenna*, closely related to *Schinia tuberculum* (Hübner), is described as new. The species is a resident of central Florida and feeds in the larval stage on *Pityopsis graminifolia* (Michx.) Nutt. The life history of the new species is outlined and the immature stages described.

While undertaking field work at the Archbold Biological Station near Lake Placid, Florida, in the fall of 1979, my wife and I collected and reared a new species of *Schinia* closely related to *S. tuberculum* (Hübner, 1827).

***Schinia rufipenna*, new species**

Description. Eyes full and globular as are those of *tuberculum*. Antennae filiform in both sexes. Inner side of foretibia with two apical spines and two or three additional marginal spines; outer side with a single apical spine and one or two marginal spines.

Maculation similar to that of *S. tuberculum* (Hbn.) (Figs. 3, 4) but better defined and usually with a strong reddish suffusion in both sexes. Species showing a sexual dimorphism similar to that of *tuberculum* with female being smaller, darker and with narrower forewings than male.

Vestiture of head and thorax dark orange, unlike the usual greenish-yellow of *tuberculum*. Upperside of abdomen black with a yellow band at posterior margin of each segment. Underside of body dark yellow or light orange.

Male with forewing varying from bright reddish-brown to light chocolate-brown, without the olive suffusion generally evident on *tuberculum*, and with crisper maculation.

Transverse anterior line double, pale-filled, broadly excurved, shallowly triarcuate. Basal space reddish-brown to light chocolate-brown; usually a pale grey or pale cream basal line evident at costal margin. Transverse posterior line usually double, excurved around cell, then essentially straight to trailing margin. Median space white to pale yellow, variably suffused with reddish-brown to light chocolate-brown; a strongly defined brown shade along costal margin; inner half of median space usually lightly suffused with brown; often the suggestion of a brown median shade. Subterminal space concolorous with basal space. Terminal space light orange or white, of variable width. Fringe varying from orange to reddish-brown with a series of dark dashes.

Hind wing black with a narrow yellow outer marginal shade and a yellow median band; median band usually divided into two patches by apex of black discal spot. Fringe yellow.

Underside of forewing dark yellow with a basal black patch and a very large subterminal black patch; discal spot variably defined at inner margin of latter; basal and submarginal black patches often fused through discal spot, leaving only one or two pale median spots or patches. Underside of hind wing dark yellow with a dark patch at inner margin, a dark discal spot, and a dark post-median line expanding toward anal angle into a broad band. Discal spot often fused proximally with inner patch and distally with post-median band.

Female. Smaller, darker, and with narrower wings than male. Median space more



FIGS. 1-4. *Schinia* spp., Lake Placid, Florida: **1 & 2**, *S. rufipenna*, n. sp., holotype and allotype; **3 & 4**, *S. tuberculum* (Hübner), male and female.

heavily suffused than in male and usually with white lines evident along the veins. Median band of hind wing usually reduced to two rather small yellow spots.

Mean expanse. Male, 21.3 mm; female, 20.3 mm.

Male genitalia (Fig. 5). Essentially the same as that of *tuberculum*, except for the conformation of the uncus. Valve elongate and flattened, with a dilated sacculus and with a constriction distal to sacculus. Ampulla reduced to a short stub. Corona consisting of 20 to 25 setae in two or three rows along apical margin of valve. Juxta with a high, narrowly rounded dorsal margin and a broadly rounded ventral margin. Uncus much stouter apically and mesally than subbasally; uncus of *tuberculum* slender, only slightly stouter distally than subbasally.

Female genitalia (Fig. 6). Indistinguishable from those of *tuberculum*; elongate and slender. Valve rather short and apically rounded, with a dense clothing of short setae and a few elongate ones. Penultimate abdominal segment densely clothed with elongate slender spicules.

Type material. HOLOTYPE: ♂ (Fig. 1), Lake Placid, Fla., 8 Nov. 1979, D. and V. Hardwick. ALLOTYPE: ♀ (Fig. 2), same locality and collectors, 2 Nov. 1979. PARATYPES: 3 ♂♂ and 5 ♀♀, same locality and collectors, 1 Nov. to 24 Nov. 1979; 1 ♀, Orlando, Fla., Oct. 1942, D. F. Berry. Holotype and allotype and 8 paratypes in the Canadian National Collection (Type No. 16843). One paratype in the collection of the Archbold Biological Station.

Life History and Habits

Schinia rufipenna occurs sympatrically in central Florida with *S. tuberculum*, and the two species have the same food plant, *Pityopsis* (formerly *Heterotheca*) *graminifolia* (Michx.) Nutt. In the immediate area in which *rufipenna* was taken, about six miles west of the town



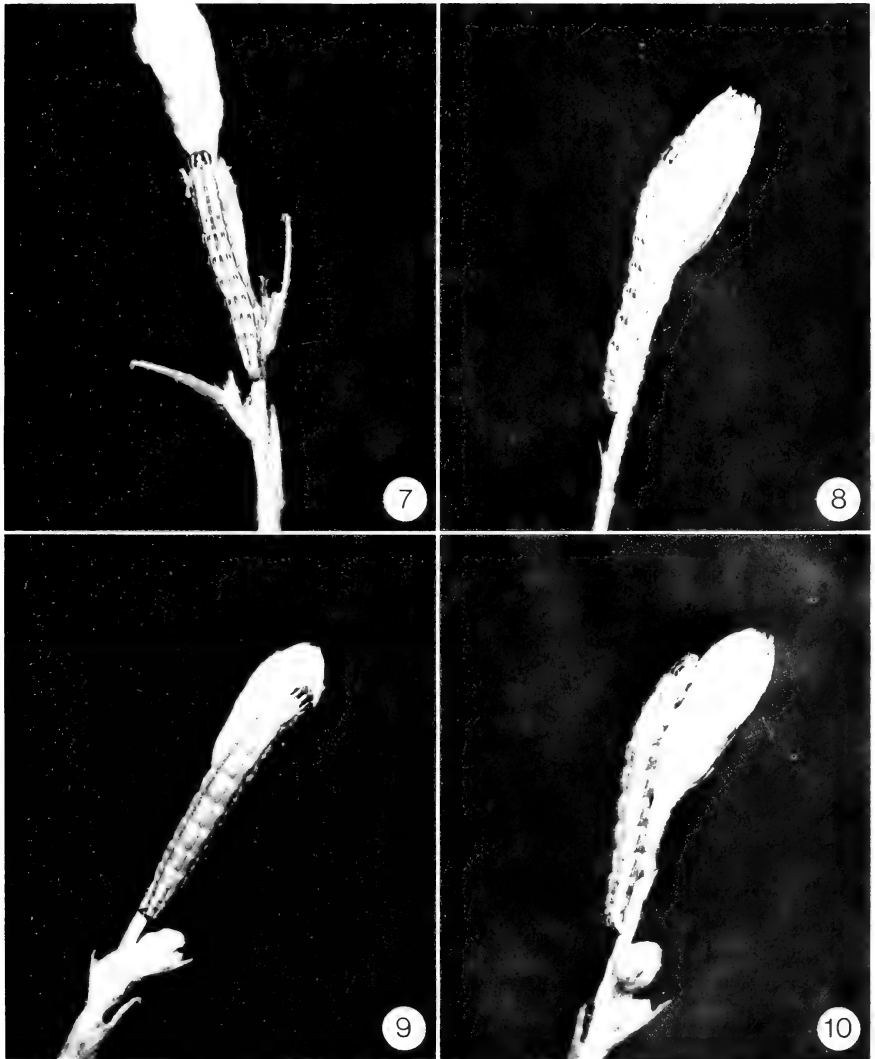
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6

FIGS. 5 & 6. *Schinia rufipenna*, n. sp., male and female genitalia.

of Lake Placid, *tuberculum* was much the commoner species as indicated by both the number of adults and number of larvae taken. The behavior and pattern of development of the two is essentially the same. Although the full globular eyes of *rufipenna* would suggest at least partially nocturnal habits, the moths were only active in the oviposition containers during the late morning and afternoon, and no adults were taken in the light trap during the calendar period that the moths were flying.



FIGS. 7-10. Ultimate stadium larvae of *Schinia* spp. on *Pityopsis graminifolia* (Michx.) Nutt.: 7 & 8, *S. rufipenna*, n. sp., dorsal and lateral; 9 & 10, *S. tuberculum* (Hübner), dorsal and lateral.

As with most species of heliothentines the adults copulate on the flowering heads of the food plant. The female inserts her ovipositor into the open head of *Pityopsis* and deposits the eggs among the florets. The newly hatched larva feeds first on the florets and subsequently on the developing seeds. During one of the median stadia

the larva moves from one head to a second. The larva continues to secrete itself in a *Pityopsis* head at least until moulting into the last stadium. The last instar does not hide in the debris at the base of the plant as do many species of the genus but conceals itself along the stems of the plant. Its long slender shape probably renders it relatively inconspicuous in this position. The majority of reared larvae matured in five larval stadia, a few in six. The duration of the larval stage among reared individuals seemed unusually protracted, its mean duration of 37.4 days contrasting strongly with the normal three-week period recorded for other species of the genus (see Hardwick, 1958).

The mature larva burrows into the ground to pupate. The species is evidently univoltine, remaining in the pupal stage until the following fall, when its food plant again comes into blossom.

Immature Stages

Egg. Pearly white when deposited; remaining unchanged until the day prior to hatching when the ocelli and subsequently the whole head capsule gradually become visible through the chorion. Egg hatching five to seven days after deposition.

First instar. Head pale orange-brown, paler than that of *tuberculum*. Prothoracic and suranal shields medium smoky-brown. Trunk white, becoming stained with yellow as larva feeds. Mean duration of stadium, 8.1 days.

Second instar. Head orange suffused dorsally with brown. Ocelli dark brown. Prothoracic shield smoky-brown with three pale longitudinal shades. Suranal shield smoky-grey with a poorly expressed, somewhat darker grey mid-dorsal band and two or three evanescent grey subdorsal lines. Mean duration of stadium, 4.5 days.

Third instar. Head orange-brown with black ocelli; often a pair of blackish arcs diverging upward and outward from near apex of frontal triangle. Prothoracic shield grey with some brown suffusion mesally; with four black longitudinal bands, the median pair converging anteriorly; prothoracic shield usually noticeably elevated above cuticular surface of trunk. Suranal shield undistinguished from remainder of trunk. Trunk yellowish-grey with brown longitudinal bands. Mid-dorsal band narrow, brown, often with a pale median shade. Subdorsal area yellowish-grey with a brown median band somewhat paler than mid-dorsal band; in larger specimens, median band with a yellow median shade. Supraspiracular area brown with a broad, white or grey, median band. Spiracular band pale grey with a white ventral line and often a brown median shade. Spiracles dark brown. Suprapodal area pale grey. Mean duration of stadium, 4.5 days.

Fourth instar. Head light orange with dark brown ocelli; often a pair of dark brown arcs diverging upward and outward from near apex of frontal triangle. Prothoracic shield elevated above general surface of trunk; white with four longitudinal black bands, the median pair converging anteriorly and occasionally fused along anterior margin of shield. Suranal shield undistinguished in maculation from remainder of trunk. Mid-dorsal band chocolate-brown with a yellow median shade. Subdorsal area white with a median band of paler brown than mid-dorsal band; median band of subdorsal area with a dull yellow longitudinal shade. Supraspiracular area brown with a broad but discontinuous median white band. Spiracular band white with a weakly expressed, multi-arcuate, pale-brown median shade. Spiracles black. Suprapodal area light grey, suffused with brown dorsally. Mean duration of stadium, 7.3 days.

Fifth instar (Figs. 7, 8). Head orange, suffused with brown dorsally; ocelli dark brown; a pair of dark-brown arcs diverging upward and outward from near apex of frontal triangle. Prothoracic shield prominent, elevated above surface of trunk; white,

often suffused with light brown mesally; with four black longitudinal bands, the mesal pair converging anteriorly and sometimes fusing along anterior margin of shield. Sural shield with maculation undistinguished from remainder of trunk. Overall color of trunk orange-brown with a distinctly checkered appearance due to segmental interruption of longitudinal banding. Mid-dorsal band pale orange with brown marginal lines; marginal lines darker and wider toward anterior margin of each segment. Subdorsal area white with a dull yellow median band; median band margined with brown lines anteriorly on each segment and with orange posteriorly. Supraspiracular area consisting of three longitudinal bands: a dorsal brown band fading to orange-brown toward posterior margin of each segment; an orange-brown ventral band usually fusing with dorsal band at posterior margin of each segment; a discontinuous white median band, wide at anterior margin of each segment but narrowing posteriorly and terminating at fusion of marginal brown bands. Spiracular band white with an inconspicuous, multi-arcuate, light-brown median shade. Spiracles black. Suprapodal area pale grey, suffused with brown dorsally along margin of spiracular band. Mean duration of stadium, 12.0 days.

Pupa. Well sclerotized and somewhat stouter than pupa of *tuberculum*; orange-brown and without characteristic green suffusion of *tuberculum*. Mesothoracic legs relatively long, terminating only a short distance anterior to apex of proboscis. Dorsum of fourth abdominal segment with a row of inconspicuous shallow pits. Anterior one-third of abdominal segments five to seven slightly elevated above remainder of segment and finely pitted; posterior row of pits the most prominent. Rims of spiracles high, forming short but definite tubes; spiracles on anterior abdominal segments on a plane with general surface of cuticle, those on segments five to seven borne in shallow oval pits at margin of raised anterior areas of these segments. Cremaster consisting of four spines borne in a single row at apex of a conical projection of tenth abdominal segment, the median pair slightly longer and stouter than the lateral pair.

DISCUSSION

From the third stadium onward the larva of *Schinia rufipenna* may be distinguished from that of *tuberculum* by the conformation of the two median dark bands of the prothoracic shield; in *rufipenna* these converge toward the anterior margin of the shield, whereas in *tuberculum* they meet the anterior margin at right angles. In the later stadia of *rufipenna*, the ground color of the trunk is reddish-brown; that of *tuberculum* greyish-mauve. Further, the last instar of *rufipenna* has a somewhat checked appearance because of the segmental interruption of the dorso-lateral banding of the trunk; the longitudinal banding of *tuberculum* (Figs. 9, 10) is continuous.

Schinia tuberculum is widely distributed in the southeastern United States. The limits of distribution of *S. rufipenna* are not known, but the species is probably confined to central Florida. The close similarity in structure and habits of the two species suggests some immediate common ancestry. During both the Aftonian and Yarmouth Interglacials of the Pleistocene, the peninsula of Florida was inundated by the Okefenokee Sea, and land areas in central Florida were reduced to a number of islands in the area now known as the Lake Wales Bridge (MacNeil, 1950).

The present competition for the same food plant between these two closely related species may suggest a fairly recent sympatry. It is possible that one population of the immediate ancestor of *tuberculum* and *rufipenna* evolved into the present day *rufipenna* during its insular isolation in the Pleistocene, whereas continental populations evolved into the contemporary *tuberculum*. With the re-establishment of land connections, *tuberculum* may have invaded the Floridian Peninsula resulting in the co-existence of the two species that we see today. Certainly, *tuberculum* is much commoner and more widespread in the Lake Placid area than is *rufipenna*. Further, on the basis of growth rates in simultaneous larval rearings, *tuberculum* is the more vigorous species. In the face of competition from its more successful relative, *rufipenna* may well represent a species on the threshold of extinction.

ACKNOWLEDGMENTS

I thank my wife Verna for patient assistance in the field; it was she who took the first specimen of *rufipenna*. I also appreciate the assistance of Mr. Eric Rockburne for the preparation of genitalic slides and for assistance with the illustrations accompanying this paper.

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A NEW SPECIES OF *EOMICHLA* FROM COSTA RICA (OECOPHORIDAE)

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ABSTRACT. *Eomichla hallwachsae* is described as new, is figured and notes on its biology are given.

Eomichla hallwachsae, new species (Figs. 1-3)

Alar expanse. 22-28 mm.

General description. Labial palpus ochraceous salmon. Antenna ochraceous-salmon; scape light ochraceous-buff. Head vertex light ochraceous-buff; posteriorly light buff; face light ochraceous-buff with ochraceous-salmon line laterally. Thorax cream-white; base of tegula zinc-orange. Forewing ground color cream-white; from basal fourth of dorsum an outwardly curved light clay color, shade extends well into cell and reaches termen beyond tornus; in cell and in its outward extremities, this clay color shade is heavily overlaid with ochraceous-buff; beyond the clay color shade an outwardly curved line of ground color with a pink tinge; base of costa zinc-orange, this color narrowly continued along costa to apex where it broadens to a narrow triangle; at apex a short, narrow dash of ground color with a tinge of pink; cilia ochraceous-buff. Hindwing ochraceous-buff; veins narrowly outlined with ochraceous-salmon; cilia ochraceous-buff. Foreleg mostly zinc-orange, with long light ochraceous-buff and buff scales on tibia and tarsal segments; midleg and hindleg mostly ochraceous-buff. Abdomen zinc-orange; abdomen spined.

Male genitalia (slide USNM 25167). Harpe base of costa with deep excavation; sacculus strongly sclerotized; cucullus curved, pointed. Gnathos a sclerotized band with lateral, curved extensions. Uncus consisting of two widely divergent arms. Vinculum subtriangular. Tegumen broader than long. Anellus a folded triangular plate. Aedeagus stout, with a narrow ridge of short teeth ventrolaterally; vesica unarmed.

Female genitalia (slide USNM 25168). Ostium transverse, narrow. Antrum broadly sclerotized. Inception of ductus seminalis dorsal, slightly before ostium. Ductus bursae very short, merging immediately with bursa copulatrix. Bursa copulatrix elongate, membranous. Signum absent.

Holotype. USNM (δ). 100849.

Type locality. Costa Rica, Guanacaste Prov., Santa Rosa National Park.

Distribution. Costa Rica.

Food plant. *Bombacopsis quinatum* (Jacq.) Dugand.

Discussion. Described from the δ holotype 23-25 May 1980, D. H. Janzen and W. Hallwachs, 2 $\delta\delta$ paratypes with identical data; 3 $\delta\delta$, η paratypes same data except 5-7 June 1980; δ , same except 8-10 June 1980 and δ with no date but reared with data number 81-SRNP-1089. Paratypes in U.S. National Museum of Natural History (USNM) and British Museum (Natural History).

This species is nearest *Eomichla regiella* (Busck) but has a whiter thorax and paler hindwing. The uncus of *hallwachsae* has a single arm on each side; the arms of the uncus of *regiella* are divided. The female of *regiella* is unknown.

Other species currently placed in the genus *Eomichla* are:

E. notandella (Busck), 1911, Proceedings of the United States National Museum, 40: 209 (Type of *Eomichla* described in *Peleopoda*). French Guiana.

E. nummulata Meyrick, 1916, Exotic Microlepidoptera, 1:546. French Guiana.

E. thysiarcha Meyrick, 1928, Exotic Microlepidoptera, 3:469. Bolivia.

E. xystidota Meyrick, 1918, Exotic Microlepidoptera, 2:215. French Guiana.



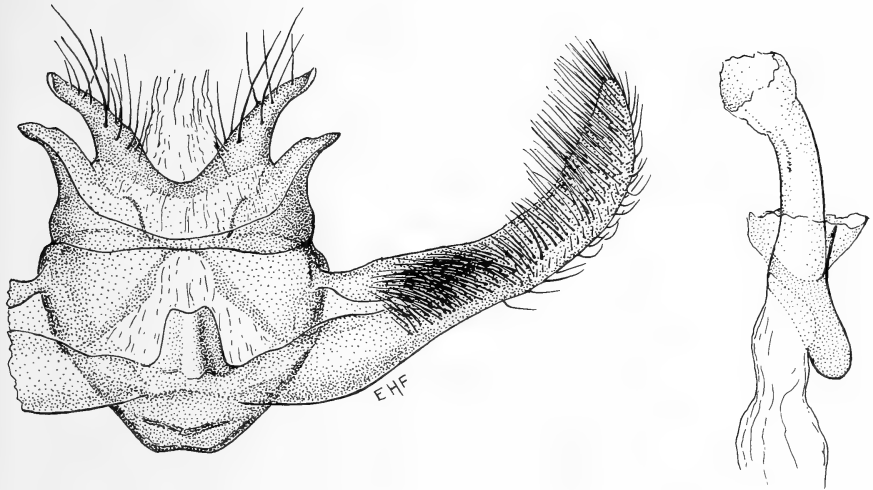
FIG. 1. *Eomichla hallwachsae*, new species: adult male paratype.

- E. marioniella* (Busck), 1911, Proceedings of the United States National Museum, 40: 208. French Guiana.
E. imperiella (Busck), 1914, Proceedings of the United States National Museum, 47: 26. Panama.
E. irenella (Busck), 1911, Proceedings of the United States National Museum, 40:209. French Guiana.
E. leucoclista Meyrick, 1930, Annalen des Naturhistorischen Museums in Wien, 44: 231. Brazil.

Natural History

The notes on the life history of this taxon which follow were written and provided by Dr. D. H. Janzen.

The only known larval host plant of *Eomichla hallwachsae* is the large native tree *Bombacopsis quinatum* (Bombacaceae). The large palmately compound leaves of *B. quinatum* have glabrous ovoid leaflets 7–15 cm long and 5–10 cm wide. The leaf is held in a roughly horizontal position and the caterpillar lives on the upper surface of the leaflet. The two halves of the leaflet blade are positioned so as to form a shallow trough with the leaf midrib running along the bottom; the caterpillar spins a dense, white, double-walled tough silk partition from one side of the leaflet blade to the other so as to leave a tunnel with the dorsal side of the silked-over leaflet midrib as its floor. This elongate silk house is 4–8 mm in length initially but becomes as much



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FIG. 2. *Eomichla hallwachsae*, new species: ventral view of male genitalia with left harpe removed and aedeagus to right.

as 25 mm long and 6–8 mm wide for the last instar larva. The house is positioned roughly in the center of the leaflet. The end toward the petiolet is closed, but the other end is always open; the front portion of the caterpillar head is visible as a black area well back from the tunnel entrance when the caterpillar is not feeding.

The caterpillar feeds by venturing partly out of the entrance of the silk tunnel, both exposed on the leaflet surface and among or underneath a more flimsy layer of silk around the tunnel entrance. It eats the surface of the leaflet down to the epidermis of the underside of the leaf but leaves the epidermis intact. The result is that, when a leaf with *Eomichla hallwachsae* is viewed from below, there are irregular 'windows' in the leaflet blade around the midrib somewhat distal from the center of the leaflet. A caterpillar may spend its entire development period on a single leaflet, or it may move to a new leaflet if its feeding has removed most of the leaf surface. If it moves it may make a new silk tunnel.

There is never more than one caterpillar per leaflet, but in a case of heavy infestation, each of the five leaflets may bear a caterpillar or an old silk tunnel.

When ready to pupate the caterpillar thoroughly reinforces the silk

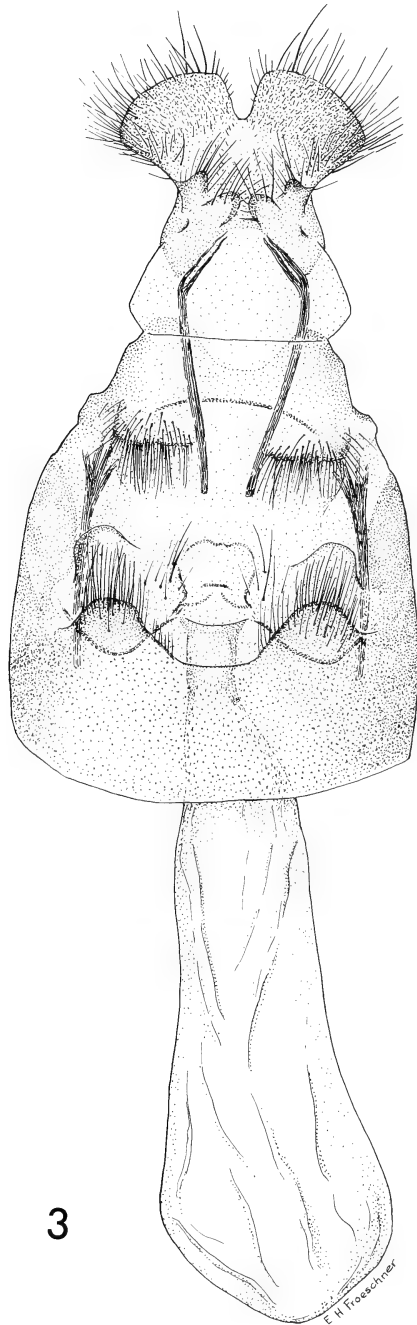


FIG. 3. *Eomichla hallwachsae*, new species: ventral view of female genitalia.

of the tunnel and spins a loosely attached tightly fitting dense silk trapdoor over the entrance and cuts through the leaf almost all the way around the site of the silk tunnel. That portion of the leaf falls free, and as the remaining leaf attachments dry, the portion with the house-cocoon either falls off the tree into the litter or becomes entangled with the leaves like any other piece of dead leaf. The caterpillar may also spin some silk attachments of the house-cocoon to adjacent green leaves, which results in the structure hanging free among the leaves. The silk at this stage is rusty brown in color, rather than the white that characterized the house when the caterpillar was in it. The white silk house looks like old spider webbing; the brown silk of the house-cocoon is a close match to dead *Bombacopsis quinatum* leaves. The cocoon-house structure is about 3 cm in length and 6–10 mm in cross-sectional diameter.

The adults emerge about one month after pupation during the rainy season, but house-cocoons maintained in dry containers in the laboratory will produce adults at least two months later when wetted. Larvae are common on *Bombacopsis quinatum* by the second month of the rainy season at Santa Rosa (June), and an occasional larva may be encountered on the foliage as late as the fifth month of the rainy season (September–October). Since *B. quinatum* is leafless from December–January until early May (dry season), the moth probably passes the dry season as a dormant pupa.

Bombacopsis quinatum is a large forest tree with a crown containing tens of thousands of leaflets. The larvae of *Eomichla hallwachsae* may be found on the foliage at any point in the crown, but they are much more common on outer leaves exposed to the sun and on leaves in the upper portion of the crown than on shaded or lower leaves. The larvae are never found on young saplings or sucker shoots (1–3 m tall) and only rarely on well-established small young trees (3–5 m in height). In the 1981 rainy season the moths were common; inspection of a large *B. quinatum* crown with binoculars yielded hundreds of leaves with the characteristic and conspicuous feeding damage. Trees growing in forest and forest edges had conspicuously more larvae on them than did trees isolated in open pastures.

The adults come to fluorescent and black lights (mostly males) placed at least 800 m from mature *B. quinatum*.

ACKNOWLEDGMENTS

I am indebted to Dr. D. H. Janzen for placing these specimens in my hands, and I am pleased to name this species for W. Hallwachs, who was one of the collectors of this new species. The drawings were done by Mrs. Elsie Froeschner and the photograph by Victor E. Kranz, Smithsonian Institution photographer. The study which produced the species described above was supported by NSF grant 8-11558.

A BRIEF DESCRIPTION OF THE PHYSIOLOGICAL TECHNIQUES—DISC GEL ELECTROPHORESIS, INCLUDING GEL PHOTOGRAPHY AND THIN LAYER CHROMATOGRAPHY

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ABSTRACT. Two physiological techniques are described: disc gel electrophoresis, including photography of the electrophoresis gels, and thin layer chromatography. Modifications of the basic techniques have been worked out which give the best results with antennal esterases from the cabbage looper moth, *Trichoplusia ni* (Hübner).

The following physiological techniques were developed during studies for the M.S. Degree in Entomology at the University of Florida, Gainesville. The goal of the research was to study the esterases, during late pupal and adult development, in the antennae of the cabbage looper moth, *Trichoplusia ni* (Hübner) and the role these enzymes may play in pheromone breakdown. Dr. Lee Miller of the Allyn Museum of Entomology, Sarasota, Florida, advised me these techniques may also be of interest to taxonomists. Discussed are the following methods: disc gel electrophoresis, photography of the gels, and thin layer chromatography.

Disc Gel Electrophoresis

The basic procedure used was that of Davis (1964). Several additions to, or modifications of, this technique were developed: 1, a Sage Instrument Syringe Pump, Model 355, was used to layer distilled water onto the tops of gels before polymerization so that they would have a flat top; 2, the separating gel (1.5 ml) was placed in gel tubes of 110 mm length and 4.5 mm internal diameter to give better resolution; 3, all solutions were made fresh after 2 weeks, and the ammonium persulfate and solution F were made fresh weekly; 4, two milliamps of current per gel tube were used initially in the studies, but it was later found that 3-4 mamps per tube produced more distinct bands; 5, 0.5 ml of 0.001% bromophenol blue, which served as a front marker, was added to 50 ml in the upper chamber of Tris-glycine buffer, pH 8.3; 6, microsyringes and micropipettes were used to layer samples in sucrose through the buffer in the upper chamber onto the tops of the stacking gels.

The electrophoresis run was terminated when the bromophenol blue front marker was about 5 mm from the bottom of the gel tube, and staining for esterases was carried out immediately. The cabbage

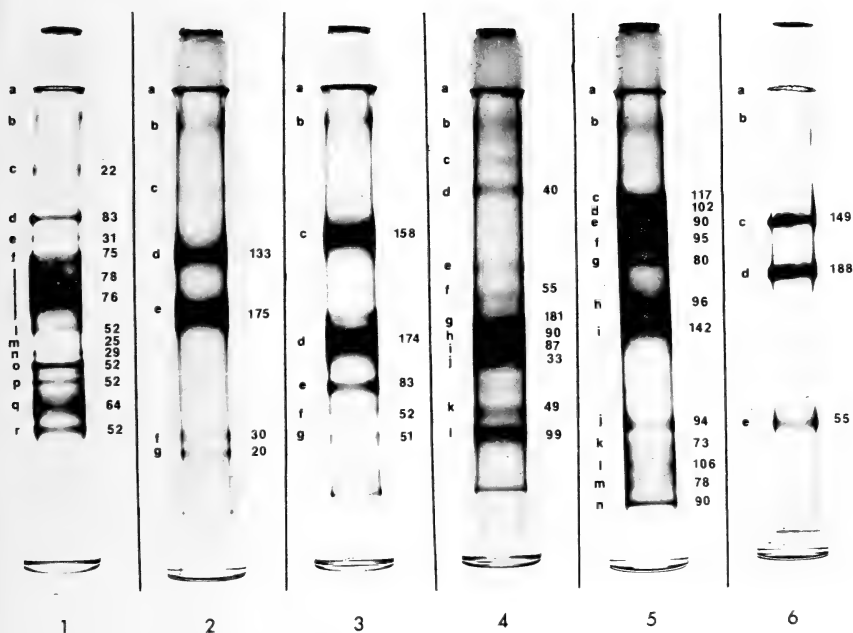


FIG. 1. Disc gel electrophoretic comparison of esterases from the antennae of female cabbage looper moths with females of five other species of moths (USDA, Gainesville, Florida colonies): **1**, cabbage looper, *Trichoplusia ni* (Hübner); **2**, fall armyworm, *Spodoptera frugiperda* (J. E. Smith); **3**, beet armyworm, *Spodoptera exigua* (Hübner); **4**, corn earworm, *Heliothis zea* (Boddie); **5**, velvetbean caterpillar, *Anticarsia gemmatalis* (Hübner); **6**, Indian meal moth, *Plodia interpunctella* (Hübner). Letters indicate bands, while numbers refer to densitometric absorbance, as measured in mm from scan.

looper (*Trichoplusia ni*) antennal esterases were detected using α -naphthyl acetate and Fast Blue RR Salt, according to the procedure of Turunen & Chippendale (1977) with the following modifications: 1, inhibitors were added to enzyme samples before electrophoresis, rather than to the gels following; 2, one ml of acetone was used to dissolve the α -naphthyl acetate before addition of phosphate buffer; 3, the amount of Fast Blue was 3 or 4 mg less than twice the amount of α -naphthyl acetate; 4, the phosphate buffer had a pH of 6.8; 5, following electrophoresis, the gels were not put into a borate solution, but rather were placed directly into α -naphthyl acetate and Fast Blue stain; 6, after staining was completed, the gels were stored in the following fixative (Mauer, 1971): methanol : water : glacial acetic acid (45:45:10). The esterase stain should be made fresh immediately before use.

Gel Photography

The gels were photographed as soon as they were stained with the α -naphthyl acetate and Fast Blue. The gels were left in small glass tubes with fixative and were positioned on a light box covered by a piece of $\frac{1}{4}$ " thick opal glass. A circular 22 watt fluorescent light was placed 10 cm below the glass. The insides of the box were covered with aluminum foil, and the bottom inside was covered with white paper.

A Nikon F-2 camera with a 55 mm Micro Nikor lens was used to photograph the gels using Kodak estar base, black and white, SO-115 (now Technical Pan Film, #2415), shot at $\frac{1}{8}$ second at f11. The film was developed at 20°C (68°F) with D-76 : water (1:1) for seven minutes. Prints were made on fresh Polycontrast or Kodabrome II, medium, glossy paper, and were developed in Dektol : water (1:2). Fig. 1 demonstrates the results of these techniques with a comparison of antennal esterases from the female cabbage looper moth, *T. ni*, and five other species of female moths.

Thin Layer Chromatography

The cabbage looper pheromone, (Z)-7-dodecene-1-ol acetate, is hydrolyzed into the following products: (Z)-7-dodecene-1-ol + acetic acid. The acetate moiety was tritiated. The two products could be separated by the following method. Gelman ITLC-SA, 20 cm \times 10 cm thin layer paper was cut into pieces 2 $\frac{1}{2}$ cm \times 10 cm and oven-dried at 100°C for 15–20 minutes. Two hundred and fifty ml beakers were used as developing chambers, which were covered with glass Petri dishes. Seven ml of developing solvent, composed of 15 parts of ethyl acetate and 85 parts benzene, were placed in the bottom of the beaker. Absorbant paper (Whatman chromatography) was placed against the inside wall of the beaker and immersed in the solvent to maintain a saturated atmosphere. Ten microliter reaction samples were spotted 1 cm from the bottom of the plate, and the plates were developed for 10–15 minutes or until the solvent front was about 1 cm from the top of the plate.

The tritiated acetic acid product stayed at the origin 1 cm from the bottom of the plate, while the unreacted pheromone went with the solvent front. The alcohol product was unlabeled and not measured by this system, although it was verified that the alcohol went up the plate to a point between the pheromone and the acetic acid at the origin. After development, the plate was cut into sections containing the labeled acetic acid and labeled pheromone and counted, using Instagel (Packard) in a Packard scintillation counter.

ACKNOWLEDGMENTS

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GENERAL NOTES

MYSCELIA ANTHOLIA (NYMPHALIDAE) IN THE REPÚBLICA DOMINICANA

According to Riley (1975, Field Guide to the Butterflies of the West Indies, p. 63) "there is no real information about the habits or habitat" of *Myscelia antholia* Godart. The species is known only from the Antillean island of Hispaniola and has been reported from Port-au-Prince, Haiti, and from El Número-Azua (1980, Marión Heredia, Naturalista Postal, 19/80) in the República Dominicana. Thus, there is only one published record of the species from the República Dominicana, and indeed there is little information available on *M. antholia*.

We spent the period between 19 June and 19 August 1981 in the República Dominicana, traveling extensively there and making a collection of 1600 butterflies. We saw or collected *M. antholia* at seven localities. Since so little information is available on the distribution or habitat of this species, it is appropriate to record our observations, which are given in temporal sequence. The first two records are open to some doubt, since they are based on individuals which were flying rapidly or which were passed while we were traveling in a vehicle. We are confident that these records are based on *M. antholia*, which is unmistakable in the field, but they should be treated with some circumspection. The remaining records are indisputable, based on clear sightings or specimens collected.

1) Prov. La Vega, 10 km SE Constanza, Cordillera Central, 1650 m, 2 July 1981. This individual was seen by the authors and W. W. Sommer as it crossed an open meadow at about 1200 h. The day was bright and sunny and the temperature 30°C.

2) Prov. La Vega, 3 km SE Constanza, Cordillera Central, ca. 1220 m, 2 July 1981. The butterfly was seen from a moving vehicle as it hovered and fluttered above a water-filled hole in the road surface at 1300 h. The weather was sunny and bright. The habitat was cut-over pine woods and cultivated fields.

3) Prov. Pedernales, Aceitillar, 35 km NE Cabo Rojo, Sierra de Baoruco, 1220 m, 19 July 1981. Seen clearly by both authors, the butterfly was flying towards and parallel to us along the road of the Alcoa Exploration Company at the bauxite mine at Aceitillar. The area is open pine woods with little shrubby undergrowth. The sighting was at 1500 h and the temperature was 26°C.

4) Prov. La Estrelleta, 10 km S Elías Piña, Sierra de Neiba, 732 m, 27 July 1981. The butterfly was seen clearly by both authors in a stand of open high-canopied hardwoods. When alarmed, the insect flew rapidly up a slope into dense woods and was not seen again. The sighting was at 1445 h and the temperature was 36°C.

5) Prov. San Juan, just SE Sabana Alta, 305 m, 29 July 1981. While we were traveling from San Juan to Azua along the Valle de San Juan, a *M. antholia* was clearly observed by both of us as it flew toward and parallel to us in an area of open fields. The habitat was generally *Acacia* scrub, but at the point of observation there was a fencerow covered with *Antigonon leptopus*, by which the butterfly flew without stopping, fled across the open field, and was not seen again. The time was 0935 h and the weather was bright and sunny.

6) Prov. Santiago Rodríguez, Loma Leonor, 18 km SW Monción, northern foothills of the Cordillera Central, 550 m, 3 August 1981. One ♀ *M. antholia* was collected in moderately dense deciduous riverine woods along the Río Toma at 1400 h and a temperature of 38°C. The butterfly was seen flying through the woods with the same erratic flight of *Hamadryas februa* Hübner; when pursued, it fled into the woods but 0.5 h later reappeared at the same site as previously and was taken while it rested on a tree trunk about 1 m from the base. The insect lit with its wings spread (thus exposing the metallic upperside), and then shortly closed them to become inconspicuous, since the ventral coloration has a bark-like camouflage. The head was pointed upward while resting. The area in the vicinity of the Río Toma is mixed pine-deciduous woods.

7) Prov. La Altagracia, 1 km N Playa Bayahibe, sea level, 16 August 1981. Three *M. antholia* were observed and two (1 ♂, 1 ♀) collected. The area is semi-xeric lowland

forest, quite dense, and all sightings were made along an unpaved road through the forest near Playa Bayahibe. The weather had been rainy the previous day (due to the passage of Tropical Wave Dennis), and the road was moderately wet and with many puddles of standing water. Over one of these, *M. antholia* was observed by the junior author; it had been drinking at 1030 h and was disturbed by the approach of the collector. It flew rapidly and erratically, low to the ground (0.5 m) about the collector's legs for about 20 seconds, then lit, head down, upon a 2.5 mm diameter sapling at the edge of the road very briefly, and when further pursued, flew into the woods. The second individual was seen as it flew along the road in a leisurely manner, close to the ground. The senior author attempted to catch it, but, alarmed, the butterfly flew some 10–12 m and came to rest on a tree trunk (0.5 m diameter), about 1.5 m above the ground and 1 m from the road within the woods. The head was pointed down and the wings were closed. When approached through the woods, the butterfly flew about 5 m further and somewhat deeper into the woods (perhaps 2 m) and landed once again with the wings closed. It was collected on this second tree. After the first alarm at the attempted capture, the insect flew in a deliberate and non-nervous manner and seemed in no hurry to reach the second tree where it rested. The last specimen was observed as it flew leisurely along the edge of the road near its opening onto the main paved road. It was netted without incident. These observations were made between 1015 and 1300 h. The weather was very hot and humid.

To summarize all the above records, in the República Dominicana *M. antholia* occurs from sea level to 1650 m but seems more common at higher elevations (above about 305 m). It is a butterfly of openings in woods (roads and other disturbed areas) into which it flies when alarmed. The flight is leisurely when undisturbed, but when pursued or in widely open areas (sightings 1, 5) it moves with determined and rapid flight. *Myscelia antholia* rests on saplings or trees, often landing with the wings open and the head either up or down, remains in this position for about 15 seconds and then folds the wings over the back to become inconspicuous. Temperatures of activity range between 26°C and 38°C.

Myscelia antholia may not be so rare as suggested by Riley; it may be rather periodic in activity or it may emerge at a time when most collectors are not in the field. The number of man-hours (33) spent at locality (7) in 1980 and 1981 without seeing *M. antholia* is truly amazing. Yet most of these hours (19) were in June and July, and these months may be too early for *M. antholia* except for scattered individuals. One other fact is pertinent: Of all Dominican localities where we saw or collected *M. antholia*, only (7) has been visited so frequently (6 times). Also, the visit to (7) when three individuals were seen was in the late morning; whereas, most other visits have been in the early afternoon when the temperatures were higher. It may be that *M. antholia*, like *Prepona amphitoe* Godart under similar circumstances, becomes inactive and rests during the heat of the day (especially in late July and August).

We wish to thank our fellow collector Kurt M. Iketani for his interest and help, and the Alcoa Exploration Company for permitting us to stay at their guest house at Cabo Rojo.

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NOTES ON THE AUTUMNAL NORTHWARD MIGRATION OF THE
CLOUDLESS SULPHUR, *PHOEBIS SENNAE* (PIERIDAE),
ALONG THE SOUTH CAROLINA COAST

On 27 August 1978 large numbers of cloudless sulphurs, *Phoebis sennae* (Linnaeus), were observed moving along the South Carolina coast in a northeasterly direction. The butterflies were flying over a salt marsh just inland from Folly Island, a barrier island south of Charleston, South Carolina. This flight continued for several days with few butterflies stopping at flowers or attempting to oviposit. The flight also was observed over grassy areas and fields a few miles inland from the coast, but the flight seemed to be most intense just inland from the barrier islands. Ten or more miles inland, the cloudless sulphurs seemed to be flying in random directions with no perceptible migration taking place. (On 3 October 1978, however, one of us (Laurie) received an inland report of cloudless sulphurs moving east in large numbers.)

On 1 September a procedure was initiated to quantify the continuing migration on the immediate coast. A 60 m wide grassy area, bounded on the southeast by a row of trees and on the northwest by the offices (located at the South Carolina Marine Resources Research Institute on James Island, two air miles (3.2 km) south of Charleston, S.C.) of the authors, was selected as a study area where daily observations could be made. All northerly-migrating cloudless sulphurs passing between the row of trees and the windows of our offices flew perpendicular to our line of sight and, therefore, could be counted with ease. Five minute counts were conducted at different time periods of each day of the migration. The total number of cloudless sulphurs passing through our observation area in northerly and southerly directions was recorded for each five minute period. Counts were made in the morning, at mid-day, and in the afternoon. General observations on wind direction, wind speed, and cloud cover were also made.

During the 1978 migration an early peak was reached on 5 September with an average of 125 cloudless sulphurs passing through the count area per five minute period, all in a northeasterly direction. The migration continued through 6 October with a second peak on 28 September of 323 butterflies moving northeasterly through the observation area per five minute count period (64.6 cloudless sulphurs per minute or about one per second). The average number of northeasterly-migrating cloudless sulphurs recorded per five minute period in 1978 was 69.5 ($n = 29$).

In 1979 a similar migration occurred, beginning again in late August (23 August). The same five minute count procedure used in 1978 was employed in 1979 and was carried out in the same study area. In 1979 the migration was most intense between 24 August and 31 August and between 10 September and 9 October. One hundred and fifty cloudless sulphurs were recorded during one count period on 31 August, and 160 butterflies were counted during a five minute period on 9 October. Fewer cloudless sulphurs migrated northeasterly during the 1979 migration, the average number of butterflies per five minute count period being 48.9 ($n = 25$).

Again, in 1980 a northeasterly migration of cloudless sulphurs was observed in the study area. The 1980 migration began in late August (28 August) and continued through 22 September; however, fewer butterflies were seen during the 1980 migration than were seen in 1978 or 1979. The average number of cloudless sulphurs observed per count period in 1980 was only 15.6 ($n = 17$) with peak counts of 31 occurring on 11 and 17 September.

A review of our general observations on wind speed, wind direction, and cloud cover reveals that the migrations were most intense on still, clear days; however, considerable flights were recorded on breezy, partly cloudy days. A marked reduction in the number of cloudless sulphurs on the wing was obvious on gusty days, with no butterflies flying on rainy days. In 1979 Hurricane David passed just south of the study area on 4 Sep-

tember, but the northeasterly migration continued on 6 September, after the rains associated with the hurricane had passed through the area.

The northeasterly migration reported herein was limited to late August, September, and early October. The cloudless sulphurs flew over marshes and grassy areas and generally avoided woodlands. Few cloudless sulphurs were observed flying along barrier island beaches, as do monarchs (*Danaus plexippus* (L.)) in their autumnal southward migration. On the other hand, the cloudless sulphurs migrated in large numbers over the salt marshes just inland from the barrier island beaches. In late September and early October of 1978 some cloudless sulphurs flew southwesterly, against the grain of the larger northeasterly migration. During one count period on 19 September 1978, 109 cloudless sulphurs were counted flying northeasterly, while 90 were recorded moving southwesterly. The total number of southwesterly-migrating cloudless sulphurs counted during this period could have been influenced by possible northeasterly head winds from Charleston harbor—just north of the observation area—that may have blown some butterflies back into the study area. During the period of 18 September to 6 October 1978 when the southwesterly-migrating cloudless sulphurs were counted, an average of slightly less than ten butterflies per five minute count period was recorded ($n = 16$).

In his discussion on the cloudless sulphur, Klots (1951, *A Field Guide to the Butterflies of North America, East of the Great Plains*, Houghton Mifflin, Boston, 349 pp.) noted that "there appears to be a considerable northward migration in the autumn." In Virginia, Clark and Clark (1951, *Smithsonian Misc. Collect.* 116(7), 239 pp.) stated that they had "kept a special watch" for migratory flights of the cloudless sulphur; however, only a few directional flights, all recorded from inland counties, have been reported in Virginia. None of these flights were mass migrations; instead, the butterflies were "widely separated and seldom in sight of each other" (Clark and Clark, op. cit.). Harris (1972, *Butterflies of Georgia*, University of Oklahoma Press, Norman, 326 pp.) pointed out that, in Georgia, the "annual fall migration of the cloudless sulphur . . . coincides with that of the monarch, . . . southeast toward Florida." In Florida, Walker (1978, *J. Lepid. Soc.* 32:178–190) caught significantly more cloudless sulphurs moving southward than northward in Malaise traps set in the autumn of 1975 and of 1976.

As mentioned earlier, the northward migration of the cloudless sulphur was only obvious along the immediate coast, which it seemed to follow northeastward. Inland, the butterflies seemed to be moving at random. In light of the fact that there are no reports from Virginia, North Carolina, or Georgia to corroborate our South Carolina migration data, several basic questions must be asked: Is this migration a local phenomenon? Or does the autumnal cloudless sulphur migration continue up the Atlantic coast? And, why, in autumn, would cloudless sulphurs be flying northward along the coast of South Carolina, while in Georgia and Florida the butterflies seem to be moving southward?

Baker (1968, *Phil. Trans. Roy. Soc. London, Ser. B, Biol. Sci.* 253:309–341; 1969, *J. Anim. Ecol.* 38:703–706) has carefully studied the migrations of British butterflies and has developed a theory of the evolution of butterfly migration. He has pointed out that most British butterflies have become migratory in response to one or more of the following factors: 1) the abundance of predators or parasites; 2) the abundance of a preferred food plant; 3) day length; and 4) climate (temperature and/or humidity). The combination of the above factors that has resulted in the cloudless sulphur migrating northward (in autumn) along the South Carolina coast (and possibly farther north) and southward in Georgia and Florida is yet to be explained.

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ABERRANT *HEMILEUCA MAIA* (SATURNIIDAE)

On 1 November 1980 while collecting in Zaleski State Forest in Vinton County, Ohio, an albino specimen of *Hemileuca maia* Drury was taken in flight along the margins of a deciduous forest. The location of the capture consists primarily of oaks (*Quercus* spp.), staghorn sumac (*Rhus typhina* L.), and yellow poplar (*Liriodendron tulipifera* L.). The species is quite common here, and numerous individuals were observed and captured along a gravel road which penetrates the forest. The aberrant specimen was taken in flight at a height of approximately two meters after emerging from the trees just east of the road. The aberrant and typical males were in search of concealed females. The specimen (Fig. 1) is very striking in appearance. The normal black melanin of the wings is wholly replaced by light beige. The tufts of red scales found at the posterior tip of the abdomen and on the thorax are very inconspicuous and nearly absent. The white areas of the wings remain but are only slightly apparent within the light ground color. The body shares completely the replacement of color, providing unquestionable evidence that the specimen is indeed an albino and not simply lacking wing scales.

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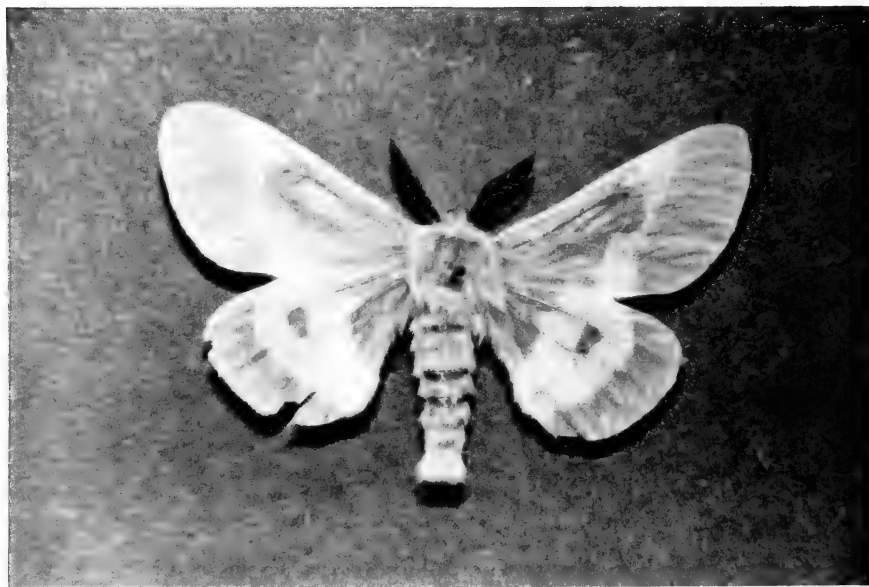
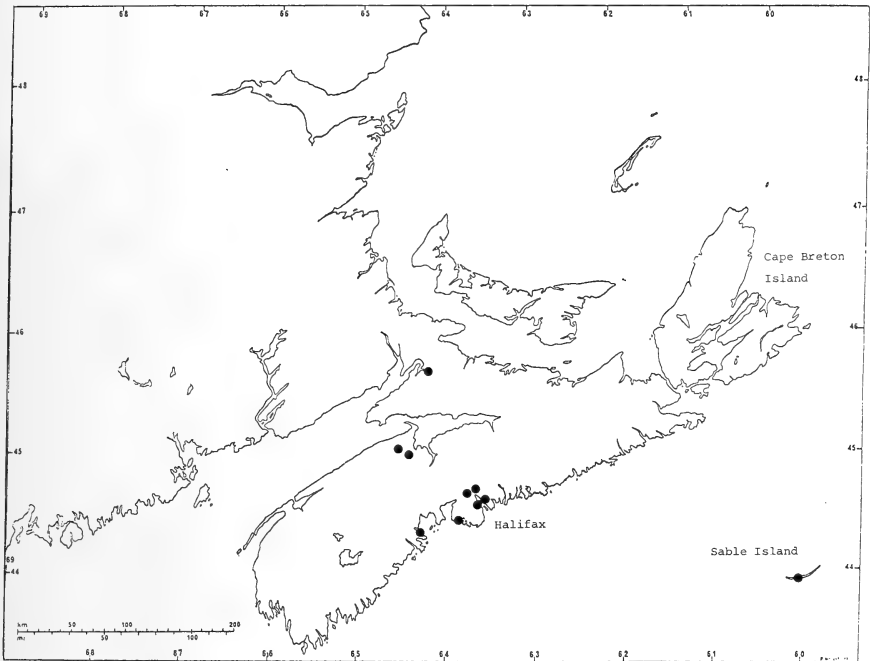


FIG. 1. Aberrant ♂ specimen of *Hemileuca maia* taken in Vinton Co., Ohio, 1 November 1980.

NOCTUA PRONUBA (L.) ON SABLE ISLAND, NOVA SCOTIA,
A RECORD OF DISPERSAL

On 22 July 1976 a number of spruce budworm moths, *Choristoneura fumiferana* (Clem.), arrived on Sable Island and were quite active in mid afternoon, flying low over the dune vegetation. It was supposed that they must have come from Cape Breton Island, 193 km (120 mi.) to the north, where an infestation was in progress. On 1 September 1981 a specimen of *Noctua pronuba* (L.) was taken in a light trap at the Meteorological Station on Sable Island. This time there was no doubt that the moth had come from the Halifax area of the mainland, 298 km (185 mi.) to the west. *N. pronuba*, a European cutworm, was first captured in Halifax in 1979 and has since spread 66 km (41 mi.) to the southwest and 137 km (85 mi.) to the north (see Map) (B. Wright & K. A. Neil, in press). It has not been taken in light traps northeast of the Halifax area.

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MAP. *Noctua pronuba* distribution in Nova Scotia, 1981.

THE SECOND SPECIMEN OF *EPARGYREUS SPANNA* (HESPERIIDAE)

Epargyreus spanna was named (Evans, 1952, Cat. Amer. HesperIIDae, Pt. II:46) on the basis of a single female with the locality datum of "Santo Domingo"; the specimen had been collected in 1855. Riley (1975, Field Guide to the Butterflies of the West Indies, p. 158) characterized and figured (Pl. 21) the species. *Epargyreus spanna* has apparently not been collected since 1855. Brown and Heineman (1972, Jamaica and Its Butterflies, p. 357) suggested that *E. spanna* is a subspecies of Jamaican *E. antaeus* Hewitson; although the two species are similar in details of the female genitalia and in having a bold silvery-white bar on the unhw, *E. antaeus* is much the smaller of the two taxa (female fw length 27-28 mm in *antaeus*, 34 mm in *spanna*). Both species appear to be rare (Brown and Heineman listed only thirteen localities for *E. antaeus*, and Evans examined only 21 specimens), but *E. spanna* has been known only from the holotype.

The specimen is a gravid female with a fw length of 35 mm. The up ground color of both wings is very dark brown, the uphw unmarked, the upfw with three subapical white dots, the lowest one in R_5-M_1 displaced more apically than those in R_4-R_5 and R_3-R_4 and comma-shaped. The remaining five spots are yellowish and arranged as in Riley's color plate except that the lowermost in Cu_2-2A slightly overlaps that in Cu_1-Cu_2 , and that in the cell is not indented along its outer margin. The unfw is marked and colored like the up. The silvery-white hw bar is 5 mm wide at its widest part and the short brown bar that breaks the costal extreme of the white bar almost completely cuts off the more discal portion of the white bar at this costal margin. Riley also showed a pale semilunar marking at the anal end of the white bar; this pale marking is barely discernible in our specimen (Fig. 1).

The area where the *E. spanna* was taken lies at 915 m and 10 km W Jayaco, Provincia de la Vega. The site is a mountain torrent, strewn with boulders and alternating with flat areas of slack water. The stream is reached by a 100 m path from the Jayaco-El Rio road. The region is generally well forested with deciduous forest, in which the forest palm (*Prestoea montana*) is common. The stream is generally open (i.e., the canopy does not close above it), and the forest may come to the stream edge, or the banks may have a border of shrubs, bushes, and grasses.

The skipper was taken at 1400 h on 17 August 1981. The precise area was along a slack-water pool about 0.3 m deep; below the pool the stream was steep and torrential,



FIG. 1. Upper and underside views of female *E. spanna* (7327 in the collection of the junior author).

above the pool a steep (and impassable) fall. The stream at this point is about 5 m wide and is open, with a high canopy on the sloping banks, but with shrubs and bushes along the stream itself. The day was overcast in general, but the sun alternately appeared and disappeared. Generally, collecting was poor and at the site of capture of the *E. spanna* no other butterflies were seen. Just below the pool *Lycorea ceres* Cramer was moderately abundant but not (the usually common) *Greta diaphana* Drury. The estimated distance of this spot is 1 km from the path from the road to the stream, but this estimate may be too great. In any event, the pool is at the upper end of the stream beyond which it is difficult to continue.

The *E. spanna* flew across the stream; the flight was slow and ponderous and not darting, perhaps due to the greatly enlarged abdomen with eggs. The skipper landed on the top of a leaf of a streamside shrub about 1.5 m above the ground and adjacent to the pool; the wings were held open. The general impression of the skipper in flight was of *Colobura dirce* Linnaeus (doubtless due to the white underside pattern), but the flight was completely different from the rapid and darting flight of that species.

We are grateful to Kurt M. Iketani for his companionship and for taking the photographs of the specimen.

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BATTUS ZETIDES IN THE REPÚBLICA DOMINICANA

The papilionid *Battus zetides* Munroe is endemic to the Antillean island of Hispaniola. Hall (1925, *The Entomol.* 58:162) considered the species "Apparently very rare" and recorded a single specimen from La Vega, República Dominicana as the only example with "exact" locality data, although there existed other specimens (with imprecise locality data—Haiti—in British collections). Riley (1975, *Field Guide to the Butterflies of the West Indies*, p. 140) gave the range in an anomalous manner: "Known only from Haiti, La Vega, and apparently very rare. Should also occur in the Dominican Republic." His statement of range is, of course, taken from Hall, but he has confused the two countries involved. Marión Heredia (1980, *Naturalista Postal*, 26/80) noted the capture of a series of specimens on 3 October 1976 at Las Auyamas, Polo, Provincia de Barahona, República Dominicana; he regarded these as the first specimens from that country, apparently unaware that Hall had mentioned the La Vega locality many years earlier. Considering the time of that record, it seems likely that it does not apply to the city of that name which lies at an elevation of about 100 m, but rather to the Cordillera Central south of La Vega. The Las Auyamas record is from an elevation of about 1000 m.

Additionally, Riley (1975:Pl. 18) figured a specimen of *B. zetides* without tails; whereas, Lewis (1973, *Butterflies of the World*, p. 23) figured a specimen with tails. This can be clarified immediately, since the plate in Riley is in error; the species is indeed tailed.

Between 19 June and 19 August 1981, we made collections of butterflies throughout much of the República Dominicana. The period of 13 July to 21 July we spent at the guest house of the Alcoa Exploration Company at Cabo Rojo. In this region there are two roads that ascend the mountains to the north: 1) Alcoa's private road to their bauxite mines at Aceitillar in the Sierra de Baoruco, and 2) the Dominican border road that parallels the Dominico-Haitian border from Pedernales (at sea level) to Los Arroyos on the southern face, and thence over the mountains (which here are a continuation of

the Haitian Massif de la Selle) to El Aguacate on the northern face. The maximum elevation reached by the Alcoa road is about 1220 m, that of the border road about 2362 m. Both offer an excellent vertical transect of the ecology of the region, going from xeric desert to mesic deciduous forest to upland pine (*Pinus occidentalis*) forest.

We were able, with the use of a jeep supplied us through the offices of Dr. Eugenio de J. Marcano of the Museo Nacional de Historia Natural de Santo Domingo, to reach Los Arroyos on the border road. This village and army post are at an elevation of about 1100 m. Much of the southern slope of the Massif de la Selle through which the border road passes was formerly rich mesic deciduous forest, but now most of this forest has been cut, and sloping fields and a few *cafetales* are the dominant vegetational features today. The road becomes barely passable above Los Arroyos, and on the day (15 July) that we reached that settlement, the higher slopes were already covered with heavy mist and drizzle at 1130 h, and it seemed pointless to proceed further. The junior author has crossed the main ridge between Los Arroyos and El Aguacate and formerly (and presumably even now) one reaches at high elevations (2300 m) a pine-clad plateau after passing through a wide horizontal band of deciduous forest within which Los Arroyos lies.

The Alcoa road, when it ascends the southern front range of the Sierra de Baoruco, reaches semi-mesic deciduous woods (as at Las Mercedes) which at about 915 m give way to pines. This pine forest continues upward to elevations of at least 1220 m; it is open, with grassy and shrubby undergrowth and in general appearance is unproductive. The road stops at the current bauxite mine at Aceitillar, but a dirt-and-rock road proceeds from there at least 12 km to the northwest and an elevation of 1130 m. The road passes several abandoned experimental mines and leads to a site called Las Abejas. Las Abejas is unique in this region, since it is upland mesic deciduous forest, apparently totally surrounded by pine forest: thus, a local enclave of deciduous forest in what is otherwise pine forest. One comes upon the Las Abejas area abruptly; the road has been traveling through pines at elevations of between 1100 and 1220 m, and then descends within a kilometer to 1130 m, in beautiful hardwood forest. The slopes are steep, and most collecting was done along the margin of the road; at Las Abejas itself, there is a wide and fairly level path that leads through the forest. Butterflies were abundant both along the road and within the forest, although the species diversity is rather limited. The region is seldom visited, and the forest seems relatively uncut. Because of the elevation, most profitable collecting must be done in the morning or early afternoon, since later in the day mist and drizzle or rain with overcast skies regularly brings an abrupt end to collecting.

On our first visit to Las Abejas on 18 July, we collected between 1130 and 1515 h; the temperature was 30°C, the weather alternately sunny and overcast. We collected along the sloping road noted above but not on the path through the forest. The senior author, within minutes of the beginning of our collecting, netted a *B. zetides* as it flew across the road. Several others were seen at this precise point, leisurely circling the tops of vine-covered trees about 10 m high and thus inaccessible. But we soon discovered that walking along the road up the slope was a ready source of specimens, where the butterflies were flying leisurely (but not seen feeding on the moderately abundant flowers). The insects seemed undisturbed by the presence of the collectors and were not unduly frightened (as are some papilionids) when attempts were made to catch them (i.e., there was no alarm behavior).

On a second visit on 19 July, we collected between 0900 and 1415 h; the temperature was 28°C and the weather was generally overcast and sunny in the morning, and overcast in the afternoon. On this occasion we collected not only along the road but also on the path through the forest. Along the latter, a few *B. zetides* were seen, especially in areas where there were openings or clearings, rarely within the woods proper. Along the road itself, we estimated that we saw 50 individuals. In fact, *B. zetides* is certainly at this locality a very common species of butterfly, if not the most common.

Our third visit was on 20 July, between 1430 and 1530 h. The day was cool and had been heavily overcast; only two *B. zetides* were seen and none collected. In fact,



FIG. 1. Upper and lower views of male *Battus zetides* (6326 in collection of junior author).

butterfly activity in general was reduced to a bare minimum, both on the road and the path.

A total of 10 *B. zetides* was secured. Most of these were taken along the road where they were abundant. We have the impression that *B. zetides* is a butterfly of dense woods, but that it flies in sunny open areas (as along roads or in clearings in the forest). The flight is slow and deliberate and generally rather high (3.5 m) above the ground, but the butterflies descend to lower levels (2 m) or may fly as high as 10 m with some degree of regularity. Securing specimens is not difficult, but the collector must be patient and await descent of the butterflies to levels within reach. Attempting to enter the forest on steep slopes to catch an individual rarely met with success.

The series consists of six males (one of which is slightly flown) and four females (three of which are slightly to well flown). Contrary to Riley's (Pl. 18) illustration, the upperside band is not unicolorous on both wings; the upperside forewing band (upfw) is paler (Pl. 11L8; color designations from Maerz and Paul, 1950, *A Dictionary of Color*) than that of the upperside hind wing (uphw) (Pl. 11I11) which may be more orange (Pl. 10L12) in fresh specimens of both sexes (see Fig. 1). More flown specimens of both sexes have the up bands much more yellow, but even in these individuals the fw band is paler (Pl. 10G2) than the hw band (Pl. 10L4). In fresh specimens, the up both wings is a rich blackish chocolate. The us markings of both wings are as figured by Riley, and the silvery arrowhead-shaped markings stand in bold contrast to the yellow, red, and black ushw markings and ground color. Forewing lengths in males vary between 35 and 40 mm ($\bar{x} = 36.0$) and in females between 39 and 44 mm ($\bar{x} = 42.0$); thus, there is some sexual dimorphism in size, but it is not striking.

It is pertinent to comment on the apparent local occurrence of this species. We also collected less than a kilometer southeast of Las Abejas. The area was pine woods, but we found a narrow run-off ravine which had a local stand of deciduous trees and a dense understory of blackberries (*Rubus* sp.). The elevation was 1220 m, thus slightly higher than Las Abejas, and at the top of the hillslope along which we collected and observed such an abundance of *B. zetides*. We collected at this second locality on 14 July (0930–1330 h; T = 30°C; bright and sunny in morning, overcast after 1200 h) and on 18 July (0920–1115 h; T = 23°C; weather alternately sunny and overcast). No *B. zetides* were seen at this locality, although there was a great deal of local butterfly activity both in the pines and in the ravine. Note that our second visit to this locality (16 July) was the same day as our first visit to Las Abejas, where *B. zetides* was common. Although there may be a variety of factors at work, certainly the most obvious is the richness and much greater areal extent of the forest at Las Abejas in contrast to the

narrow stand of deciduous trees at the ravine. It may well be that *B. zetides* demands extensive stands of forest.

It may also be instructive to compare the old La Vega locality and Marión's Las Auyamas locality with Las Abejas. The former lies much lower (assuming that the specimen(s) came from La Vega itself, an unlikely possibility) but is in a basically mesic area (presently much cultivated but with *cafetales* and *cacaotales* and their high-canopy shade-trees). If the La Vega material came from south of that city on the northern slopes of the Cordillera Central, these slopes today are open pine woods with some deciduous forest in wide ravines (as below Buena Vista). The latter may well be or have been satisfactory for *B. zetides*, but we visited this area in June 1981 and saw no individuals. Las Auyamas on the other hand is in the uplands of the Sierra de Baoruco. This area presumably was once well forested, since there are still extensive *cafetales* with their shade trees present (=pseudoforest). The junior author visited the Las Auyamas area on 4-6 August 1980, but the weather conditions, due to the passage of Hurricane Allen, were not propitious for butterfly collecting. Still, the area about Las Auyamas seems suitable for *B. zetides* and rather comparable to that at Las Abejas.

We are grateful to the staff of the Alcoa Exploration Company, especially to Sr. Alfredo Lebrón and Sr. Victor García, for allowing us to stay at their facility at Cabo Rojo; without the loan of the jeep from the Museo Nacional under the directorship of Dr. Marcano, the trip to Las Abejas would have been more arduous, and we are grateful to him and his staff for their assistance. The illustration is the work of Kurt M. Iketani; we acknowledge his efforts with pleasure.

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PUPAL SIZE AND EGG PRODUCTION CHARACTERISTICS IN *ROTHSCHILDIA FORBESI* (SATURNIIDAE)

Rothschildia forbesi Benjamin occurs in the United States in the Rio Grande Valley, Texas. According to Ferguson (*in* R. B. Dominick et al., 1972, *The Moths of America North of Mexico*, fasc. 20.2B, Bombycoidea) there is only limited information available on the biology and early stages of this species. During 1981 I used a series of 23 wild *R. forbesi* pupae, and five of the subsequent adult females to collect data for methods development modeling. The *R. forbesi* were used simply because they were available for study at the time a modeling data set was needed. However, the data that were collected, aside from being used for methods development research, provide fundamental information on pupal dimensions and egg production characteristics for this little-studied species.

Pupal sex was determined by examining the genital openings, which were very distinctive in the *R. forbesi* pupae studied. Males had a single opening on the venter of the 9th abdominal segment; and females had single openings on the venter of the 8th and the 9th abdominal segments. All pupal sex determinations were confirmed at adult emergence. Pupal weights and dimensions, determined as described by Miller et al. (1982, *J. Lepid. Soc.* 36:207-216), are summarized in Table 1. Mosher (1916, *Ann. Entomol. Soc. Amer.* 9:136-158) described pupae of *Rothschildia orizaba* (Westwood) and *R. cincta cincta* (Tepper) (the latter under the name *R. jorulla*; see C. Lemaire, 1978, *Les Attacidae Americains*, Attacinae, Neuilly-sur-Seine, France), indicating that *R. orizaba* pupae were 23-27 mm in length and about 50 mm in circumference; while

TABLE 1. Weights and dimensions of *Rothschildia forbesi* pupae.

Measurement ¹	Mean \pm S.D.	
	Male (n = 12)	Female (n = 11)
Weight	2.06 \pm 0.22	3.20 \pm 0.48
Length	27.65 \pm 1.25	29.85 \pm 1.73
Width	11.20 \pm 0.39	13.70 \pm 0.81
Circumference	37.91 \pm 2.31	45.45 \pm 2.98
Antenna length	11.58 \pm 0.51	13.08 \pm 0.99
Antenna width	3.50 \pm 0.52	3.09 \pm 0.30
Antenna length to width ratio	3.38 \pm 0.55	4.23 \pm 0.46

¹ Weights in g; dimensions in mm.

R. jorulla pupae were 25–28 mm in length and about 45 mm in circumference. She did not discuss *R. forbesi* pupae, nor did she state the numbers or sexes of pupae of the other *Rothschildia* species she examined. The information presented here for *R. forbesi* (Table 1), however, is in general agreement with the sizes reported by Mosher (1916) for the other species of *Rothschildia*.

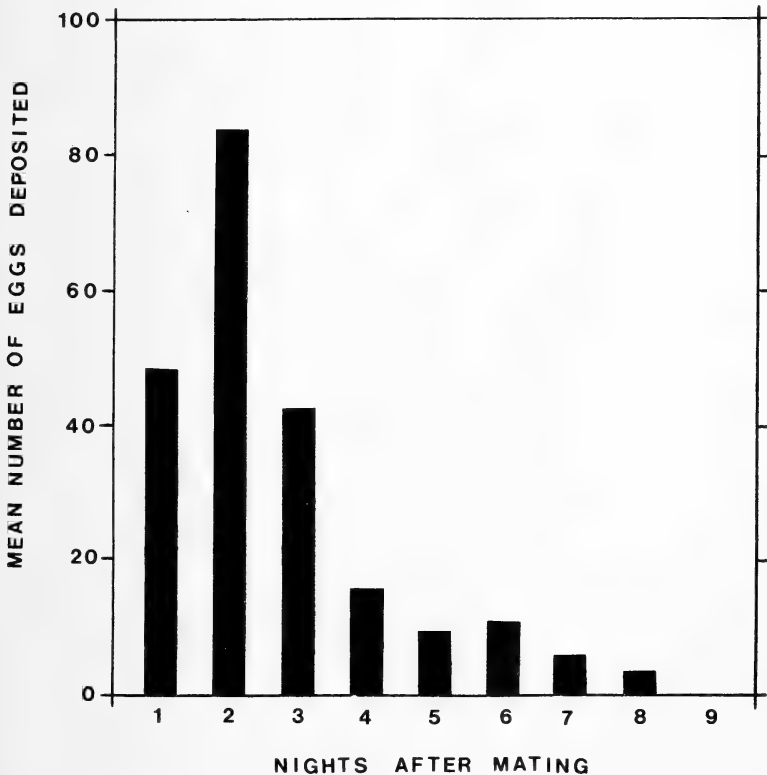


FIG. 1. Oviposition pattern for *Rothschildia forbesi* females.

Five of the females that emerged were mated, and eggs were collected in paper bags each night thereafter until death occurred. Later, the bags were cut open and all eggs were counted. To determine total egg complement the abdomen of each female was dissected after death and eggs remaining in the ovaries were counted. The average egg complement was 232.40 ± 42.76 ; the average number of eggs deposited was 216.2 ± 53.14 . Thus, on a percentage basis the females deposited an average of 92.95 ± 13.48 percent of the eggs they emerged with. The only known information on *R. forbesi* egg production is the report by Collins and Weast (1961, Wild Silk Moths of the United States, Collins Radio Co., Cedar Rapids) that one female laid "all" of her eggs (156) in one night. In the *R. forbesi* studied here, the average longevity after mating was 7.80 ± 0.84 nights; most of the deposited eggs (>80 percent) were laid during the first three nights after mating. None of the females deposited all eggs in any one night. The three-night average for eggs was 57.92 ± 11.42 . There was a positive correlation between egg complement and the three-night average for eggs ($r = 0.70$), which is described by the following regression equation, where E_{d3} = three-night average eggs and E_t = egg complement:

$$E_{d3} = 25.35 + 0.15E_t$$

The oviposition pattern for *R. forbesi* (Fig. 1) is similar to patterns known for other giant silkworm moths (*Hyalophora cecropia* (L.), Tashenberg & Roelofs, 1970, Ann. Entomol. Soc. Amer. 63:107-111; *Hyalophora gloveri gloveri* (Strecker), Miller, 1978, J. Lepid. Soc. 32:233-234; *Callosamia promethea* (Drury), Miller & Cooper, 1977, J. Lepid. Soc. 31:282-283; *Antheraea polyphemus* (Cramer), Miller & Cooper, 1980, J. Lepid. Soc. 34:256-259).

The author acknowledges with gratitude the assistance of R. S. Peigler, who collected the *Rothschildia forbesi* pupae at Harlingen, Texas, in January 1981. The opinions contained herein are those of the author and should not be construed as official or reflecting the views of the Department of the Army.

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OCCURRENCE OF *MEGISTO CYMELA* (SATYRIDAE) AT FLOWERS, WITH A BEHAVIORAL NOTE

Most Satyridae are thought not to normally utilize nectar sources (Emmel, 1975, in Howe (ed.), *The Butterflies of North America*, p. 80). *Megisto cymela* (Cramer) to my knowledge has never been recorded visiting flowers. On 9 July 1980 and 5 July 1981 I observed repeated nectaring by this species on staghorn sumac, *Rhus typhina* L., in Philadelphia, Pennsylvania.

The habitat is a burn area dominated by the grass *Andropogon scoparius*. There are many clumps of trees and shrubs invading this area, such as gray birch (*Betula populifolia*), bigtooth aspen (*Populus grandidentata*), hawthorns (*Crataegus* spp.), cherries (*Prunus* spp.), and staghorn sumac (*Rhus typhina*). It is surrounded by a climax Transition Zone woodland which is part of the Wissahickon Creek Ravine in Fairmount Park, Philadelphia. This burn scar, where the butterflies were seen, is actually at the top of part of this ravine about 104 m above sea level.

Megisto cymela is univoltine here, emerging in mid or late June, with worn individuals being found in August. These common butterflies are usually found flying near the ground in their characteristic weak dancing or skipping manner, moving in and out

of shrubs or thickets of small trees. On 9 July 1980 a single individual was seen nectaring on the yellow-green inflorescence of *Rhus typhina*. On 5 July 1981 at 1400 h, two individuals were seen nectaring on this flower species in a shaded thicket. The day was cloudy and very humid with the air temperature about 29°C. The first individual was observed for over 15 min, moving slowly from one blossom to another before disappearing out of view. The second one was found in another clump of these trees but nectared at the flowers only briefly. The first butterfly seen on 5 July 1981 had initially been found resting on the leaves of *Rhus typhina* with its wings open and flat, very much like a geometrid moth. Later, another individual was also found resting on leaves of these trees in this manner, certainly very uncharacteristic of members of this family.

Other butterflies of interest found in this area include *Parrhasius m-album* (Bdv. & LeConte), *Satyrrium liparops* (LeConte), *Harkenclenus titus* (F.), *Atrytonopsis hianna* (Scudder), and *Hesperia metea* Scudder. The latter, however, may have been recently extirpated here.

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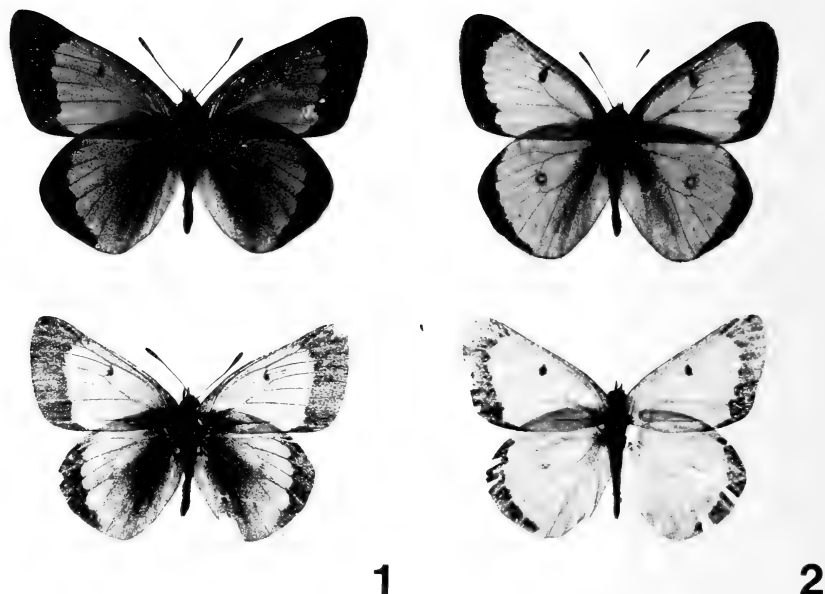
THE "WHITE MALE" VARIANT OF *COLIAS* (PIERIDAE): TWO NEW RECORDS FROM COLORADO

Male *Colias* butterflies with their ground color white or near-white, in contrast to the typical yellow and orange phenotypes, are extremely rare. Such "white males" have been reported in at least seven *Colias* species (see review by Remington, 1954, *Adv. Genetics* 6:403-450). Wild captured white males are few; they occasionally segregate out of inbred laboratory strains and mass cultures of these pierids. Here I report captures of two more white male *Colias*, one being from a species in which this variant has not previously been recorded.

On 8 July 1977 I collected a white male *C. meadii* Edw. (Fig. 1) at the Mesa Seco, elev. 3590 m, 8 km west of Lake City, Hinsdale County, Colorado. I am not aware of other captures of white males for this *Colias* species. The specimen was initially mistaken for an "alba" female as it flew down a steep grade. *C. meadii* "alba" females are themselves uncommon in Colorado (Remington, 1958, *Proc. X Intl. Congr. Entomol.* 2:787-805; Ferris, 1972, *Bull. Allyn Museum* 5:1-23) and have never been captured at Mesa Seco during a decade of mark-recapture studies by Watt's Stanford research group (W. B. Watt, pers. comm.).

I also collected a white male *C. philodice eriphyle* Edw. (Fig. 2) on 3 August 1977 in an alfalfa field near State Route 92, elev. 1645 m, 8 km west of Hotchkiss, Delta County, Colorado. The "alba" phenotype frequency in *C. p. eriphyle* females in some of these agricultural populations is in the neighborhood of 15 percent or less. Here, as in much of North America, positive identification of some white females to species is hampered by the presence of migrant *C. eurytheme* Bdv. (whose "alba" frequencies in western Colorado are generally below 10 percent) and concomitant introgression. Rearings of "alba" females from pure yellow *C. p. eriphyle* (and the reciprocal) taken in fields near Montrose, Colorado, demonstrate that "alba" does occur in pure *C. p. eriphyle* and not just as a result of introgression with *C. eurytheme*.

It should be noted that the coloration of "white male" *Colias* differs significantly from that of their white female counterparts. White males, and some of the white



FIGS. 1, 2. White male *Colias*: **1**, specimens of *Colias meadii*; top: normal male; bottom: white male; **2**, specimens of *Colias philodice eriphyle*; top: normal male; bottom: white male. Locality data given in text. Color filter used to enhance contrast between white males and normal males.

females, are products of autosomal alleles recessive to others for typical ground coloration (e.g., the genes "whitish" and "blonde," Remington, 1954, *Lepid. News* 7:139-145). These characters are not sex-limited, as is "alba," but it is believed that "whitish" and "blonde" females generally pass unnoticed due to their phenotypic similarity to

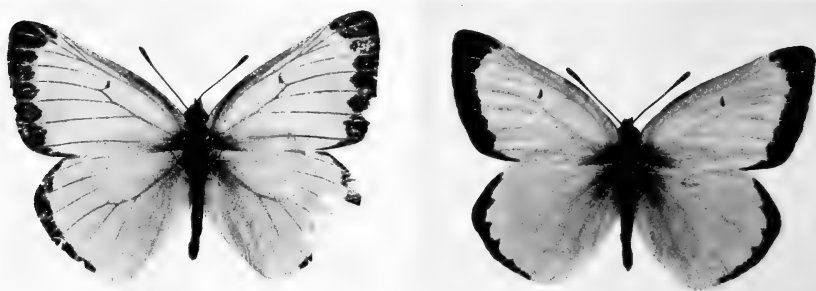


FIG. 3. Specimens of *Colias alexandra*: **Left**, male "black-vein" variant; **Right**, normal male. Locality data given in text. Compare "black-vein" *C. alexandra* to the white male and "black-vein" *C. meadii* in Fig. 1.

the vastly more abundant "alba" females. For recent reviews of the biochemistry and adaptive value of the "alba" variant see Watt (1973, *Evolution* 27:537-548) and Graham et al. (1980, *Proc. Natl. Acad. Sci. USA* 77:3615-3619). The selective (if any) and biochemical details of the white male coloration remain unknown.

The new white male *C. meadii* also exhibits a second interesting genetic character, that of "black-vein" (Fig. 1 does not show this character particularly well). A typical and a wild-captured "black-vein" *C. alexandra* Edw., both taken 5 km east of Crested Butte, elev. 8950 m, late June 1977, are shown for comparison (Fig. 3). Ae (1958, *Genetics* 43:564-576) demonstrated that "black-vein" is almost certainly the product of a single autosomal allele. The white male *C. meadii* is indeed curious, as the viability and/or penetrance of the "black-vein" character appear low (*ibid.*; Remington, *op. cit.*). The two white males have been deposited in the entomological collections at the Peabody Museum of Natural History, Yale University.

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ON THE STATUS OF *PSEUDOTHYATIRA EXPULTRIX* (GRT.) AND *EUTHYATIRA PENNSYLVANICA* J. B. SMITH (THYATIRIDAE)

Pseudothyatira cymatophoroides (Guenée, 1852) and *P. expultrix* (Grote, 1863) were described as distinct species and continued to be regarded as such until about 1917. I am not sure who was responsible for the change, but in the Barnes & McDunnough check list of that year *expultrix* was treated as a form of *cymatophoroides*. There it remained until 1966, when Werny, in a world revision of a large part of the Thyatiridae, restored it to specific rank (p. 322), citing in support of this some minor genital differences as well as the more obvious differences in wing markings. I have dissections of several specimens of each form and can see no differences in the genitalia. The two "species" always occur together, from Newfoundland to British Columbia, south to northern California, Maryland, West Virginia, Kansas, and in the Appalachians to North Carolina (probably, also the White Mountains, Arizona, but only one example seen, a male of the nominate form from Pinetop, Navajo Co., about 8000 ft, R. B. Nagle collection). I have recently seen both forms from a locality much farther south than previously reported—West Feliciana Parish, Louisiana (V. A. Brou collection). It is, therefore, not surprising that doubts concerning the validity of Werny's taxonomic change should have persisted. I know that these moths have been reared by others, but no conclusive results of such a test have appeared in the literature.

On 31 May 1980 I collected at bait a female of the nominate (well-marked) form (Fig. 1) at Colesville, Montgomery Co., Maryland, and from eggs laid by this moth reared a brood of 37 adult progeny in August and September of the same year. The larvae were reared on *Betula nigra* L., *B. populifolia* Marsh, and *Prunus virginiana* L., as available. Sixteen of the offspring were of the nominate form (Fig. 2), and 21 were of form *expultrix* (Fig. 3), showing conclusively that these are indeed forms of the same species.

The situation with respect to *Euthyatira pudens* (Guenée, 1852) and *E. pennsylvanica* J. B. Smith, 1902 is not so certain. Werny (1966, *Untersuchungen über die Systematik der Tribus Thyatirini, Macrothyatirini, Habrosynini und Tetheini* (Lepidoptera: Thyatiridae), Inaugural-Dissertation, Universität des Saarlandes, Saarbrücken, Germany, pp. 237, 245) also elevated *pennsylvanica* from the status of an infrasubspecific form to that of a species. The few *pudens* that have been reared from eggs have turned



FIGS. 1-3. *Pseudothyatira cymatophoroides*: **1**, ♀, Colesville, Montgomery Co., Maryland, 31 May 1980, parent of brood; **2**, ♂, reared from ♀ shown in Fig. 1; **3**, ♂ of form "*expultrix*," reared from ♀ shown in Fig. 1. About natural size.

out to be of the same form as the parent, which does not prove anything. There is still a need for broods to be reared from females of *pennsylvanica*. The circumstances are different from those of *E. cymatophoroides* in that normal *pudens* has a very wide distribution similar to that of *cymatophoroides*; whereas, *pennsylvanica* seems limited to certain areas of the Middle Atlantic States. This is the region where industrial melanism has been most prevalent in North America, affecting perhaps as many as a hundred species, and I had supposed that *pennsylvanica* was the industrial melanic of *pudens*.

Werny (p. 245) also introduced a problem of authorship with respect to the name *pennsylvanica*. In elevating the name to specific rank, he listed himself as author in accordance with Article 10b of the International Code of Zoological Nomenclature. Although Smith (1902, J. N.Y. Entomol. Soc. 10:34) referred to *pennsylvanica* by the ambiguous term of "variety," it is clear from the original description that he was applying the name to an infrasubspecific form. In his check list published the next year, Smith (1903, Check List of the Lepidoptera of Boreal America, Amer. Entomol. Soc., Philadelphia, p. 61) listed it as "*b pennsylvanica* Sm.," as though it were a subspecies, but again, it is clear from the general context that he did not differentiate between infrasubspecific forms and subspecies. Other authors of that period, such as Dyar, also failed to make this distinction or did so inconsistently. Barnes & McDunnough (1917, Check List of the Lepidoptera of Boreal America, Herald Press, Decatur, Illinois, p. 96) did consistently make the distinction and treated *pennsylvanica* as a subspecies. The elevation of *pennsylvanica* to the rank of a species group name by Barnes & McDunnough far antedates that of Werny, and it appears that they should be cited as the authors in the event of its continued use in a specific sense. However, in the new *Check List of the Lepidoptera of America North of Mexico* (Hodges et al., in press) I have returned *expultrix* and *pennsylvanica* to their former status as synonymic names based on forms, with their original authorship, and have had to add *pennsylvanica* Werny, 1966, to the synonymy of *E. pudens*.

Werny's 1966 work is not easily obtained, and the reader may wish to note that it was reviewed in this journal by J. C. E. Riote (1969, J. Lepid. Soc. 23:101).

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THE PROPER CITATION FOR THREE SPECIES NAMES
PROPOSED BY S. H. SCUDDER

The three names treated in this note are *Chrysophanus dione*, *Apatura proserpina* and *Hesperia iowa*. The three were each proposed in two different articles published sufficiently close to each other to cause some trouble. One of these articles is a report of the minutes of the meeting of the Entomological Section of the Boston Society of Natural History for 26 February 1868 in the Proceedings of the Society, vol. 11, p. 401, 1868. The other article is "A preliminary list of the butterflies of Iowa." It appeared in the Transactions of the Chicago Academy of Science, 1:326-337, "1867-1870."

The following is the treatment of these names by cataloguers and checklists from Kirby in 1871 to Miller & Brown in 1981. In it "B" stands for reference to the Boston publication and "C" to the Chicago one. The dates presented are abbreviated thus: '68 for 1868 and so forth.

Catalogue or list	Date	<i>C. dione</i>	<i>A. proserpina</i>	<i>H. iowa</i>
Kirby	1871	B '68	B '68	C '69
Strecker	1876	B '68	B '68	C '68
Edwards	1877	C no date	C no date	B no date
Edwards	1884	C '69	C '69	C '68
Skinner	1896	C '69	B '68	C '68
Dyar	1902	C '69	B '68	no data
dosPassos	1964	'68	'68	'68
Miller & Brown	1981	C '69	C '70	C '69

Barnes & McDunnough (1917), Barnes & Benjamin (1926), and McDunnough (1938) cite no dates nor original description data; dosPassos cites dates but nothing more.

Notice that only dosPassos is consistent. He at least cites the same year, 1868, for publication of the three names. Strecker also is consistent so far as the date is concerned but not for the publication in which the names were first published. Only W. H. Edwards, 1884, and Miller & Brown, 1981, are consistent for the periodical but not for the dates. What is the correct date and periodical?

Publication of the names in the Proceedings of the Boston Society of Natural History was not directly by Scudder but by the secretary of the Entomological Section. This situation is covered by Article 50 (a) of the International Code of Zoological Nomenclature. The names are to be credited to Scudder, not to Mann. Volume 11 was completed and published in 1868. Scudder's names became valid sometime after 26 February and before 31 December of that year.

The only volume of the Transactions of the Chicago Academy of Science was published before 31 December 1870. Scudder dates his manuscript "Boston, October 22nd, 1869." Since none of the signatures of this journal are dated, publication must be considered "31 December 1870" according to the "Code." The date on Scudder's manuscript itself places the Chicago appearance of the names after their appearance in the Boston journal.

The proper citation of each of the three names: *Chrysophanus dione*, *Apatura proserpina* and *Hesperia iowa*, all sired by S. H. Scudder, is: **Proceedings of the Boston Society of Natural History, 11:401, 1868.** The signature containing the names is 26 and is dated May 1868.

LIRIMIRIS MERIDIONALIS (SCHAUS), A NOTODONTID MOTH
ASSOCIATED WITH COCOA (*THEOBROMA CACAO* L.) IN BELIZE

Knowledge of the biology of the large Neotropical notodontid moth, *Lirimiris meridionalis* (Schaus), is limited to the early descriptions of adults of this species and allied ones from Costa Rica (Schaus, 1901, Trans. Entomol. Soc. London 1901:257-343; 1904, Trans. Amer. Entomol. Soc. 30:135-178; 1911, Ann. Mag. Nat. Hist. 7:262-285; 1912, Ann. Mag. Nat. Hist. 8:34-57). But, one early report from Argentina mentions that the caterpillar of the related species, *L. lignitecta* Walker, feeds on *Chorisia insignis* Kth. (Bombacaceae) and pupates in the soil (Schreiter, 1943, Acta Zool. Lilloana 1:7-44). Seitz (1907, Macrolepidoptera of the World, American Rhopalocera, Notodontidae 6: 901-1452, A. Kernan, Stuttgart) was, therefore, correct in stating that, although the Notodontidae of the Neotropical Region were diverse, very little is known about the life cycles and larval food plant associations of most genera and species. This note reports the discovery of *L. meridionalis* feeding on cocoa, *Theobroma cacao* L. (Sterculiaceae), in Belize. It constitutes not only the first published record of a larval food plant for this species but also the first description of the larval and pupal stages, including notes on behavior.

During August 1981 I discovered three caterpillars of *L. meridionalis* feeding on the mature leaves of *T. cacao* in Field Block 18 of the Hummingbird Hershey Cocoa Farm (88°38'W, 17°8'N) located about 18 road miles southeast of Belmopan. A good general description of this cocoa farm is available (Harler, Agribus. Worldwide, April/May 1981: 22-31). The discovery of the caterpillars was made during the rainy season. They were found on a cocoa tree with a well developed leafy canopy. The caterpillars were collected and confined with fresh cuttings of cocoa leaves to a large, clear plastic bag for further rearing. At the time of collection, a ceratopogonid midge (Diptera) was found attached to the cuticle of one caterpillar. The midge, together with the caterpillar, was gently placed in a separate rearing bag for further observation, as the midge appeared to be feeding on the caterpillar.

When collected the caterpillars were about 30 mm long, but they attained nearly 100 mm in length (and 15-17 mm in width) by the time of pupation (3 September 1981 for the first one), following about three weeks in captivity. Each caterpillar molted once in captivity, suggesting that they were in the fourth instar at the time of discovery (assuming five instars prior to pupation).

A macro-description of the caterpillar follows: Head capsule glossy butterscotch-yellow with two dorsal pairs of black dots, a central dot on each side, and three latero-ventral pairs. Background body color white with large black splotches. "Collar" connecting head capsule with rest of body, yellow. First thoracic segment with dorsal black patch with white in center, lateral black mottling and a row of long, lateral white hairs. Second thoracic segment entirely white with one pair of dorsolateral white hairs, shorter than those of first segment. Third thoracic segment white with pairs of black spots, one central and two larger ones dorsolateral. Dorsolateral hairs also present. Segments 4 through 6 similar to 3, but segments 6 and 7 without hairs. Segment 6 entirely white dorsally with a lateral black wedge-shaped streak continuous with intricate dorsal black pattern on 7. Segments 8 and 9 entirely white with small lateral black spot on 9. Conspicuous black wedge-shaped pattern on segments 10 through 12. Thin, irregular black line delineates lateral from ventral sections lengthwise; all legs and ventral cuticle butterscotch-yellow speckled with many small black dots. Last three segments enlarged, almost bulbous and thicker than the head capsule. These segments yellow with black speckling. Segments 9 through 11 with lateral long white hairs. Dorsolateral protuberances on last three segments with long white hairs, and a latero-ventral set on last segment as well. Anal plate shiny black. Together with anal plate, last three segments resemble a false head. When feeding, the caterpillar emits a loud

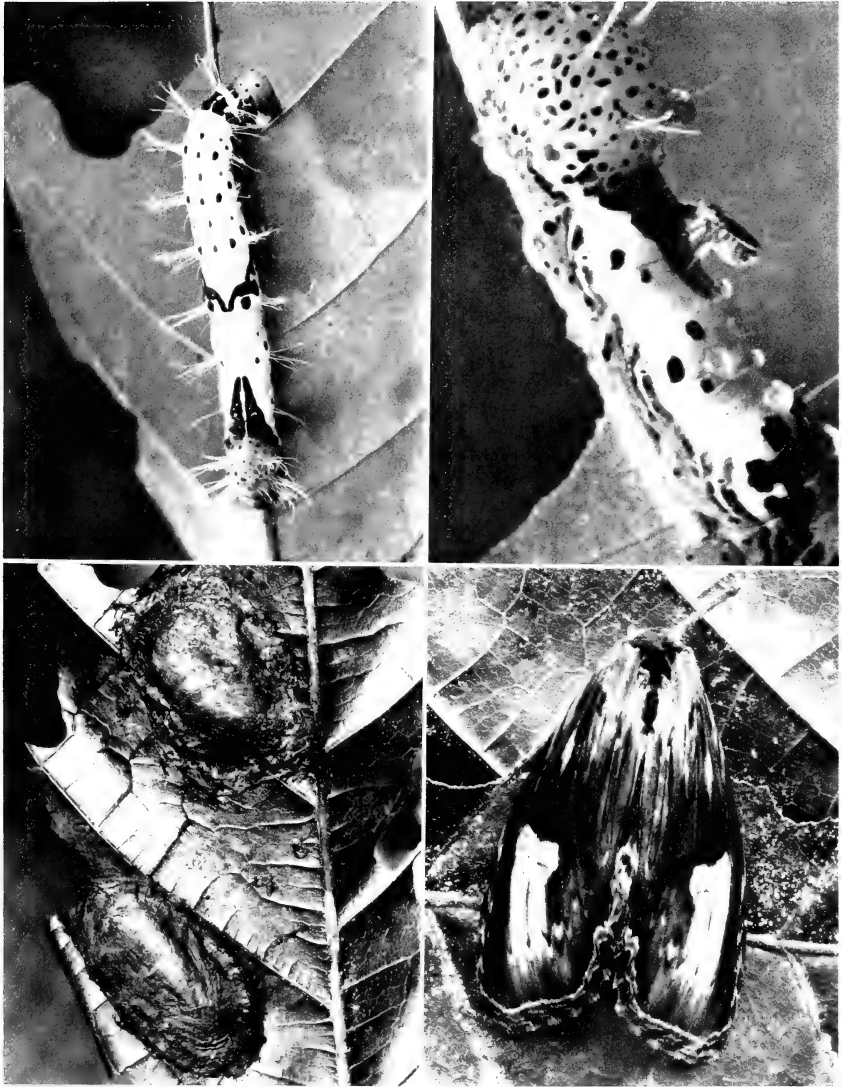


FIG. 1. Life cycle of the notodontid moth *Lirimiris meridionalis* (Schaus). **Counterclockwise, top to bottom:** biting midge *Forcipomyia* (*Microhelea*) *fuliginosa* (Meigen) (Diptera: Ceratopogonidae) feeding on the caterpillar of *L. meridionalis* at Hummingbird Hershey Cocoa Farm in Belize; fourth instar feeding on mature cocoa leaf; two cocoons with top cocoa leaf peeled away to show the flattened, compact structure; newly-eclosed adult moth.

clicking sound, clearly audible from several feet away. During the rearing period, the appearance of the caterpillar did not change. But, it becomes an active prepupa, turning completely yellow-orange and the body contracts greatly in size. In captivity, the caterpillar makes a thin, dark-brown papery cocoon wedged between dead cocoa leaves;

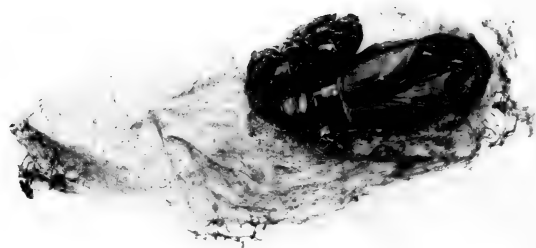


FIG. 2. **Below:** pupal case, cast-off exuvium, and cocoon of *L. meridionalis*. **Above:** mounted specimen reared from the Belize sample of caterpillars and deposited in the permanent collections of the Milwaukee Public Museum.

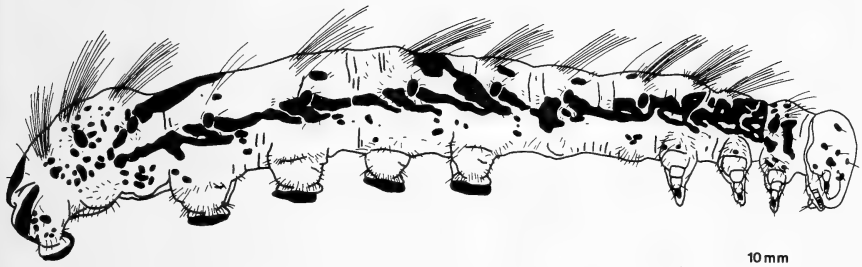


FIG. 3. Schematic line drawing of the fifth instar caterpillar of *L. meridionalis*.

it is conspicuously flattened dorsoventrally. The life stages studied are shown in Figs. 1 and 2, and an approximate schematic representation of the caterpillar's appearance is given in Fig. 3. The cocoon is loosely made of coarse strands of silk holding leaves together to comprise a flat envelope. The pupal stage lasts 18 days under the rearing conditions employed.

While either feeding or resting, the caterpillar assumes a tight "J" position, with the head curled around and partly concealed with the bulbous hind region. It was determined that a biting midge, *Forcipomyia (Microhelea) fuliginosa* (Meigen) (Diptera: Ceratopogonidae) was sucking haemolymph from one caterpillar (Fig. 1). The discovery was made at 0900 h, and the midge remained in the position even when the caterpillar was transferred to a plastic bag from the tree. At 1700 h the same day, the midge was still attached at the same spot on the cuticle. By this time the caterpillar appeared traumatized, with the cuticle darkening. By 0700 h the following day the midge was no longer feeding and the caterpillar appeared healthy once again. This caterpillar survived to pupate and produce an adult.

Although three caterpillars were found on the same cocoa tree, it is unlikely that *L. meridionalis* oviposits in clusters, as noted for some Temperate Zone notodontids (e.g., Farris & Appleby, 1980, *J. Lepid. Soc.* 34:368-371; Holland, 1916, *The Moth Book*, Doubleday, Page & Co., New York and Garden City, 479 pp.). *Lirimiris meridionalis* was originally described from adults collected in British Guiana (Schaus, 1904, op. cit.), and because the caterpillars, as for most notodontids with known life cycles, are tree-feeders, little else was discovered about this species. It is very doubtful that this species has been studied (R. W. Poole, pers. comm.). In the Temperate Zone notodontids have diversified considerably at the generic level in terms of larval food plant selection (e.g., McFarland, 1975, *J. Lepid. Soc.* 29:112-125; 1979, *J. Lepid. Soc.* 22(Suppl. 3):72 pp.), but sometimes a single species exhibits considerable polyphagy (Dirks, 1937, *Maine Agric. Expt. Sta., Orono, Bull.* 389, 162 pp.). In some tropical and subtropical regions, there is considerable diversification of larval food plant patterns among genera (e.g., Pinhey, 1975, *Moths of Southern Africa*, Tafelberg Publ., Cape Town, 273 pp.). Also noted to vary greatly among genera and species is the type of cocoon construction or pupation habit (Kendall, 1974, *J. Lepid. Soc.* 28:243-245; Farris & Appleby, op. cit.).

There are no published records of *L. meridionalis* being associated with cocoa as a larval food plant (Costa Lima, 1936, *Terceiro Catalogo Nos Insectos Que Vivem Nas Plantas Do Brasil*, Minist. Agricult., Rio de Janeiro, 460 pp.; Entwistle, 1972, *Pests of Cocoa*, Longmans, London, 779 pp.). The association may be of economic interest since there are some records of other notodontids in the tropics being serious defoliators of fruit trees (e.g., Fujii & Yoshida, 1981, *Proc. Hawaiian Entomol. Soc.* 23:345-350), although some studies reveal very low densities of a single herbivorous insect species in large stands of a single food plant species (e.g., Solomon, 1981, *Ecology* 62:1205-1214). Although some Lepidoptera associated with cocoa in Brazil have tachinid (Dip-

tera) parasites associated with them (Silva, 1980, Rev. Theobroma 10:257-259), the impact of biting midges such as *F. (M.) fuliginosa* on caterpillars is probably slight. Neotropical biting midges of the genus *Forcipomyia* and the subgenus *Microhelea* are ecto-parasites on a variety of plant-associated insects (Wirth, 1971, Entomol. News 82: 229-245; 1972, Ann. Entomol. Soc. Amer. 65:564-577), and particularly the soft-bodied caterpillars of Lepidoptera (Wirth, 1972, J. Lepid. Soc. 26:65).

The general lack of information on the association of *L. meridionalis* with cocoa anywhere in the Neotropical Region tentatively suggests that the interaction is very patchy regionally, even though this notodontid and related species are known from various localities in Central and South America. But, given the close evolutionary affinity between the Sterculiaceae and the Bombacaceae (Cronquist, 1981, An Integrated System of Classification of Flowering Plants, Columbia, New York, 1262 pp.), it is not surprising to find closely related species of *Lirimiris* associated with both tropical plant families (this report and Schreiter, op. cit.). Because of intense commercial interest in cocoa, there exists an unusually long list of herbivorous insects associated with this fruit tree (e.g., Entwistle, op. cit.); but there is still a dearth of biological data on *L. meridionalis*. A fourth-instar caterpillar of *L. meridionalis* was discovered on *T. cacao* at Finca la Tigra, near La Virgen (10°23'N, 84°07'W), Heredia Province, Costa Rica, on 2 March 1983. The association of this moth with other Sterculiaceae warrants investigation.

I thank Dr. R. W. Poole for confirming the determination of the moth, and Mss. Joan Jass and Susan Borkin with literature searches. Dr. Willis W. Wirth identified the biting midge. Christine Deniger prepared the line drawing in Fig. 3. Special thanks to Gordon R. Patterson of Hershey Foods Corporation for arranging my stay at Hummingbird Hershey, and to Norris Wade and his staff there for assistance and fine hospitality. This report is a by-product of research on cocoa funded by the American Cocoa Research Institute.

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BOOK REVIEW

THE AUDUBON SOCIETY FIELD GUIDE TO NORTH AMERICAN BUTTERFLIES, by Robert Michael Pyle. 1981. Alfred A. Knopf, Inc., New York. Format $3\frac{3}{4}'' \times 7\frac{1}{2}''$ (approximately). 917 pp., 759 color figures, pictorial keys, several halftone figures integrated into the text. Durable flexible binding. Price: \$11.95.

This book is one in a series of practical nature guides being published in standard format by the Audubon Society. They are designed for field use and appear to be rugged enough to withstand a fair amount of abuse. The size is convenient to fit into a day pack or large pocket. The flexible plastic cover should wear well.

In reviewing a book of this nature one must consider the potential audience. The Introduction states: "This book is designed for everyone who wants to know how to identify butterflies in backyards, parks and gardens, as well as in woods and fields." The book certainly meets this goal. It is not directed toward the serious taxonomist but should be of interest even to specialists.

The book begins with the usual discussion of butterfly anatomy and biology accompanied by appropriate illustrations. This section is followed by comments on survival, habitat, observing butterflies, methods of identification and nomenclature. A detailed section then describes how to use the guide. The Audubon Society has adopted a standard format for its nature guides that involves color, pattern, silhouette, and geography. Three illustrative examples are provided to aid the reader in learning how to use the guide to identify an observed butterfly. The illustrations group butterflies by color and silhouette, and not according to taxonomic placement. Each double page of illustrations has a thumbtab guide in the mid-left margin denoting color, pattern, or silhouette. This enables the reader to locate quickly the section containing an unknown species. This method is standard throughout the guide series.

The colored illustrations follow immediately the prefatory material and include some photographs of eggs, larvae, and pupae, as well as adults. Nearly all of the North American butterflies are shown in natural color; a few appear in the subsequent text in black-and-white.

Most of the photographs are of naturally posed butterflies in the field, representing the specimen as it would be observed at rest. A few have been rotated in position, apparently for artistic purposes. Some of the photographs represent obviously pinned material (one specimen lacks its antennae), and some appear to be of either stunned or chilled specimens that have been posed on various substrates. For the most part the quality of the color reproduction is excellent, having been done by the Swiss firm of Nievergelt Repro AG, Zurich. A few obvious exceptions regarding color fidelity are Figs. 97, 98, and 116 (all sulphurs), and Fig. 265 (the Florida duskywing), which exhibits an unnaturally intensified iridescence.

The focus in the illustrations is generally sharp and clear, with Figs. 117 and 635 (the sleepy orange and astarte fritillary respectively) notable exceptions. The hesperine skipper photographs are generally superb, although a few are poorly illuminated and would present identification problems for the casual observer. The hairstreak photographs are the best that I have ever seen, especially those of the *Callophrys-Mitoura-Incisalia* group. The color fidelity is very good. Despite the excellent photography, it would be difficult to make positive field identification of many species without actually catching them, simply because they are too wary for prolonged observation.

Common names are used in the color figure captions, and the reader is referred to the scientific text, which follows the plates, for further discussion. The technical section is arranged according to family in the order: Papilionidae, Pieridae, Lycaenidae, Riodinidae, Libytheidae, Nymphalidae, Satyridae, Danaidae, Hesperidae, Megathymidae. A glossary and index complete the book.

The scientific nomenclature follows that in "A Catalogue/Checklist of the Butterflies of America North of Mexico" (Memoir No. 2 of the Lepidopterists' Society). There are some radical changes in nomenclature from the 1964 dos Passos Checklist (Memoir

No. 1 of the Lepidopterists' Society). For Holarctic genera, names have been brought into agreement with European usage. Various subgeneric names have been elevated to full generic status.

Quite a few new common names have been validated in the book, which is unfortunate. In 1980 a joint committee composed of members from the Lepidopterists' Society and the Xerces Society was formed to develop an approved list of common names. The committee report and recommendations have yet to appear. Consequently, further common name confusion may occur. In most cases the new vernacular names are descriptive of either larval host plant preference or adult maculation.

In the technical section approximately one page is devoted to each species. The butterfly is first described and then compared with similar species, followed by information about life cycle, flight period, habitat and range. Notes on local habitats are included when pertinent, such as: "Huckleberry heaths in the higher parts of Yellowstone Park are good places to seek clear examples of this sulphur"; with reference to *Colias pelidne*. Discussion is restricted to the species level; there is no discussion of subspecies, although color and pattern variations are mentioned. No authority names or dates are placed following the scientific names. This appears to be the style adopted for the Audubon guides, and not an omission on the part of the author.

The book appears to be accurate and current. Even the recently described *Clossiana acrocneema* (Gall & Sperling) is included. The extinct Xerces blue is also illustrated. One omission was noted in the description of *Epidemia dorcas*, page 523. The book states that the life cycle is undescribed, when in fact, W. W. Newcomb published the life history in 1911 in the Canadian Entomologist. The butterfly shown in Fig. 396 as the hickory hairstreak appears actually to be one of the forms of the banded hairstreak (Fig. 394). These two species are difficult to separate. I would question combining two taxa that have been formerly called *Agriades aquilo* and *A. glandon* in North America into the single taxon *A. franklinii* (Curtis). Since the North American counterparts of *aquilo* and *glandon* exhibit the same habitat and host plant preferences as their European congeners, it would appear appropriate to use *franklinii* for the coastal races and *rustica* W. H. Edwards for the montane species. This comment, however, actually relates to the Catalogue, since it dictated the nomenclature used by Pyle. *Lycaeus cupreus* is incorrectly listed as *Chalceria cupreus*. Considering the scope of this book, the points mentioned above are minor.

This new Audubon Society guide should prove an invaluable aid to nature lovers and beginning lepidopterists. Even the serious amateur and seasoned specialist should find it a handy reference for identifying species from unfamiliar regions of North America. In general the text is concise and the color photography excellent. It is unfortunate that not all species are shown in color. Within the format constraints placed by the guide series and the intended audience, Robert Pyle has done an admirable job. At the price of \$11.95 the book is a real bargain and a highly recommended addition to any lepidopterist's library.

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BOOK REVIEW

BUTTERFLIES AND MOTHS OF NEWFOUNDLAND AND LABRADOR, THE MACROLEPIDOPTERA by Ray F. Morris. 1980. Agriculture Canada, Research Branch, Publication 1691. 407 pp., 40 text figs., 34 col. pls. Obtainable from Canadian Government Publishing Centre, Supply and Services Canada, Hull, Quebec K1A 0S9. \$US 18.00, \$CAN 15.00.

This attractively bound and well illustrated volume is a treatment of about 55 species of butterflies and 488 moths reported from Newfoundland and Labrador, giving scientific and common names, distribution, flight period, information on immature stages, 34 colored plates showing almost every species, about 30 distribution maps, a check list, and a glossary of terms. The introduction consists of a short history of lepidopterological studies in the region and of sections on geography and climate, basic anatomy, development, and collecting of Lepidoptera. Keys and descriptions for identification are not included and mostly are not needed, as colored illustrations usually serve this purpose well for the larger Lepidoptera. The book deserves recognition as the first fully color-illustrated guide intended to cover all macrolepidoptera occurring in any state or province of North America. For the illustrations alone it is a bargain that no one interested in Canadian macrolepidoptera will want to miss. The quality of the plates is variable but mostly good; the quality of many of the specimens used for the photography could have been better. Typography is excellent, and there are almost no printing errors except a disconcerting omission of commas from numbers of four or more digits (e.g., 103 600 km² on page 16). I noted only one misspelled name; "*paralis*" should read *parilis* (p. 174), and one *lapsus* in a plant name: *Viburnum* in error for *Vaccinium* (p. 92).

Of particular interest are records of two European noctuids reported from North America for the first time. These are *Agrochola lota* (Clerck) and *Acronicta auricoma* (F.).

The book does suffer from a variety of shortcomings that should be discussed in some detail because of its potential biogeographic importance in documenting the fauna of one of the more interesting areas in North America. Morris does not seem to appreciate the geographical nature of subspecies, because in at least six instances he reports the occurrence of different subspecies of the same species in Newfoundland. All the *Papilio glaucus* would surely have to be subspecies *canadensis*. The black female reported from Newfoundland by Clark & Clark, cited by Morris, is in the U.S. National Museum. It is very old (Oberthür collection) and probably mislabelled. The only ringlet in Newfoundland is *Coenonympha tullia mcisaaci* (the two specimens as figured are female and male of *mcisaaci*), and all *Callophrys augustinus* must surely be subspecies *helenae*. Similarly, one would think that there should be only one subspecies of *Nymphalis milberti*, *Carsia sororiata*, and *Dysstroma hersiliata*. However, *N. milberti viola* is said to be concentrated mainly in the southern part of the island and nominate *milberti* to be more prevalent northward. If this observation is correct, then nominate *milberti* may be moving in from the mainland through Labrador and diluting the endemic subspecies *viola*. Nominate *Anomogyna perquiritata* is reported from Labrador and subspecies *beddeci* from Newfoundland. But *perquiritata* was described from the White Mountains, New Hampshire, and I cannot see that New Hampshire material differs from *beddeci* in any significant way. I regard the latter as a junior synonym.

I noted the following misstatements. Under *Oeneis jutta* (p. 45), how could Möschler have reported *terraenovae* from Labrador in 1860 when this subspecies was not described until 1935? The species of *Vanessa* (p. 58) do not hibernate as adults or pupae but are annual immigrants from much farther south, probably not overwintering anywhere in Canada. The currently accepted family name for *Ctenucha* is Ctenuchidae rather than Amatidae (p. 78). Morris (p. 138) refers to my account of *Leucania comma* in Newfoundland as unpublished when indeed it was published (1963, Can. Entomol. 95:105-107).

Considering that about 542 species are involved, errors of identification are few.

However, identification problems of several kinds have found their way into the work. Sometimes the determinations of previous authors are accepted without question. Thus the records of *Boloria chariclea* are almost certainly based on misidentifications of *B. titania*. The former is a high arctic tundra species that would not be expected in Newfoundland. *Anomogyna fabulosa* is treated as two species, being included both under its correct name and as *A. sincera*. The latter is a palearctic species with which the nearctic *fabulosa* was confused before being described as distinct in 1965. The record of *Schrankia turfosalis* is based on a misidentification of one of the similar North American species, and the correct generic name for this group is *Hypenodes* Doubleday. Three species of *Hypenodes*, *H. fractilinea* (Sm.), *H. palustris* Fgn., and *H. sombrus* Fgn., are known from Newfoundland, but none is listed. *Alypia octomaculata* should have been deleted from the list or verified, as it is almost certain that the original record was based on misidentified specimens of *A. langtoni*. Confusion of these two species in the north where both might occur has become almost a tradition, but it should be noted that the hosts of *octomaculata* (Vitaceae) are absent from Newfoundland. Similarly, it would have been better to have disposed of *Utetheisa idae* in the introduction or a footnote instead of giving it formal listing as though it were really a part of the fauna. As Morris tells us, *U. idae* was described from Swain's Island, Newfoundland, in error for Swain's Island, Samoa.

Other misidentifications are simple errors of the author or of those who did identifications for him. The following should be noted: *Polia leomegra*, described from Newfoundland, and *P. carbonifera*, from Alberta, refer to forms of the same species that should have been listed as *leomegra*. As it turns out, however, both are now regarded as synonyms of *P. rogenhoferi*, and the *rogenhoferi* that he lists was described in 1980 as a new species, *P. propodea* McCabe, too late for inclusion in Morris's book. *Hyphantria cunea* and *H. textor* are generally regarded as one species, although Morris lists both. One is left guessing as to how he distinguished them. His figure of *cunea* on plate 10 is the immaculate form that has been regarded as *textor*, and his figure of *textor* appears to be *Spilosoma congrua*, not otherwise known from Newfoundland but possibly present. On plate 26 the figures of *Malacosoma americanum* (Figs. 1, 2) and *M. disstria* (Figs. 3, 4) are reversed. Pl. 28, Fig. 9, shows a specimen of *Dysstroma truncata* (not listed) as *D. walkerata*, although Fig. 10 is correctly determined as *walkerata*. The latter is the peculiar black and white subspecies that occurs there. The species illustrated as *Thera contractata* (Pl. 28, Fig. 16) is *T. juniperata* (L.), an introduced palearctic species now widely distributed in the Northeast. The report of *T. otisi* is puzzling because the illustration (Pl. 28, Fig. 17) really does look more like that species than like *contractata*. Otherwise, I would dismiss it as a probable misidentification of *contractata*, which I have collected in Newfoundland myself. Pl. 31, Fig. 6, shows an aberrant specimen that I would not recognize as *Anacamptodes vellivolata*, although it may be one. Pl. 31, Fig. 14, appears to show a specimen of *Homochlodes lactispargaria*, not *H. fritillaria* as stated. Fig. 15 on the same plate shows the summer form of *Plagodis phlogosaria*, which would not be expected to occur in Newfoundland where there is no second brood. Only the spring form shown in Fig. 16 should be present. Differentiation between nominate *Metarranthis duaria* and its supposed northern subspecies, *septentrionaria*, is unsatisfactory because both were described from Canada. Whatever name is used, the Newfoundland population is certainly of the usual northern type and variable, as the species is everywhere. The U.S. National Collection has Newfoundland specimens even darker than that shown on Pl. 32, Fig. 2, the "subspecies" said not to occur there. The specimen shown on Pl. 29, Fig. 25, as *Perizoma basaliata* is not that species but *P. grandis* Hulst. Both species occur in Newfoundland. Pl. 29, Fig. 32, shows what appears to be a specimen of *Hydrelia condensata* (Gn.) rather than *inornata*, the latter name being a synonym of *lucata* (correctly identified in Fig. 31). Inasmuch as *Cerastis tenebrifera* does not occur in Nova Scotia, I question the records from Newfoundland and think it more likely that they were based on misidentified specimens of the closely similar *Metalepsis fishi*. The species of *Hyppa* reported as *indistincta* appears to be what I have identified from Newfoundland as *H. brunneicrista* Sm.; at least it almost exactly matches material

of the latter species from Alberta. The type of *indistincta* in the U.S. National Museum is something different. Pl. 33, Fig. 3, shows a specimen of *Estigmene acrea arizonensis* Roths. that must have come from the western U.S. In choosing an example for illustration, the author apparently overlooked the fact that eastern males, including those from Newfoundland, always have yellow hindwings.

The one most irritating feature of the book is its failure to indicate the geographical source of the illustrated specimens, especially those representing rare or doubtfully identified species. Obviously, some of those shown are from Newfoundland or Labrador, but many are not, and the permanent visual evidence that might have been afforded by the inclusion of label data in the legends is needlessly lost. Illustrations of the following species are among many for which specimen data would have been of considerable interest: *Speyeria atlantis* (does not look like subspecies *canadensis*); *Spilosoma congrua* (identified as *Hyphantria textor*); *Arctia caja* (not the arctic subspecies that occurs in Labrador); *Agrotis volubilis* (figure correctly identified as *volubilis*, but is the specimen from Newfoundland? I had supposed, perhaps incorrectly, that *A. musa* replaces *A. volubilis* there); *Agrotis obliqua* (questionable record of a western species); *Amathes c-nigrum* (now *Xestia* spp.) (very pale hindwings; looks like a European specimen); *Cerastis tenebrifera* (questionable record); *Cucullia asteroides* (the figured specimen is this species, but its presence in Newfoundland is unlikely); *Lithophane lepida* (not the brightly marked form that one would expect in Newfoundland; looks like southern subspecies *adipel* Benj.); *Trichoptexia exornata* (figure does not appear to agree with the very large, distinctly marked form common in Newfoundland); *Platysenta sutor* (a southern species that occurs only as a casual immigrant northward); *Epizeuxis aemula* (appears to be the true *aemula*, although all Newfoundland material that I have seen belongs to a different, closely related species); *Itame argillacearia* (not in Nova Scotia); *Itame exauspicata* (not in Nova Scotia); *Agrochola lota*; and *Acronicta auricoma* (new North American records).

Another criticism concerns the way in which life history information is cited. The statement, "Details of the immature stages in Newfoundland and Labrador are not available," appears frequently, thus implying that such information, when given, is original or from some local source. Obviously, this is not so. I found no evidence in the introduction or elsewhere that any Lepidoptera were reared in connection with this project and concluded that the data were gleaned from many sources. I noted two conspicuous instances of misleading host information. Wax myrtle (*Myrica cerifera*) is an impossible host for any *Rheumaptera* species (p. 239) because it is a southern shrub that grows only where these moths do not occur. They do feed on *Myrica gale* and *M. pensylvanica*. In the discussion of *Papilio brevicauda* (pp. 33, 34), what has long been recognized as the major host plant is not mentioned. This is a seashore umbel, *Ligusticum scoticum*, whole stands of which sometimes may be decimated by larvae of this butterfly. The plants cited, *Heracleum* and *Angelica*, seem to be secondary hosts that are not much used where *Ligusticum* is available.

Although Morris searched the literature extensively for Newfoundland and Labrador records, he overlooked a few. *Psychophora phocata* (Möschler) was described from Labrador. *Hydriomena exculpata nanata* McD. is represented from Hopedale, Labrador by a paratype in the Canadian National Collection (and there are specimens from Newfoundland in the British Museum (Nat. Hist.)). Covell (1970, Trans. Amer. Entomol. Soc. 96:145) reported *Scopula limboundata* (Haw.) from Grand Lake, Newfoundland. *Anomogyna homogena conditoides* Benj. was originally described from a large series from Salmonier, on the Avalon Peninsula. Forbes (1954, Cornell Exp. Stn. Mem. 329:249) mentioned a specimen of an unidentified *Merolonche* species from Hopedale, Labrador. Although the location of that specimen is unknown to me, I verified the presence of such a species by collecting *Merolonche ursina* Sm. (otherwise a Rocky Mountain species) in southwest Newfoundland. In a paper on host records that I published in 1975 (U.S. Dept. Agric. Tech. Bull. 1521), several species are mentioned from Newfoundland, and two of these are not reported by Morris. The larva of *Papaipema harrisi* (Grt.) was collected from stems of cow parsnip, *Heracleum lanatum*, at Millville,

Codroy Valley, and *Homochlodes lactispargaria* (Wlk.) was reared on braken fern, *Pteridium aquilinum*, from a female collected at the same place.

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Cover illustration: Adult of the squash vine borer, *Melittia cucurbitae* (Harris) (Sesiidae), which occurs in the eastern half of the United States and along the Gulf Coast into Vera Cruz, Mexico. The larvae are destructive borers in the vines of various cultivars of *Cucurbita* spp. (squash, pumpkins and gourds). Original drawing by Dr. Charles S. Papp, Sierra Graphics & Typography, 1722 J Street #19, Sacramento, CA 95814, USA.

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A NEW CLEARWING MOTH (SESIIDAE) FROM CENTRAL AMERICA: A STEM BORER IN *MIMOSA PIGRA*

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AND

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ABSTRACT. The eggs, last instar larva, pupa, and adult of a new species of Sesiidae, *Carmenta mimosa*, are described. This species is known to occur from southern Mexico to Nicaragua and has been reared from *Mimosa pigra* L.

This species is being described now to provide a name for a publication on insects injurious to *Mimosa pigra* L. (Leguminosae) in Honduras. This plant, native from Mexico to Argentina, is a serious weed pest in parts of northern Australia and Thailand. A survey to seek potential biological agents for control of the weed was conducted in 1981. This complements work by Australian scientists looking for natural enemies of *M. pigra* mainly in Brazil.

Engelhardt (1946) included 24 North American species in his concept of the genus *Carmenta*. MacKay (1968) in her study of the larvae of North American species restricted the genus *Carmenta* by placing some species of the "complex" in her "new genus I" and in *Alcathoe* Hy. Edw., based solely on larval characters. Duckworth and Eichlin (1977a) considered 25 species to be in the genus north of Mexico, three more having been added to the list since that publication. Heppner and Duckworth (1981) list 31 species of *Carmenta* worldwide, mostly from the New World but a few from the Australian region. Preliminary sorting of the Neotropical species by Eichlin reveals that the genus will eventually contain many more species (200+) once this portion of



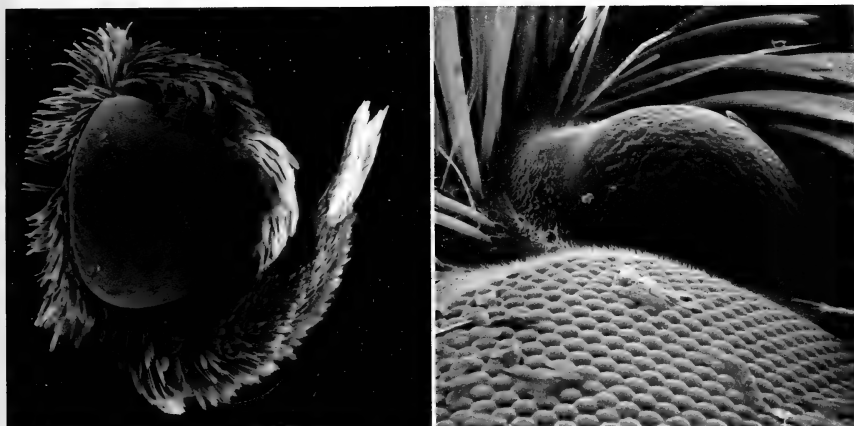
FIG. 1. *Carmenta mimosa*, n. sp., allotype female, near Linares, Nuevo Leon, Mexico.

major revisionary studies on Western Hemisphere Sesiidae has been concluded (Duckworth & Eichlin, in prep.).

One species from Argentina and Chile, *C. haematica* (Ureta), has been recommended for biological control of broomweed, *Gutierrezia* sp. (DeLoach, 1980).

***Carmenta mimosa* Eichlin and Passoa, new species**
(Figs. 1-22)

Description. Male: Head (Figs. 2-3) with vertex brown-black; front brownish gray, some white scales laterally; proboscis present, coiled; occipital fringe white or pale yellow dorsally, brown-black laterally with a few white scales mixed; antenna relatively short, thickened apically, less than one-half of forewing length, ciliate ventrally, dorsally brown-black with yellow powdered to apex, strongest apically; labial palpus slightly exceeding top of front, expanded somewhat laterally with roughened scales but sculptured ventrally appearing flattened, brown-black, strongly mixed with white ventrally, some pale yellow dorsally and on apical segment. Thorax brown-black, with narrow subdorsal yellow stripes; laterally with pale yellow at wing base and anteriorly. Abdomen constricted at base, brown-black, pale yellow on anterior half of segment 1, narrow pale yellow bands on posterior margin of segments 2, 4, 6 and 7 but may vary from bands only on 2 and 4 to bands on all segments, the latter condition apparently uncommon; ventrally, characteristically with segments 1 and 2 white, segment 4 pale yellow on posterior half, scales on posterior end forming keel; anal tuft not conspicuous at rest, narrowed to blunt point, laterally downwardly appressed, brown-black with some white scales mixed laterally.



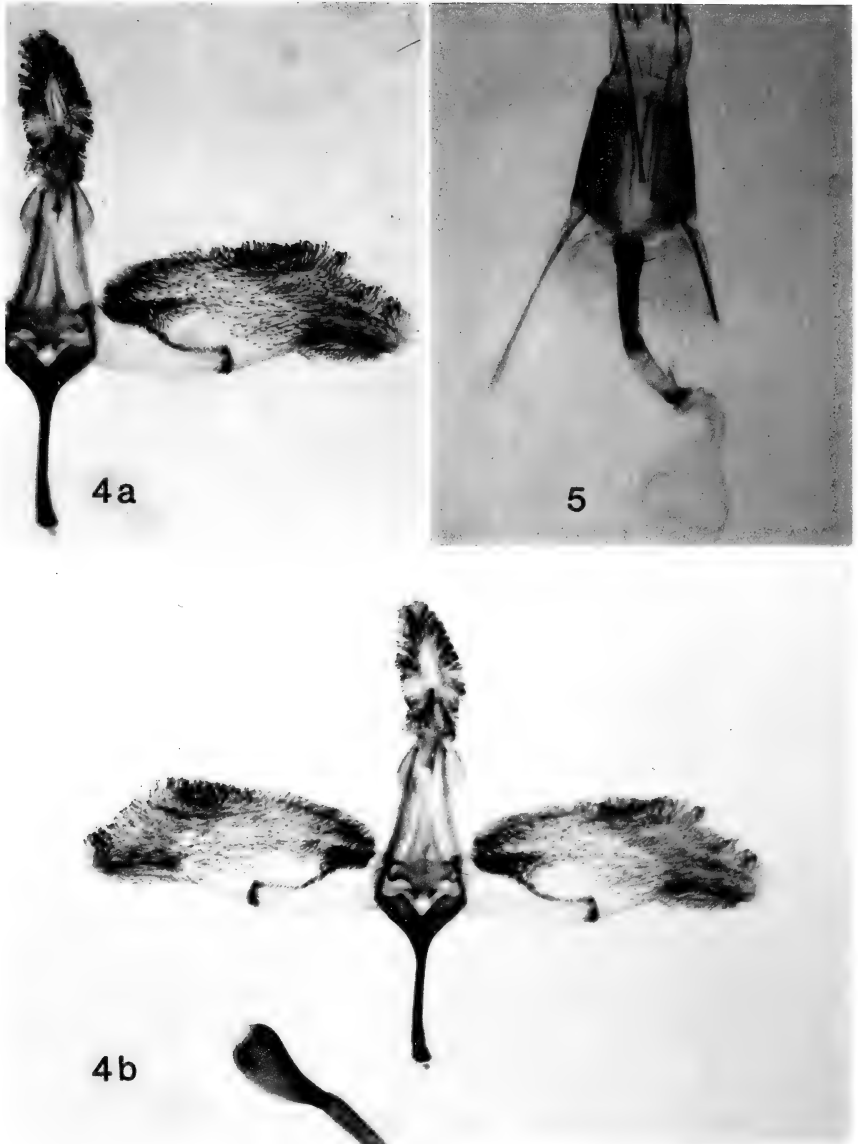
FIGS. 2, 3. Scanning electron micrographs of head of *Carmenta mimosa*, n. sp. **2** (left), side view, $\times 44$; **3** (right), close-up of ocellus, $\times 320$.

Legs mostly brown-black, pale yellow at base of forecoxa; some white mixed on tibial tufts, on spurs and powdered inside. Forewing mostly hyaline, margins very narrow, brown-black with pale orange to pale yellow powdered on discal spot, and margins, including apically between veins; more strongly powdered on underside of wings. Hindwing hyaline; costal margin powdered pale yellow; fringe concolorous with margins, becoming white at wing base. Wing length of male and female, 6–9 mm. Male genitalia (Figs. 4a, b) typical of *Carmenta* species, having elongate saccus approximately one-half length of valva, and saccular ridge apically abruptly downcurved to ventral margin of valva.

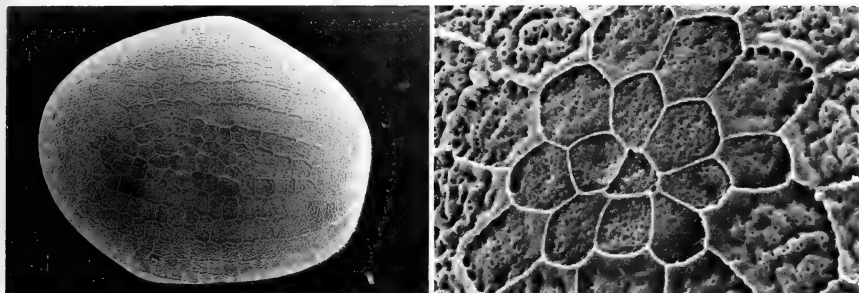
Female (Fig. 1): Antenna as on male but lacking ventral ciliation. Maculation much like described for male, perhaps with broader apical margin on forewing. Female genitalia (Fig. 5) typical for the genus, having ductus bursae pigmented and sclerotized for more than half its length (about two-thirds), with ductus seminalis originating from ductus bursae anteriorly beyond middle.

Egg (Figs. 6, 7). Somewhat obovoid in shape, $0.50 \pm 0.03 \times 0.33 \pm 0.02$ mm, with anterior end (micropylar end) slightly flattened; posterior end rounded; top rounded, perhaps slightly depressed in center, bottom flattened. Surface of chorion minutely bumpy, resembling skin of orange; covered by aeropyles; reticulate pattern of low narrow ridges which intersect to form irregular, mostly hexagonal designs. Micropyle consisting of nearly triangular shaped pit with hole at each corner, surrounded by rosette of about seven oblong petal-like primary cells, which are then surrounded by approximately 11 larger secondary cells of similar shape; surface within micropylar cells smoother than surface of other cells, with reduced number of aeropyles.

Larva (Figs. 9–19). Body cream colored; head tan-brown; tonofibrillary platelets faintly visible, forming two wide horizontal bands; adfrontals nearly reaching vertical angle; six stemmata: stemmata 5 and 6 separated from 1–4; prothoracic shield with two oblique lines, one on each side of midline; below this is group of pigmented spots; pinacula inconspicuous, concolorous with body. Mouthparts: Mandible with four teeth; two lateral mandibular setae present; spinneret about two times length of basal segment of labial palps; hypopharyngeal complex with proximomedial region membranous, each side with long ridge covered by fine spines; two minute stipular setae present. Crochets: Homoideous, uniserial, fewer on A6 compared to A7 ($\bar{x} = 31:39$ total number respectively); anal prolegs have small papillae above anal crochets. Chaetotaxy (setae as in MacKay, 1968):



FIGS. 4, 5. Genitalia of *Carmenta mimosa*, n. sp. (ventral view). 4a, b, male genitalia; 5, female genitalia.

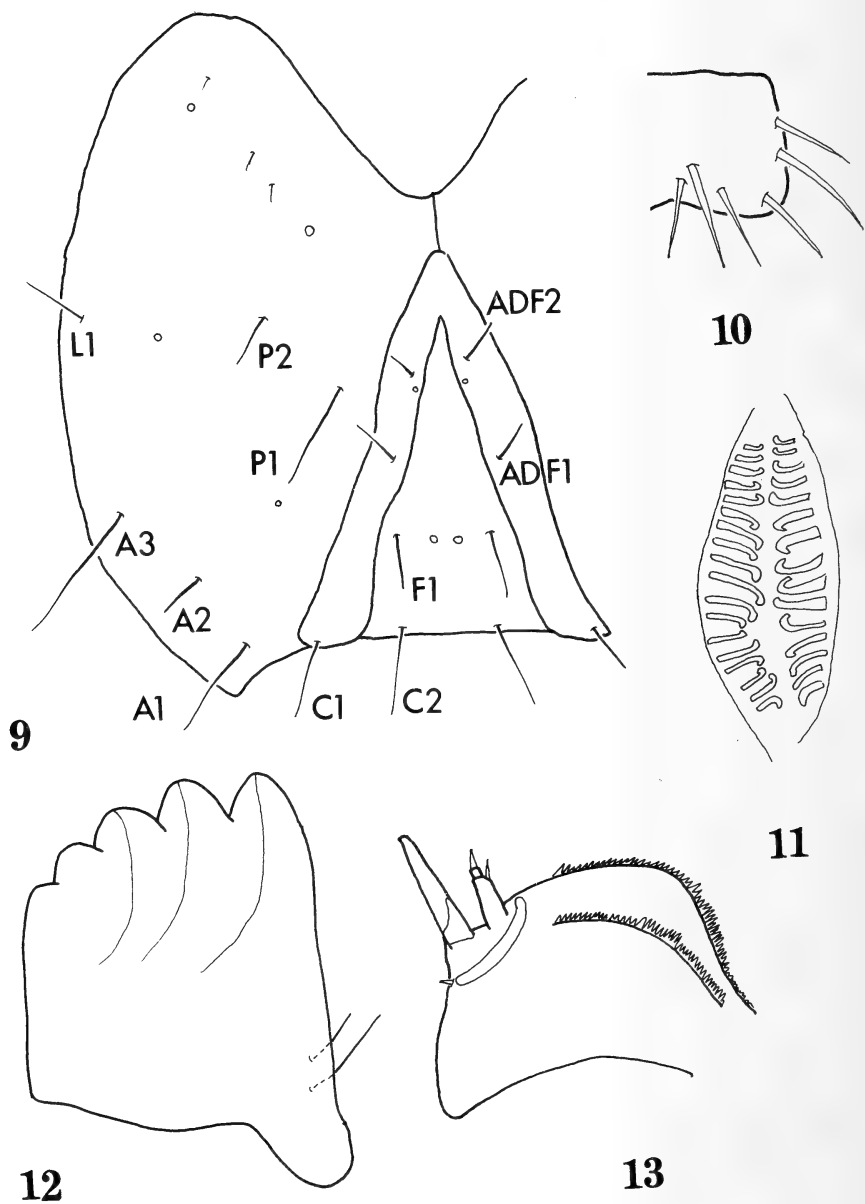


FIGS. 6, 7. Scanning electron micrographs of egg of *Carmenta mimosa*, n. sp. 6 (left), top view (micropyle on right end), $\times 180$; 7 (right), close-up of end with micropylar area, $\times 600$.

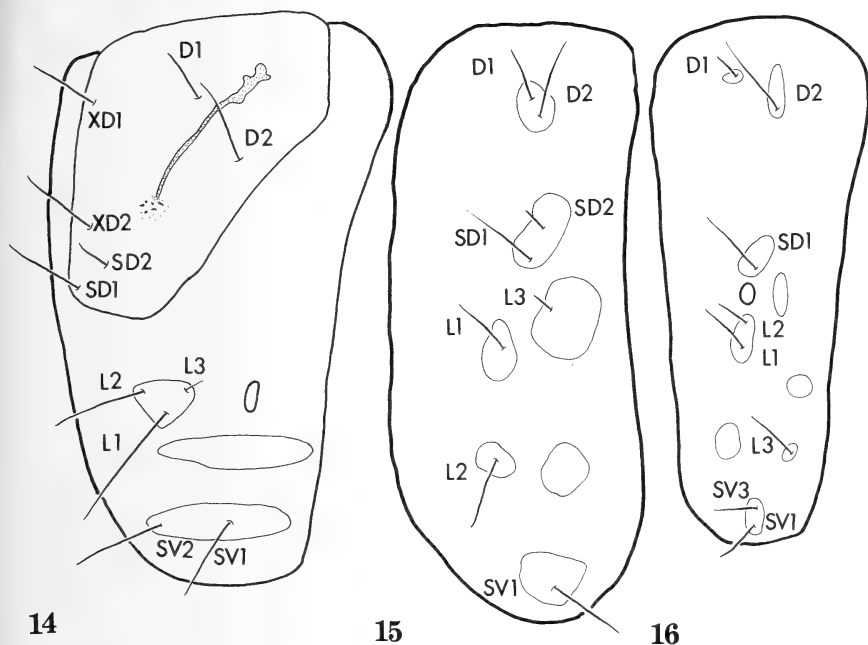
Head with Adf1 and Adf2 widely separately from each other; frontal setae in line with frontal pores; clypeal setae as shown; labrum with medial and lateral setae as shown. Epicrania with three vertical setae in straight line angled toward Adf2; P1 long, below P2; L1 and A3 above A1 and A2; O1 between stemmata 2 and 3; O2 below stemma 1;



FIG. 8. Larva of *Carmenta mimosa* in chamber exposed in branch of host plant, *Mimosa pigra*.



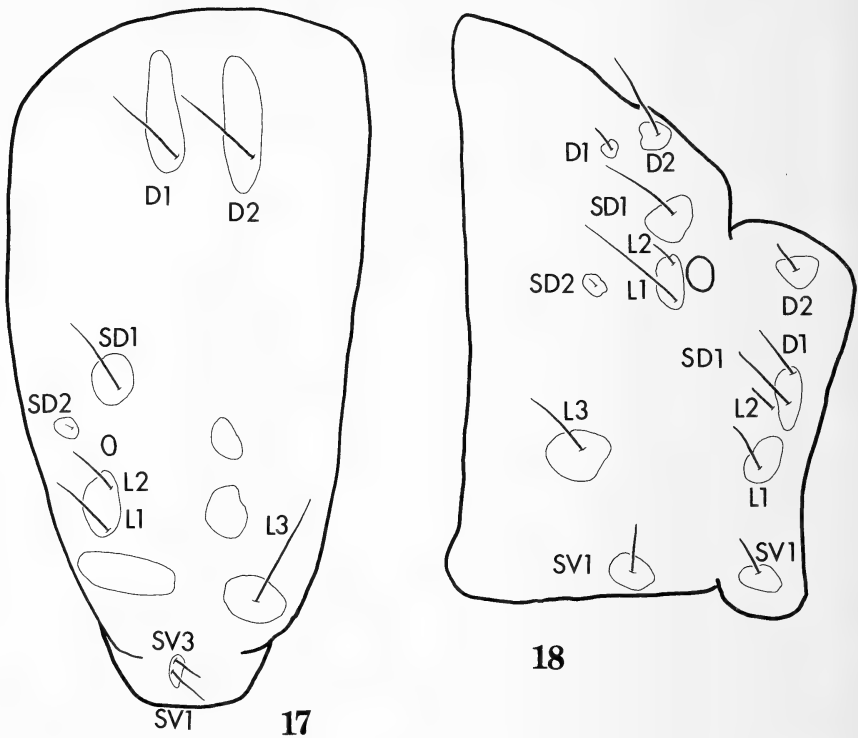
FIGS. 9-13. *Carmenta mimosa* larva. 9, epicrania and front; 10, labrum; 11, crochets on abdominal segment one; 12, mandible, ventral view; 13, spinneret and hypopharyngeal complex. (See p. 206 for abbreviations used in figures 9-19.)



FIGS. 14-16. *Carmentia mimosa* larval chaetotaxy (lateral view). 14, prothorax; 15, mesothorax; 16, first abdominal segment.

SO3 below stemma 6; SO2 between stemmata 5 and 6; O3 remote from SO3 and stemma 6. Prothorax with D2 longer than D1; XD1, XD2 and SD1 in a vertical row, SD2 smaller, behind and below XD2; prespiracular group trisetose, L3 much shorter than L1 or L2, all on triangular pinaculum; two SV setae widely spaced. Mesothorax with D2 longer than D1, both on same pinaculum; SD1 on same pinaculum with SD2; the position of L1 variable, more commonly close to L3, or equidistant between L3 and L2; one sub-ventral seta behind and below L2. Abdominal segment one with D2 below D1; SD2 minute; SD1 above spiracle; L2 and L1 below spiracle on same pinaculum; L3 closer to SV3 than to L1; SV group bisetose, on same pinaculum. Abdominal segment seven with D2 longer than D1, each one on an oblong transverse pinaculum; SD1 above spiracle; SD2 minute, in front of spiracle; L1 and L2 on same pinaculum, below spiracle; L3 widely spaced from L1; SV group bisetose, on same pinaculum. Abdominal segment eight with D2 above D1; SD1 below D2 and D1; L1 longer than L2; SD2 minute, in front of L2 + L1; L3 below SD2; one SV seta present. Abdominal segment nine with D2 above D1 and SD1, latter two setae on one pinaculum; L2 present but reduced; L1 above SV1. Anal shield with SD1, L1 and D2 along margin; D1 smaller and set inward; one ventral seta present on all segments.

Pupa (Figs. 20-23). Uniformly tan-brown in color. Head: Frons with projecting circular ridge and two large carinae near eyes; labrum triangular, with 4 setae, inner ones largest; mandibles elevated; maxillary palps present, almost reaching maxillae; antennae about $\frac{3}{4}$ length of wings; maxillae long, ending slightly before caudal margin of wings; labial palps present, widest in middle. Thorax: Prothoracic femur exposed; dorsum of prothorax with single median transverse ridge, mesothorax with one median ridge flanked



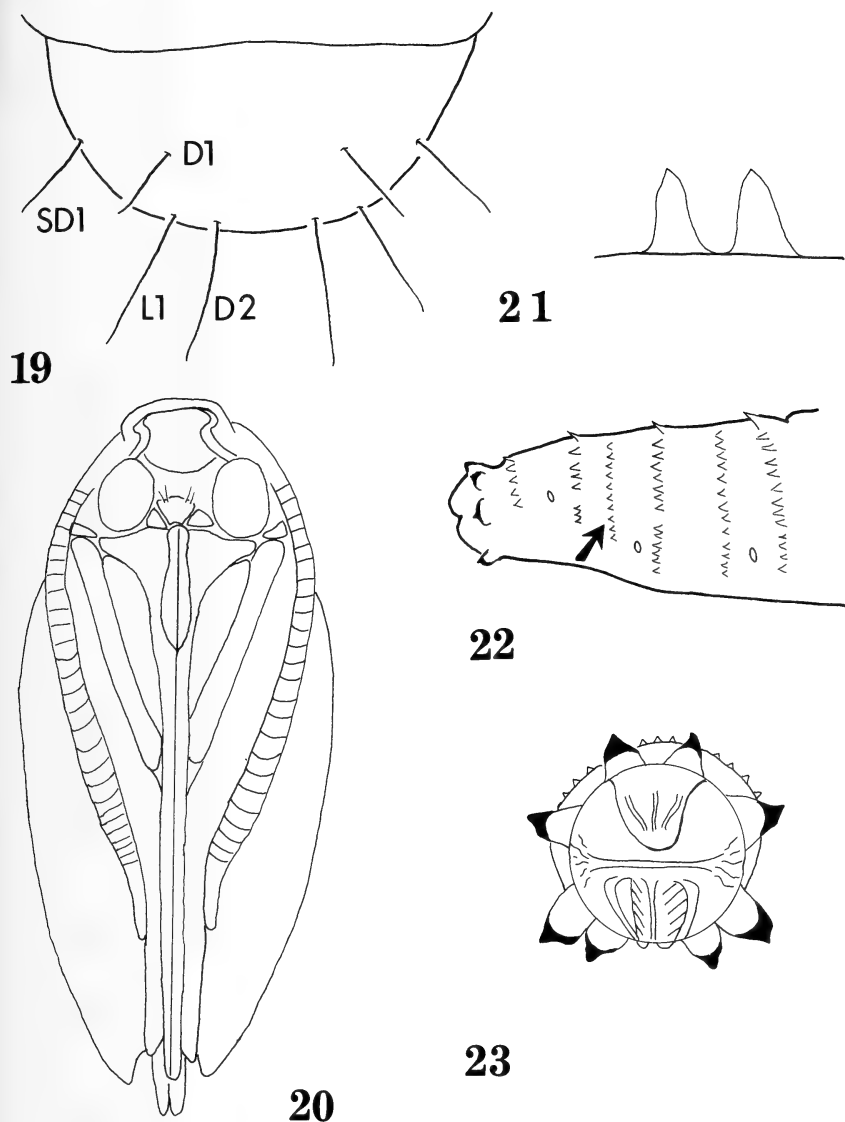
FIGS. 17, 18. *Carmenta mimosa* larval chaetotaxy (lateral view). **17**, seventh abdominal segment; **18**, abdominal segments 8 and 9.

on each side by two furrows; prothoracic leg about half length of maxillae; only tips of metathoracic legs exposed. Abdomen: A2 and A8-9 with single transverse row of stout spines dorsally; A3-6 with two rows of dorsolateral spines, those on anterior margin larger and more stout than those on posterior margin; on A7 males have two rows, females one; cremaster absent, in its place eight flattened spines irregularly spaced in circular pattern with their tips heavily sclerotized.

Host. *Mimosa pigra* L. (Figs. 24-25).

Distribution. MEXICO: Nuevo Leon, Michoacan and Oaxaca; HONDURAS and NICARAGUA.

Types. HOLOTYPE: ♂, HONDURAS, 30 km SE Siguatopeque, VI-15-1979, J. A. Chemsak, collector (California Insect Survey, Berkeley). ALLOTYPE: ♀, MEXICO, Nuevo Leon, 18 mi. W Linare, IX-17-76, J. A. Powell & J. A. Chemsak, collectors (California Insect Survey, Berkeley). PARATYPES 21: 2♂♂, 1♀, HONDURAS, Dept. Comayagua, Comayagua, reared ex. *Mimosa pigra*, S. Passoa, coll. I-9&10-81, (1 ♂, 1 ♀) emerged I-12-81, (1 ♂) emerged II-10-81, Genitalia Slide CDA #520, (1 ♀) Genitalia Slide CDA #610; 13 ♂♂, HONDURAS, Yoro, El Progreso, IV/10-15/79, C. Gentry, Pherocon 1C trap baited w Z,Z-ODDA, (1 ♂) Genitalia Slide CDA #522. 1 ♂, NICARAGUA, San Ramon, Matagalpa, VII-11-78, C. Gentry, Pherocon 1C trap baited w Z,Z-ODDA. 2 ♂♂, MEXICO, Oaxaca, Temascal, K. H. Janzen, collector (California Insect Survey, Berkeley), (1 ♂) X-10-1963, (1 ♂) X-3-1963, Genitalia Slide CDA #094; 1 ♀, MEXICO, Michoacan, Cotija, IX-14-



FIGS. 19-23. *Carmenta mimosa*, larva and pupa. 19, anal shield, dorsal view; 20, pupa, ventral view; 21, close-up of pupal abdominal spines; 22, pupal abdomen, lateral view, male (female lacks the indicated row); 23, caudal view of pupal terminal abdominal segment.

24



25



FIGS. 24, 25. *Mimosa pigra*, host plant for *Carmenta mimosa*, Comayagua, Honduras.

1975, B. Villegas (University of California, Davis). Paratypes will be distributed among the two California institution collections listed above; Florida State Collection of Arthropods, Gainesville; National Museum of Natural History, Washington, D.C., and Passoa's collection.

Also, the following material was studied: HONDURAS, Dept. of Comayagua, on *Mimosa pigra* (5 preserved larvae and 4 pupae associated with the reared adults mentioned above): 3 larvae in alcohol, 2 on slides with skin (lepidoptera mandible slides #200, 201, S. Passoa collection), 4 pupae, 2 cast pupal exuviae (one with larval skin mounted, lepidoptera mandible slide #19, Fla. State Coll. of Arthropods), 1 in alcohol (died close to eclosion, female genitalia dissected out, genitalia slide #267, S. Passoa Coll.), 1 pinned, Honduras, Dept. of Comayagua, Comayagua, XII-8-1981, in stem of *Mimosa pigra*, larva, not fully grown, lepidoptera mandible slide #18, Fla. State Coll. of Arthropods. This material will be placed in the Florida State Collection of Arthropods, University of California (Berkeley), and Passoa's private collection.

Discussion. With its clear wings, slender legs, shortened antennae, abdomen with narrow pale banding and constricted "waist," labial palps sculptured to resemble mandibles when viewed face-on, *C. mimosa* effectively creates the impression of being a small species of vespid wasp. In Honduras the genus *Polybia* (Hymenoptera: Vespidae) resembles *C. mimosa* in markings, and this wasp is relatively common.

As reported in the above data the adults from Comayagua, Honduras were reared from *Mimosa pigra*. A male and female emerged on 12 January 1981 from pupae extracted from the branches a few days earlier. Another male emerged on 10 February 1981 from a section of branch where the larva was first observed on 9 January. Another larva was collected at the same clump of plants a year later (Fig. 8).

The 13 male adults from El Progreso, Honduras were collected from 10 April to 13 June 1979 in sticky traps baited with a sex attractant containing about 96% of the Z,Z isomer of 3,13-octadecadien-1-ol acetate (Z,Z-ODDA), a major component of the sex pheromone systems of various sesiids (Duckworth & Eichlin, 1977b; Karandinos et al., 1977; Sharp et al., 1978; Sharp & Eichlin, 1979; Neal & Eichlin, 1983; Nielsen, 1979; Reed et al., 1981). An additional male was captured in the same manner in Matagalpa, Nicaragua, 11 July 1978.

The Mexican specimens were captured in September and October. From the limited label data it appears as though the flight period extends over a long time (April to October); or the flight period varies depending on the locality; or there is more than one generation per year; or the actual situation involves some combination of the above possibilities.

Carmenta prosopis (Hy. Edwards), a slightly smaller species on the average (wing length 5–8 mm) occurring from northern Mexico into southwestern United States, has been reared on several occasions from species of *Prosopis* (mesquite) and from *Mimosa biuncifera* Benth., where they developed as inquilines in hymenopteran-caused stem galls

(Engelhardt, 1946). *C. prosopis* also has the somewhat unusually shortened antennae found on *C. mimosa* but lacks the narrow waist and differs in several details of maculation and structures of the genitalia. Two other species in a closely related genus, *Aegerina harti* (Druce) and *A. vignae* (Busck, 1929), are known to be borers in various leguminous plants, some of which are cultivated species (Duckworth & Eichlin, 1978). These moths also have shortened antennae and constricted abdomens but differ from *C. mimosa* mainly in details of genitalic morphology.

In Mosher's key (1916), the pupae of *C. mimosa* will key out with *Podosesia* Möschler and *Memythrus* Newman (= *Paranthrene* Hübn-ner), due to the unarmed clypeus. However, *Paranthrene* are larger, 20–25 mm, than *C. mimosa* which measures only 8–15 mm. *Podosesia*, as illustrated by Mosher, differs from *C. mimosa* in that the maxillae extend $\frac{3}{4}$ of the way to the caudal margins of the wings. In *C. mimosa* they extend $\frac{9}{10}$ that distance.

The larva of *C. mimosa* agrees with MacKay's (1968) definition of the genus in having both D1 and D2 on large pinacula, especially on abdominal segment seven. The prespiracular group is arranged in an equilateral triangle rather than in an obtuse angle as in other members of the genus *Carmenta* as defined by MacKay. Specific identification will likely depend on small differences in the size and shape of the various pinacula. Unfortunately, these pinacula can be difficult to see unless the larval skin is cleared. Certain pinacula lacking setae are present but were not named by MacKay. In this study they are all illustrated but also left unnamed.

External symptoms of larval damage include exit holes in the stems of the host and frass extruding from the holes. *C. mimosa* apparently was not seriously damaging its host in Honduras. However, larvae were collected from the same clump of plants in successive years, and such cumulative damage might weaken the plant in the long run. *C. mimosa* might be effective as a biological control agent in areas where strong winds and heavy rains make such a weakness in the stem a liability to the plant. Although the borer was never collected from any commercial crops in Honduras during a three year period (Passoa, unpub. data), some related species attack economically important legumes. Host specificity tests on this insect should include legumes. The use of pheromones for sampling populations could allow for easy evaluation of establishment if releases are made.

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We thank the following individuals and their institutions for the loan of material used to describe this species: D. H. Habeck, University of Florida, Gainesville; J. A. Powell,

University of California, Berkeley; R. O. Schuster, University of California, Davis. We are grateful to C. R. Gentry, USDA/SEA-AR, Southeastern Fruit and Tree Nut Laboratory, Byron, Georgia, for trapping the series of specimens with attractants in Honduras and supplying them for this study. Thanks also to J. H. Tumlinson, USDA/SEA-AR, Insect Attractants, Behavior and Basic Biology Research Laboratory, Gainesville, Florida, for providing attractants used in this and most of our research. We appreciate the constructive reviews of the manuscript by G. Buckingham and D. Habeck, University of Florida, Gainesville. Preparation of genitalia slides and other technical assistance were provided by Magda R. Papp, Biological Technician, California Department of Food and Agriculture, Sacramento.

Special thanks are due to Kyra Carroll, Peace Corps (Honduras); her company during long field trips, sharp eyes for collecting, and help in choosing field sites are appreciated. The field work in Honduras was supported by the International Plant Protection Center, Aquatic Weed Program, at the University of Florida. We wish to thank M. Fonseca, Agriculture Director, Peace Corps, Honduras, for his guidance. G. Reyes, Regional Director, Recursos Naturales, Comayagua, kindly provided office space and equipment needed to carry out this study.

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Abbreviations used in figures (9-19) of immature stages:

- (A1, A2, A3)—first, second and third anterior setae
- (ADF1, ADF2)—first and second adfrontal setae
- (C1, C2)—clypeal setae
- (D1, D2)—first and second dorsal setae
- (F1)—frontal seta
- (L1, L2, L3)—first, second, and third lateral setae
- (P1, P2)—first and second posterior setae
- (SD1, SD2)—first and second subdorsal setae
- (SV1, SV2, SV3)—first, second, and third subventral setae
- (XD1, XD2)—first and second prothoracic dorsal setae

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OBITUARY

JOSEPH MULLER (1903-1982)

Joseph Muller of Lebanon, New Jersey died in September 1982 at the age of 79 years.

Joe had pretty much devoted a lifetime to Lepidoptera. He came to this country from his native Alsace-Lorraine as a young adult and spent the remainder of his life in New Jersey. He was always identified with the Newark Entomological Society and indeed for years the Fall meeting of that group was held at his home. He loved to recall the society beer fests of an earlier era.

Joe was an authority on the butterflies and moths of New Jersey and frequently reported new records, particularly moths, from our state. He authored many articles, some of which appeared in the *Journal of the Lepidopterists' Society*. In recent years, one of his favorite haunts was the farm of Dr. Brooke Worth in Eldora, Cape May County, which has been featured in national publications of the Nature Conservancy and Audubon Society.

The Muller collection has been donated to the American Museum of Natural History. His spirit and interest in insects and his zest for the chase live on with those who knew him well.

JOHN J. BOWE, *Van Neste Medical Arts Center, 127 Union Street, Ridgewood, New Jersey 07450.*

VARIATION AND HOST SPECIFICITY IN THE YUCCA MOTH, *TEGETICULA YUCCASELLA* (INCURVARIIDAE): A MORPHOMETRIC APPROACH

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Las Cruces, New Mexico 88003

ABSTRACT. Moths presently recognized as *Tegeticula yuccasella* Riley were collected from flowers of *Y. baccata*, *Y. elata*, and *Y. torreyi* from Dona Ana County, New Mexico. All three yucca species occurred sympatrically and only *Y. elata* bloomed later than the other two. A morphometric analysis, using characters of the wings and genitalia and color of the antennae, was carried out on 225 individuals. The data were separated into three groups based on plant host species and analyzed using a stepwise discriminant analysis. Significant separation between the three groups resulted, with only three misclassifications. Three presumed separate taxa were described and compared based on the analysis, although it was not possible from this study to determine their relationship to nominotypic *T. yuccasella*. For this reason, no new specific names are given.

Mutualistic relationships between plants and insect pollinators occur frequently in nature. Insect dependence on the plant for reasons other than a nectar source, however, are much less common. The relationship between the orchid *Stanhopea* and Euglossinae bees, and that between wasps of the family Agaonidae and fig trees, are both examples of highly specific pollination relationships (Dressler, 1968; Ramirez, 1969). In these relationships, specific pollinators exist for closely related species of plants and maintain genetic isolation between the species with which they are sympatric. These highly specific pollination relationships provide a strong basis for speciation and genetic isolation (Baker, 1963).

The mutualistic relationship between the yucca plant and the yucca moth is well known (Riley, 1872; Trelease, 1893; and Rau, 1945). The female moth, with its specialized mouthparts for depositing pollen in the stigma of the pistil, is the only effective pollinator of yuccas. The moth does not obtain nectar from the plant but is dependent upon it for the development of its larvae. The female deposits eggs in the ovary of a flower where the larvae feed on seeds until reaching maturity.

In contrast to the examples above, specific yucca moth pollinators are not known for sympatric and closely related yucca plants, except in yucca moths which pollinate Californian yuccas. Only two moth species are thought to pollinate all other species of yuccas in the United States and Mexico. One of these, *Parategeticula pollenifera* Davis, is known only in southeastern Arizona and Mexico (Davis, 1967). The other moth, *Tegeticula yuccasella* Riley, as presently recognized, is widely distributed across the United States and Mexico.

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Davis (1967) found that variation in the wings and genitalia of *T. yuccasella* was greater than in any other member of the subfamily Prodoxinae. Davis examined individuals from 11 species of yucca across the geographic range of *T. yuccasella* and found that differences in the wing measurements could be ascribed to geographical variation but that differences in the genitalia could not. The variation in the genitalia showed a high correlation with plant host species. Davis proposed that possibly a specific pollinator had evolved for each of the four sections (subgenera) of *Yucca*. *Yucca brevifolia* Engelm. and *Y. whipplei* Torr., which belong to the sections *Clistocarpa* and *Hesperoyucca*, respectively, are found in California and have specific pollinators. Davis postulated that *T. yuccasella* was a specific pollinator for the section *Chaenocarpa* and that possibly a sibling species is in the process of evolving for the section *Sarcocarpa*.

Southern New Mexico presents an excellent opportunity to examine variation in *T. yuccasella* due to host specificity for two reasons. First, three species of yucca representing two sections of the genus occur sympatrically in the area. *Yucca baccata* Torr. and *Y. torreyi* Shafer are members of the section *Sarcocarpa* and *Y. elata* Engelm. is a member of the section *Chaenocarpa*. Second, this sympatry minimizes the occluding effects of geographical variation, and one can concentrate on variation due principally to plant host specificity.

Basic differences that exist in the ecology and morphology of these three yucca species may be important when considering host specificity in plant pollination. The flowers are different in position on the plant, shape, odor, and time of flowering. *Y. elata* bloomed approximately one month later than *Y. baccata* and *Y. torreyi*, which were blooming simultaneously. Since adult yucca moths emerge when yuccas are first blooming, it was possible to collect adults from *Y. baccata* and *Y. torreyi* at the same place and time; whereas, adults from *Y. elata* were collected at the same place but at a different time.

Two possibilities are being explored: either 1) a specific pollinator has developed for the section *Chaenocarpa* and another for the section *Sarcocarpa*; or 2) a specific pollinator exists for each of the three species of yucca in southern New Mexico. The latter implies that more than one moth species pollinates the section *Sarcocarpa*.

MATERIALS AND METHODS

T. yuccasella were collected from newly opened flowers of yuccas from seven cities in the Las Cruces area of Dona Ana County, New Mexico, during the spring of 1979. All collecting was done during the day when individuals were inside flowers and could be easily captured. Moths were normally only found in newly opened flowers; therefore,

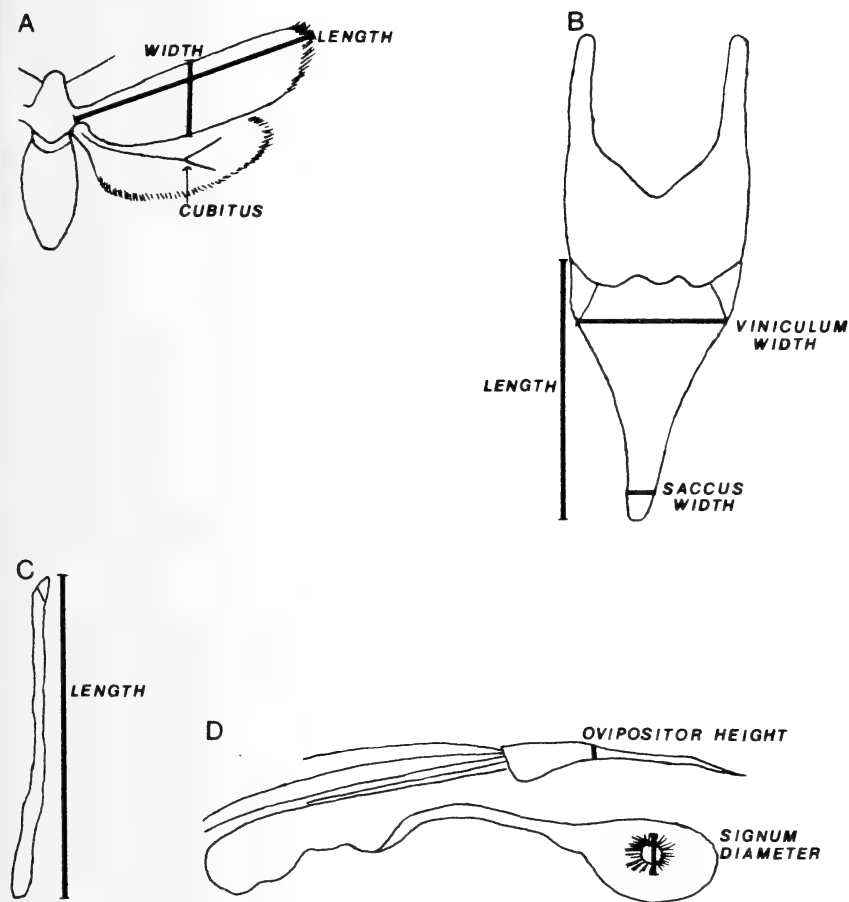


FIG. 1. Morphometric measurements taken from *T. yuccasella*: A, right forewing; B, male genitalia; C, aedeagus; D, female genitalia.

the number of suitable flowers at a given site on a given day was limited. An attempt was made to remove every moth from each plant found to be harboring moths. *Y. baccata* was first noted in bloom on 10 April, and had finished blooming by the last week in April. The first *Y. torreyi* seen in bloom was 14 April, and the last finished blooming by the end of April. *Y. elata* did not begin blooming until the third week in May although a few were observed in bloom until the end of June.

All specimens used in the morphometric analysis are deposited in the Museum of Entomology, Department of Biology, New Mexico State

TABLE 1. Means and standard deviations (mm), with sample sizes in parentheses, for *Tegeticula* collected from *Y. baccata*, *Y. torreyi*, and *Y. elata*.

Males	<i>Y. baccata</i>	<i>Y. torreyi</i>	<i>Y. elata</i>
Wing length	10.64 ± 0.46 (79)	11.43 ± 0.49 (67)	10.08 ± 0.63 (89)
Wing width	2.70 ± 0.20 (79)	3.05 ± 0.18 (67)	2.85 ± 0.22 (89)
Length of genitalia	2.50 ± 0.09 (52)	1.92 ± 0.09 (48)	1.53 ± 0.11 (49)
Width of vinculum	0.80 ± 0.08 (37)	0.90 ± 0.09 (30)	0.88 ± 0.12 (34)
Width of saccus	0.15 ± 0.03 (41)	0.20 ± 0.03 (46)	0.18 ± 0.04 (43)
Length of aedeagus	2.85 ± 0.14 (51)	2.19 ± 0.12 (48)	1.72 ± 0.13 (50)
Females			
Wing length	12.73 ± 0.61 (75)	13.28 ± 0.54 (66)	11.55 ± 0.55 (86)
Wing width	3.11 ± 0.21 (75)	3.47 ± 0.18 (66)	3.21 ± 0.20 (86)
Diameter of signum	0.40 ± 0.03 (24)	0.82 ± 0.10 (24)	1.04 ± 0.11 (23)
Height of ovipositor	0.10 ± 0.02 (17)	0.13 ± 0.02 (19)	0.09 ± 0.02 (21)

University, Las Cruces. Genitalia were removed from 150 males and 75 females and prepared following the method described by Burns (1964).

Characters were measured using a dissecting microscope with an ocular micrometer. Six quantitative characters for males and four for females were measured (Fig. 1). Male characters included the maximum length of the right forewing, width of the right forewing (as measured from a point perpendicular to the point where the cubitus of the hind wing branches), genitalic length (defined as the maximum length of the vinculum, to the tip of the saccus), width of the saccus, width of the vinculum, and length of the aedeagus. Female characters included the same two wing measurements plus the diameter of the signum including rays and height of the base of the ovipositor. The genital nomenclature follows Klots (1956). In addition to these quantitative characters, a single qualitative character was analyzed: in both males and females the color of the antennae. Seven categories were established: two categories were all yellow or all brown and the remaining five were bicolored as follows: white-black, light brown-black, white-yellow, white-brown, and light brown-yellow.

Six groups were obtained by separating according to the three host species and sexes of the insects. All analyses and programs used were of the BMDP series developed by the Health Science Computing Facility, University of California (Dixon, 1975). Basic statistics (BMDP1D) were carried out for each group to obtain means and standard deviations. Each of the six groups was subdivided by collecting sites and analyzed via analysis of variance (BMDP1V) to test for differences in means among localities. This was carried out to ensure that geograph-

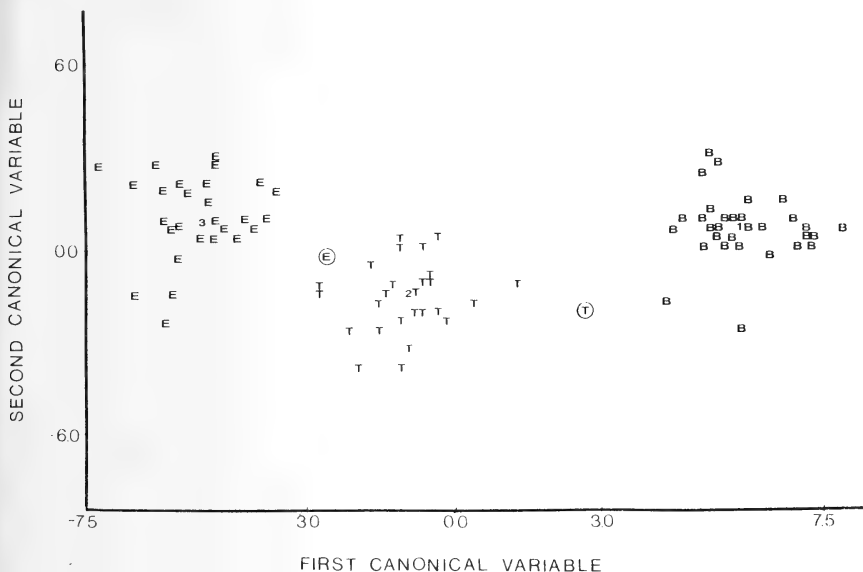


FIG. 2. Plot of the first two canonical variables from the stepwise discriminant analysis for 91 *Tegeticula* males. Numbers represent centroids; **E** represents individuals collected from *Y. elata*, **T** represents individuals collected from *Y. torreyi*, and **B** represents individuals collected from *Y. baccata*.

ical variation was nonsignificant ($P < 0.05$). After these preliminary analyses, separate discriminant analyses (BMDP7M) for males and females were used for determining discrimination among the three plant host groups. The discriminant function used is based on the Mahalanobis D^2 value, a measure of the metric distance between population centroids (Atchley & Bryant, 1975).

RESULTS

Two hundred and twenty-five moths were measured (Fig. 1). Wing and genitalic characters were quite distinct for each plant host group and are given in Table 1.

Fig. 2 shows the plot of the first two canonical variables for each of the three groups of males. The variables entered in their order of significance were length of the genitalia, wing length, length of the aedeagus, and width of the saccus. Of 91 individuals (the remaining cases were dropped because they contained missing data) there were only two misclassifications, giving an overall percent correct classification of 98.9. Misclassifications are circled on the figure.

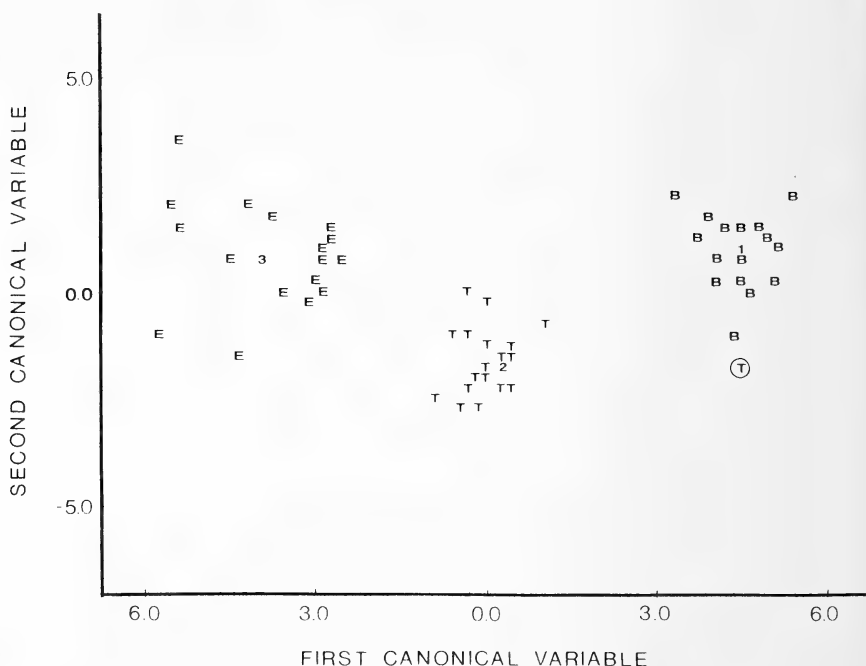


FIG. 3. Plot of the first two canonical variables from the stepwise discriminant analysis for 54 *Tegeticula* females. Numbers represent centroids; **E** represents individuals collected from *Y. elata*, **T** represents individuals collected from *Y. torreyi*, and **B** represents individuals collected from *Y. baccata*.

Fig. 3 shows the plot of the first two canonical variables for each of the three female groups. Signum diameter, antennal color, ovipositor height, and wing length were the characters entered in their order of significance. There was only one misclassification out of 54 individuals, giving an overall correct classification of 98.1%.

Table 2 shows the eigenvalues and coefficients for the first two canonical variables for both sexes. The first canonical variable is the linear combination of characters added that best discriminates among the groups.

A separation of groups of this magnitude with such little misclassification is strong evidence that three distinct taxa are present, especially when coupled with the host-specificity and sympatry data. It appears that three taxa of moths exist in southern New Mexico among populations previously considered to represent one species, *T. yuccasella*. One of the taxa revealed by the discriminant analyses may represent a geographical component of nominotypic *T. yuccasella*. Further re-

TABLE 2. Eigenvalues and coefficients for the first two canonical variables for males and females based on stepwise discriminant analysis.

Variable	Females	
	Coefficients for canonical variables	
	1	2
Wing length	-0.00364	-0.12587
Antennae color	-1.23943	0.69803
Signum diameter	-0.27162	-0.15915
Ovipositor height	0.37599	-0.88764
Constant term	8.37599	16.0337
Eigenvalue	12.0282	1.55944
Variable	Males	
	Coefficients for canonical variables	
	1	2
Wing length	-0.04152	-0.21477
Genitalia length	0.23821	0.12548
Aedeagus length	0.11516	-0.09967
Genitalia width	-0.19504	-0.49490
Constant term	-17.9077	17.9449
Eigenvalue	21.6712	0.89412

search needs to be conducted to determine the hierarchic ranking of the three taxa. Therefore, I include a diagnosis of each below without proposing formal names.

COMPARISON OF TAXA STUDIED

Tegeticula ex *Y. baccata*: Head white, with antennae usually white for the first half of length and black to tip, or occasionally antennae appear completely black due to wear; maxillary tentacle fully developed and labial palpus brown; thorax white; forewings white dorsally except for almost black fine line along proximal half of length of costal vein; forewings dark gray ventrally except for white fringe; length of the forewings 9.43 to 11.7 mm in males and 11.43 to 14.14 mm in females; hind wings dark gray dorsally, hind wings dark gray ventrally for costal one-third of length and lighter posterior two-thirds; fringe of hind wing gray, occasionally white; abdomen pale brown dorsally and white ventrally. Genitalia (Fig. 4): tegumen bilobed with lobes widely separated; saccus elongate and narrow; aedeagus elongate and slender, length 2.4 to 3.1 mm; ovipositor with convex minutely serrate ridge with slightly more than 30 teeth; height of the base of the ovipositor intermediate between other two species; signum and rays small with diameter 0.32 to 0.47 mm; number of rays exceeds 20.

This form was only collected from newly opened flowers of *Y. baccata* with the exception of six individuals collected on *Y. torreyi* flowers. These six individuals emerged after all available *Y. baccata* flowers were gone and *Y. torreyi* was the only yucca in bloom.

Tegeticula ex *Y. elata*: Head white, with antennae brown, yellow or bicolored white-brown; maxillary tentacle usually fully developed and labial palps brown; thorax white; forewings white dorsally except for fine black line along costal vein; forewings tan ven-

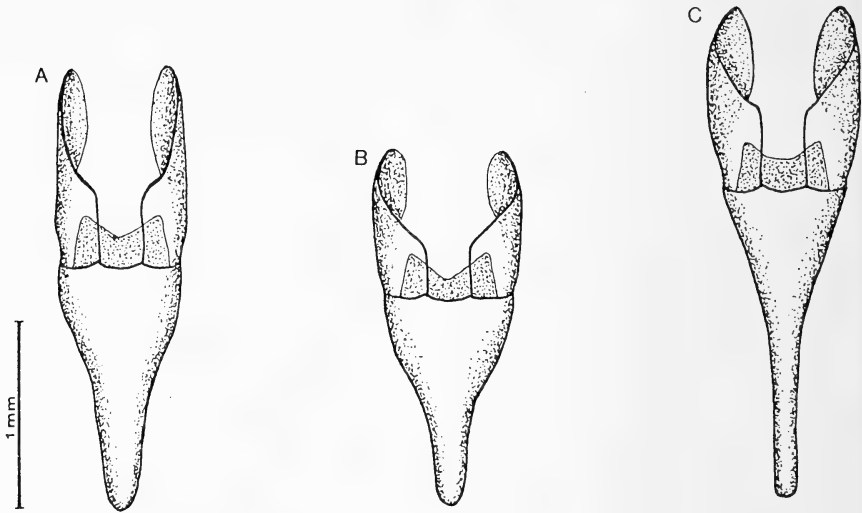


FIG. 4. Drawings of male genitalia: **A**, *Tegeticula ex Y. torreyi*; **B**, *Tegeticula ex Y. elata*; **C**, *Tegeticula ex Y. baccata*.

trally except for white fringe; occasionally white extends into margin of wing slightly; length of forewings 8.57 to 11.86 mm in males and 10.07 to 13.29 mm in females; hind wings tan to almost white dorsally; hind wings brown ventral costal one-third of length and white posterior two-thirds; fringe on hind wings white; abdomen white dorsally and ventrally. Genitalia (Fig. 4): tegumen bilobed with lobes widely separated; saccus much shorter and wider than in *Tegeticula ex Y. baccata*; aedeagus also much shorter, length 1.4 to 2.0 mm; ovipositor with minutely serrate ridge with slightly more than 30 teeth; height of the base of the ovipositor lowest of the three species; signum and rays largest in diameter of the three species, diameter 0.90 to 1.30 mm; number of rays exceeds 20.

This form was collected in newly opened flowers of *Y. elata*. This was the only available yucca species in bloom at the time these moths were active.

Tegeticula ex Y. torreyi: Head white, with antennae yellow or bicolored white-yellow; maxillary tentacle fully developed and labial palpus brown; thorax white; forewings white dorsally except for fine black line along costal vein; forewings gray ventrally with white fringe; gray lighter than in *Tegeticula ex Y. baccata*; length of forewings 10.43 to 13.00 mm in males and 12.14 to 14.57 mm in females; hind wings light gray ventrally, costal one-third of wing darker gray than posterior two-thirds; abdomen pale brown dorsally and white ventrally. Genitalia (Fig. 4): tegumen bilobed with lobes widely separated; saccus elongate but not as much as in *Tegeticula ex Y. baccata*; saccus wider than *Tegeticula ex Y. baccata*; aedeagus elongate and slender, length 2.0 to 2.8 mm; ovipositor with minutely serrate ridge with slightly more than 30 teeth; height of the base of the ovipositor intermediate between the other two species; signum and rays only slightly more narrow than *Tegeticula ex Y. elata*, diameter 0.43 to 0.93 mm; number of rays exceeds 20.

This form was collected from newly opened flowers of *Y. torreyi*. *Y.*

baccata was also in bloom at the same time but no individuals were collected from that plant.

Species Diagnosis

The characters that are best for distinguishing among the three moths are antennal color, wing color, abdomen color, male genitalia length and width, aedeagal length, signum diameter, and height of the base of the ovipositor. The genitalia and wing measurements given by Davis (1967) for *T. yuccasella* are highly variable and overlap those of these three moths in each case and cannot be used to separate them. It should be noted that the measurements taken by Davis included individuals collected from *Y. baccata*, *Y. elata*, and *Y. torreyi* in southern New Mexico and probably do not all represent *T. yuccasella*.

DISCUSSION

The results of this study support the hypothesis that a single species of moth exists for each of the three species of yucca in southern New Mexico. The data do not support Davis' hypothesis (1967) that one species exists for each of the sections of the genus *Yucca*. *Tegeticula* ex *Y. baccata* and *Tegeticula* ex *Y. torreyi* both have hosts within the section *Sarcocarpa* and are quite distinct morphologically. *T. yuccasella* as described by others, then, is a composite species. The study also implicates that in the Las Cruces area, one of these three moths may represent a subspecies of nominotypic *T. yuccasella*. To answer this question, additional studies similar to this one need to be carried out at other localities between southern New Mexico and Missouri (the collection locality for the holotype of *T. yuccasella*). Moreover, analyses of yucca moths and their hosts over broader geographic ranges may identify additional species of *Tegeticula*.

Justification for assigning specific status to these three taxa would stem from morphological distinctness and fidelity to species of yucca. Samples collected from the same locality can be either individual variants of the same species or else different species (Mayr, 1969). In deciding between the two alternatives, it is important to examine characters such as the genitalia which are not subject to a great deal of individual variation and look for intermediacy between the groups. If differences among groups are found consistently in unrelated characters, specific rank is further implicated (Mayr, 1969). All three groups from this study are sympatric and show differences in the genitalia, as well as other very different characters such as wing length and antennal color. No individuals with intermediate characters were found and this indicates an absence of gene flow, particularly between moths collected

on *Y. baccata* and *Y. torreyi*, where blooming times were simultaneous. Temporal isolation appears to exist among the *Y. elata* group and the two previous groups, because blooming times and thus time of moth emergence are a full month apart. Since moths only live two to three days, overlap between breeding periods is not possible. Therefore, blooming times serve as a principal mechanism for isolating the *Y. elata* group from the other two groups in the area. Following the above criteria, moths taken from the three plant host species are themselves distinct species.

Six *Tegeticula ex Y. baccata* were collected from flowers of *Y. torreyi*. Two of these were included in the discriminant analysis and account for misclassifications. These moths emerged in an area where all the *Y. baccata* had finished blooming and *Y. torreyi* was the only available flowering yucca. This shows that, although moths usually maintain host specificity, individuals potentially can and do use alternate yucca hosts if the preferred host is unavailable. The fact that these individuals were observed in the presence of *Tegeticula ex Y. torreyi* further supports the conclusion that there is no gene flow between the two because no intermediates were observed.

ACKNOWLEDGMENTS

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IMMATURE STAGES OF *ANACAMPTODES HERSE* (SCHAUS) (GEOMETRIDAE) ON SOYBEAN IN HONDURAS

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ABSTRACT. *Anacamptodes herse* is recorded from Honduras for the first time. The larvae were reared on soybean and are described with the pupa.

The genus *Anacamptodes* contains 24 species distributed throughout the New World from Canada to Costa Rica (Rindge, 1966; McGuffin, 1977). Three species of *Anacamptodes* are recorded as pests (Dixon, 1982; Furniss & Carolin, 1977; Zimmerman, 1958), but none is a problem in Honduras. Geometrids are important defoliators of soybeans in other parts of the world. Panizzi et al. (1980) listed four genera attacking soybeans in Brazil (*Iridopsis*, *Oxydia*, *Semiothisa*, and *Stenalcidia*). Park et al. (1978) considered six genera important in Japan (*Ascotis*, *Biston*, *Bizia*, *Scopula*, *Serraca*, and *Ectropis*).

Rindge (1966) reported *Anacamptodes herse* (Schaus) from Mexico and Costa Rica while stating the immature stages were unknown. This paper describes the mature larva and pupa of *A. herse* and establishes its occurrence in Honduras. Larvae were initially swept from and reared on soybean, *Glycine max* (L.) Merrill, outside the city of La Paz, department of La Paz, Honduras. These larvae were associated with a high population of *Anticarsia gemmatalis* Hbn. (Noctuidae) but were not causing economic damage.

METHODS AND MATERIALS

The larvae were described from three shed skin preparations with associated adults in addition to larvae preserved in alcohol. A male (genitalia slide #159, shed skin and mandible slide #166, S. Passoa coll.) and two females (genitalia slides #145, 285, shed skin and mandible slides 116, 221, S. Passoa coll.) were examined. Color photographs also aided in the descriptions.

Collection data are as follows: Honduras, Jutiapa (near Danli), 1-IX-1979, larva on soybean leaf, coll. E. M. de Vasquez, mandible slide #169, S. Passoa coll.; Honduras, La Paz (near Comayagua), 14-VIII-1980, larva on soybean, mandible slide #170, S. Passoa coll., male and female emerged 28-VIII-1980, coll. S. Passoa; Honduras, El Zamorano, Escuela Agricola Panamericana, 9-IX-1982, larva on soybean, female emerged 24-IX-1982, coll. S. Passoa.

The shed skins of the last instar larvae after pupation were first softened in 10% potassium hydroxide for 24 hours. Later they were washed in acid alcohol followed by increasing alcohol concentrations

until absolute alcohol was reached. At this point the head was removed. The epicrania, frontal area, mandibles, and hypopharyngeal complex were separated from each other. Slide mounted material was cleared in clove oil and mounted in balsam. Two of the three shed skins were stained in mercurochrome and slide mounted. The other was preserved in alcohol.

RESULTS

Larva: Coloration of living material: head reticulated with light brown spots on a cream ground, top of vertex tipped with brown, middle of frontal area often with a black spot, body faintly lined with long dark green-brown and white stripes on a light green ground, thoracic legs and all spiracles both tan-brown, A2 with a black dorsal projection usually tipping seta D2, often another black spotted tubercle on A2 behind and below the spiracle touching L1, D1 of A8 tuberculate and black (Figs. 1, 12).

Early instar larva: yellow-green with a tan head, dorsal tubercle of A2 present but reduced in size, lateral tubercles absent.

Chaetotaxy: Head with P2 directly above P1, A2 in front and below A3 and above A1, L1 above O2, O1 centrally located between stemmata, adfrontals with AF1 and AF2 widely separated, F1 above and behind C2, C1 close to C2, labrum with L1 and L2 longer than L3, M1, M2, and M3 as shown (Figs. 7, 8). Prothorax with XD1, XD2, D1, and D2 approximately equidistant from each other, SD1 and SD2 closely spaced, L1 above and in front of L2, SV group bisetose (Fig. 10). Mesothorax with D1, D2, SD1, and SD2 in a vertical line, D2 and SD2 widely separated, L3 longer than L1 or L2, one SV seta present (Fig. 11). Second abdominal segment with D1 and D2 level with each other, SD1 in front of the spiracle, L1 behind the spiracle, L2 above L3, SV2 absent, SV3 above and behind SV4, SV4 above SV1 (Fig. 12). Sixth abdominal segment with D1 above D2, SD1 in front of spiracle, L1 behind it, L2 directly above L3 (Fig. 13), five SV setae present on A6 proleg. Eighth abdominal segment with D setae as in A6, SD1 closer to the spiracle, L1 equidistant from L2 and SV3, one SV seta present (Fig. 14). Ninth abdominal segment with D1 in front and below D2, SD1 above L1, L1 above SV1 (Fig. 14). Tenth segment with SD1 and D1 widely spaced, L1 and D2 close together, all four setae on the anal shield, CD1 above CD2, both on the paraproct, LG3 above LG2 and LG1, CP1 above CP2 (Fig. 14). One ventral seta is present on each segment, SV2 absent on A1 (Fig. 20).

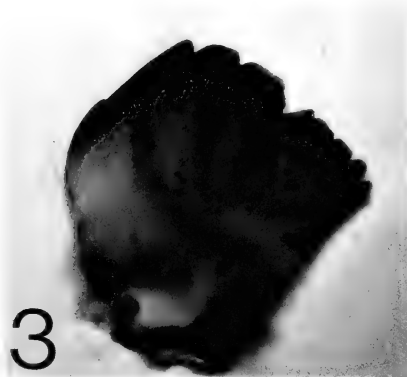
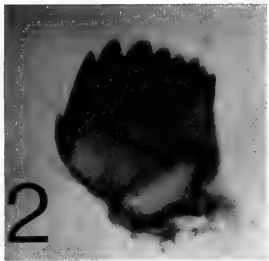
Mouthparts: mandible shape variable, usually with eight teeth (Figs. 2, 3), sometimes all worn smooth (Fig. 4), first four teeth larger than the others, lateral tooth and two mandibular setae present. Hypopharyngeal complex with labial palps about as long as spinneret, small stipular setae present, proximomedial region membranous sparsely covered with fine spines (Figs. 5, 9).

General: last instar larva about 22 mm long, setae arising from small black chalazae, skin granulated with short truncate cones (Fig. 18), tarsal claw rounded with three clubbed setae at its base (Fig. 6), A6 with crochets incompletely formed into two groups in early instar larvae (Fig. 19). Mature larvae with biordinal mesoseries in unbroken band.

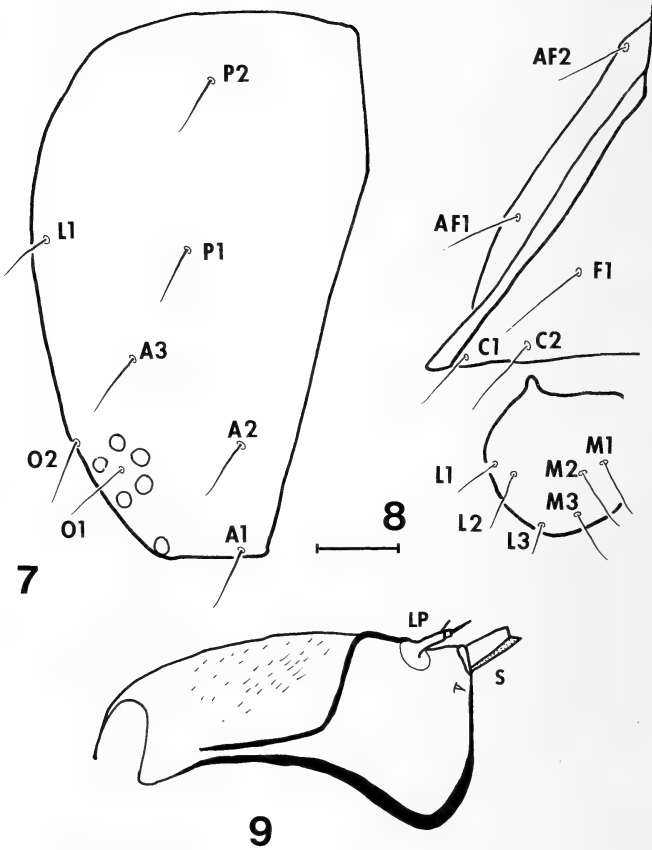
Pupa: With large eyes, semicircular labrum, oblong labial palps, and maxillae extending with antennae to caudal margin of wings, prothoracic femur exposed, prothoracic leg extending about $\frac{3}{4}$ length of maxillae, mesothoracic leg ending near antennae (Fig. 15). Prothoracic callosity oval and spinose (Fig. 16). Cremaster with two diverging spines forming "V" between them, usually broken (Fig. 17), but each spine actually bifurcate at tip. Abdominal segments punctate. Length varies, 12 mm (male) to 16 mm (female), colored reddish brown.

DISCUSSION

The position of the protuberances on A2 is an important character separating *Anacamptodes* from its close relatives (Heitzman, 1982),



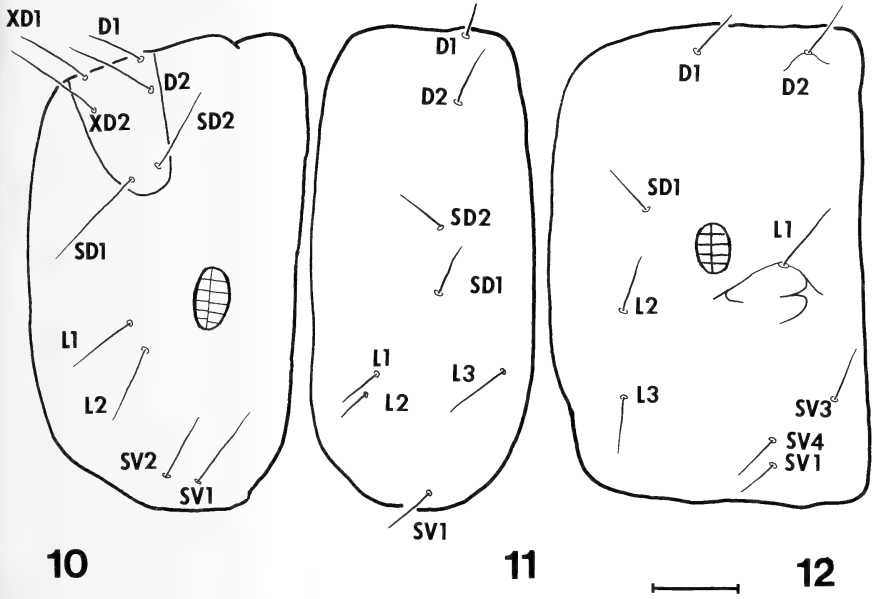
FIGS. 1-6. *Anacamptodes herse* larva: 1, dorsolateral view of mature larva showing defoliation of soybean leaf in the background; 2, mandible with all teeth sharp; 3, mandible with teeth partially worn; 4, mandible with teeth worn smooth; 5, hypopharyngeal complex; 6, tarsal claw and its setae. (Scale line = 5.5 mm, 0.4 mm, 0.3 mm, 0.3 mm, 0.4 mm, 0.5 mm, respectively)



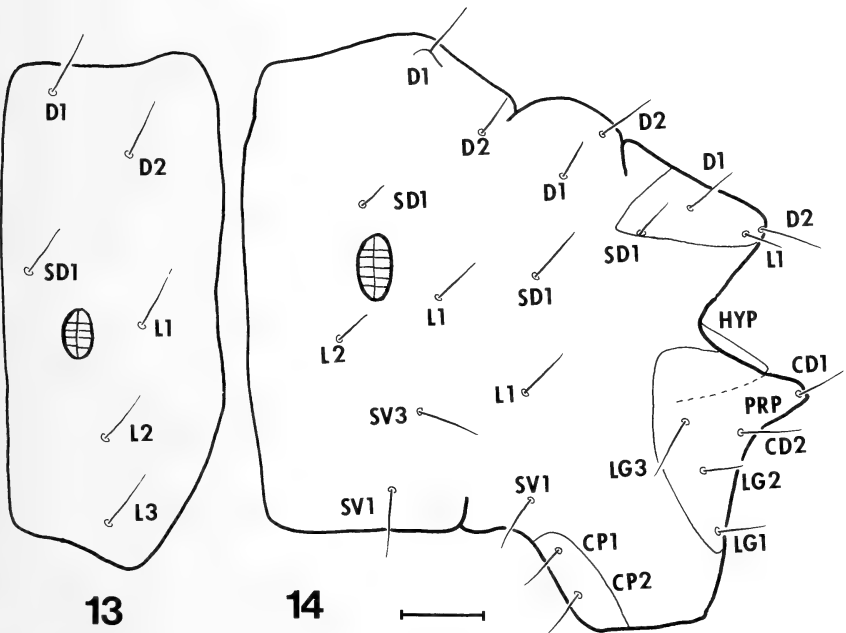
FIGS. 7-9. *Anacamptodes herse* larval head structures: 7, epicrania; 8, adfrontal area and labrum; 9, hypopharyngeal complex; scale line = 0.25 mm, 0.25 mm, and 0.15 mm, respectively. (A = anterior setae; AF = adfrontal setae; C = clypeal setae; F = frontal setae; L = lateral setae; LP = labial palps; M = medial setae; O = ocular setae; P = posterior setae; S = spinneret)

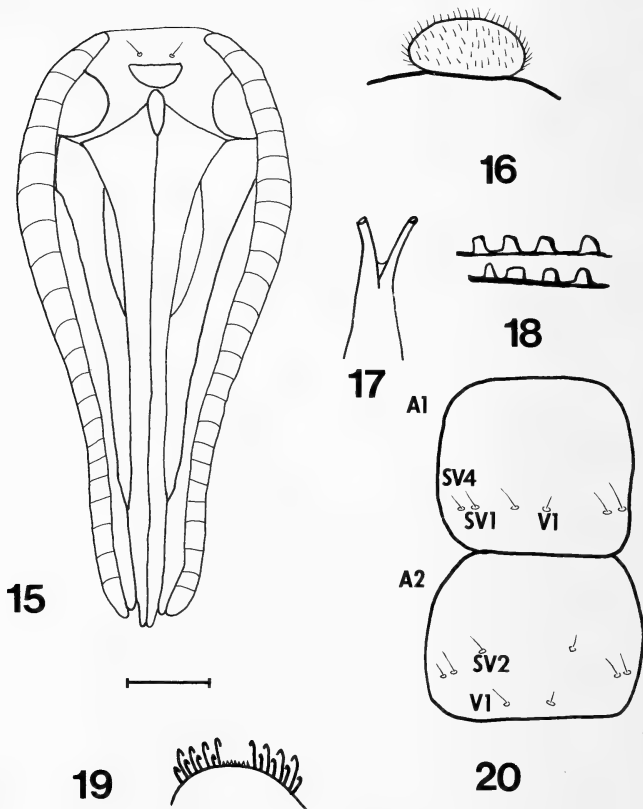
but their size and shape is variable and may be missing in early instars. Younger larvae of *A. herse* have the D2 protuberance reduced in size and the L2 protuberance absent. Similar results were reported by Comstock and Dammers (1946) studying *Anacamptodes fragilaria* (Gross-

FIGS. 13, 14. *Anacamptodes herse* chaetotaxy continued: 13, Anterior portion of A6; 14, Segments 8, 9, and 10. Scale line = 0.3 mm. (CD = dorsal coxal setae; CP = posterior coxal setae; D = dorsal setae; HYP = hypoproct; L = lateral setae; LG = lateral setae of the proleg; PRP = paraproct; SD = subdorsal setae; SP = spiracle; SV = subventral setae)



FIGS. 10-12. *Anacamptodes herse* chaetotaxy: 10, prothorax; 11, mesothorax; 12, 2nd abdominal segment; scale line = 0.3 mm. (A = abdominal segment; D = dorsal setae; L = lateral setae; SD = subdorsal setae; SP = spiracle; SV = subventral; XD = prothoracic dorsal setae)





FIGS. 15-20. Details of *Anacamptodes herse* larva and pupa: 15, pupa, ventral view; 16, prothoracic callosity; 17, pupal cremaster; 18, skin of larva at 400 \times ; 19, crochets of A6; 20, ventral view of A1 and A2; scale line = 1.4 mm, 0.4 mm, 0.7 mm, 0.025 mm, 0.4 mm, and 0.5 mm, respectively. (SV = subventral setae; V = ventral setae)

beck). Only the last instars have the protuberances present, earlier instars lack them. Two separate rearings of the related *A. defectaria* (Gn.) from Gainesville, Florida, show a variation in the size and shape of D1 on A2. Some have a large upright conical protuberance, while others show a more flattened ridge-like structure. Given the above variation in the genus, it would be difficult to generalize and present the typical form of *A. herse* without a large series of larvae. McGuffin (1967) described *Anacamptodes angulata* Rindge from Mexico on *Artemisia* sp. as having "a dorsal ridge on A2 between setae D2, seta D1 on A8 prominently tuberculate," which is similar to the situation in *A. herse*. Color pattern can also be variable. Furniss and Barr (1967), cited by McGuffin (1977), reported four color forms of *A. clavinarina profanata* (Barnes and McD.) in the field. This variability in structure and color makes specific identification difficult. McGuffin (1977) relied

on distribution and hosts to separate the Canadian species of *Anacamptodes* instead of larval morphology.

The chaetotaxy is also very variable. The following setae can be more anterior than illustrated: A1 (head); SV2, SV1 (T1); D1, SV4, SV1 (A1); and L3 (A6). These setae can be more posterior than illustrated: P setae (head); D2 (A1); SD1 (A6) and SV1 (A8). The spiracle of A6 may lie directly above L2, more posterior than shown. M2 and L3 (T2) can be more dorsad, L1 (A6, A8) more ventrad, than the normal position. Finally, the AF, SD (T1), and L (T1) setae can be closer to each other than illustrated.

Little information is available for other tropical species of *Anacamptodes*, but an important similarity is shared by the Canadian species of *Anacamptodes* and *A. herse* concerning the relative length of the D setae on A3 compared to the spiracle size on that segment. In both cases the D setae are as long, or longer, than the spiracle.

It is worth noting that an as yet unidentified *Anacamptodes* was reared on soybean at Zamorano, Honduras. Unfortunately, no information is available on its early stages. Therefore, collectors wishing a positive specific determination must depend on rearing an adult male. The male genitalia of *A. herse* are distinctive (Rindge, 1966).

ACKNOWLEDGMENTS

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NEW HOST RECORDS FOR OLETHREUTINAE (TORTRICIDAE)

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ABSTRACT. Host records are given for 33 species of Nearctic Olethreutinae in the genera *Epiblema*, *Eucosma*, *Pelochrista*, *Phaneta*, *Cydia*, *Ecdytolopha*, *Ethelgoda*, *Grapholita*, *Satronia*, *Episimus*, *Larisa*, and *Zomaria*.

Host plant records have been published for nearly half of the approximately 800 species of Nearctic Olethreutinae. The following records are given for 33 species represented in the U.S. National Museum of Natural History and the Florida State Collection of Arthropods; specimens in the latter are indicated by FSCA following the entries. Identifications of the Olethreutinae were made by the senior author. Plant identifications have not been confirmed since their original identifications; host information is given as recorded on the label, except the nomenclature has been emended following Kartesz and Kartesz (1980). Family names of hosts are given after the initial listing of the plant genus. The letter (n) represents the number of specimens reared. Dates are given as on the specimen labels and do not imply natural emergence times because of the various rearing conditions.

The publication of host records should be tempered with a precautionary note. The following records do not imply that the listed plant species is the favored host. Some species may be incidental hosts, while others may represent the plant upon which the larva was collected and not necessarily the plant on which the larvae were feeding or the plant upon which the female oviposited. More than one larval collection record from a particular plant provides greater evidence of the preferred host. As some plant species might possibly be misidentified, it is here recommended that voucher specimens of host plants be maintained in a reference collection accompanying the reared insect.

EUCOSMINI

Epiblema benignata McDunnough

Artemisia dracunculus L. (Asteraceae)—Washington: Whitman Co., Snake River opp.

Clarkston, J. F. G. Clarke, gall maker on stem (6n).

Artemisia vulgaris L.—same data as *A. dracunculus* (49n). An additional series of 15 specimens has been reared from *A. vulgaris* at Wilma, Whitman Co., by Clarke. However, these individuals did not form galls on the stems. The reared adults are slightly smaller than those from Clarkston, but do not differ in maculation or genitalia.

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- Epiblema sosana* (Kearfott)
Ambrosia acanthicarpa Hook. (Asteraceae)—CALIFORNIA: Los Angeles Co., Sierra Madre (1n); Riverside Co., Sunnymead (6n); San Bernardino Co., Cucamonga (5n); R. D. Goeden and D. W. Ricker; AA Lots 69-2A, 69-47A, 69-6B, 69-7B, 68-2B.
- Epiblema scudderiana* (Clemens)
Heterotheca subaxillaris (Lam.) Britt. & Rusby (Asteraceae)—FLORIDA: Alachua Co., Gainesville, 22 Aug. 1980, D. H. Habeck, A-2663, FSCA (3n).
- Eucosma agricolana* (Walsingham)
Artemisia vulgaris L.—WASHINGTON: Whitman Co., em. 8 May–5 Jun. 1932, J. F. G. Clarke (10n).
- Eucosma bilineana* Kearfott
Helianthus tuberosus L. (Asteraceae)—ILLINOIS: Du Page Co., Hinsdale, em. 24 Jan.–24 Feb., Satterthwait (10n).
- Eucosma bolanderana* (Walsingham)
Machaeranthera canescens (Pursh) Gray (Asteraceae)—ARIZONA: Pinal Co., Superior, em. 24 Sept. 1937; boring in roots (1n).
- Eucosma mandana* Kearfott
Solidago sp. (Asteraceae)—WASHINGTON: Whitman Co., Almota, em. 15 Mar.–16 May, J. F. G. Clarke; boring in roots (9n).
- Eucosma ridingsana* (Robinson)
Heterotheca villosa (Pursh) Shinnors (Asteraceae)—WASHINGTON: Whitman Co., Snake River opp. Clarkston, em. 13 Sept., J. F. G. Clarke (1n).
 "Greasewood"—COLORADO: El Paso Co., Garden of the Gods; root borer (1n).
- Eucosma totana* Kearfott
Chrysothamnus nauseosus (Pall.) Britt. (Asteraceae)—IDAHO: Lincoln Co., 4 mi. NE Richfield, 21 Jul. 1961, W. F. Barr (1n).
- Pelochrista rorana* (Kearfott)
Helianthus annuus L. (Asteraceae)—WASHINGTON: Whitman Co., Almota, em. Jan.–May, J. F. G. Clarke, in roots (12n).
- Phaneta amphorana* (Walsingham)
Grindelia sp. (Asteraceae)—WASHINGTON: Whatcom Co., Bellingham, em. 19 Oct.–20 Dec. 1932, 1933, J. F. G. Clarke (15n).
- Phaneta argenticostana* (Walsingham)
Artemisia dracuncululus L.—WASHINGTON: Whitman Co., Snake River opp. Clarkston, em. 13 May 1932, J. F. G. Clarke (4n); Wilma, em. 22 Mar.–5 May 1935, J. F. G. Clarke (3n).
- Phaneta dorsiatomana* (Kearfott)
Artemisia vulgaris L.—WASHINGTON: Whitman Co., Snake River opp. Clarkston, em. 31 Jan.–13 Mar. 1933, J. F. G. Clarke (7n); Wilma, em. 18 Feb.–17 Mar. 1934, J. F. G. Clarke (13n).
- Phaneta misturana* (Heinrich)
Artemisia tridentata Nutt.—IDAHO: Owyhee Co., 7 mi. S Bruneau, 10 Apr. 1963, O. O. Fillmore, 020-19 (1n); Twin Falls Co., 6 mi. W Rogerson, 11 Apr. 1963, W. F. Barr, 843-01 (3n).
- Atriplex confertifolia* (Torr. & Frem.) S. Wats (Chenopodiaceae)—IDAHO: Cassia Co., 6 mi. NE Malta, 22 May 1962, W. F. Barr, 764-01 (1n).
- Phaneta stramineana* (Walsingham)
Haplopappus sp. (Asteraceae)—TEXAS: Cameron Co., Brownsville, May 1945, Lot 45-13040, Brownsville 59044 (3n).
- Haplopappus suffruticosus* (Nutt.) Gray—ARIZONA: Pima Co., 35 mi. S Tucson, em. Oct. 22, 1937, A. Voth and L. P. Wehrle (2n).

GRAPHOLITINI

- Cydia populana* (Busck)
Populus tremuloides Michx. (Salicaceae)—ARIZONA: Kaibab National Forest. 4 Jun. 1965, D. A. Pierce, Hopk. #51106-6 (2n).

- Cydia flavicollis* Walsingham
Pithecellobium unguis-cati (L.) Benth. (Fabaceae)—FLORIDA: Sugarloaf Key, 22 Apr. 1945, Lot 45-8793 (1n).
P. arboreum (L.) Urb.—PUERTO RICO: Mayaguez, in seeds (2n).
- Cydia garacana* (Kearfott)
Populus sp.—ILLINOIS: Cook Co., Chicago, 16 Jun. 1920, E. Beer (1n).
- Cydia ingrata* (Heinrich)
Fraxinus pennsylvanica Marsh. (Oleaceae)—NORTH DAKOTA: Bottineau Co., 9 Jun. 1970, M. E. McKnight, Hopk. #54051 (1n).
- Cydia lautiuscula* (Heinrich)
Salix sp. (Salicaceae)—WASHINGTON: King Co., Seattle, 25-27 Apr. (6n).
- Ecdytolopha mana* (Kearfott)
Celtis sp. (Ulmaceae)—TEXAS: Cameron Co., Brownsville, 20 Apr. 1945, Lot 45-9929, in leaf gall (1n); Travis Co., Austin, 29 Jun., 3 Aug. 1953, J. Riemann, in petiole gall (6n).
- Ethelgoda texanana* (Walsingham)
Stillingia sylvatica Garden ex L. (Euphorbiaceae)—FLORIDA: Charlotte Co., 13 Sept. 1949 (1n).
Stillingia sp.—FLORIDA: Polk Co., Lake Alfred, 1 Jun.-16 Jul., L. J. Bottimer (3n).
Euphorbia sp.—TEXAS: "Monard," 18-20 Jun., L. J. Bottimer, in seed capsules (2n).
- Grapholita conversana* (Walsingham)
Trifolium douglasii House (Fabaceae)—IDAHO: Idaho Co., Grangeville, em. 6 Apr., T. R. Chamberlin and L. P. Rockwood (9n).
- Grapholita lana* (Kearfott)
Lupinus sp. (Fabaceae)—CALIFORNIA: San Diego Co., Cuyamaca Lake, 27 Apr. 1935, C. Dammers, on leaves (1n).
Sophora leachiana M. Peck (Fabaceae)—OREGON: Josephine Co., 6 May 1977, Cheryl Crowder (6n).
- Grapholita lunatana* (Walsingham)
Lathyrus sp. (Fabaceae)—OREGON: Washington Co., Forest Grove, July 1924, S. K. Keen (1n); Multnomah Co., Portland, em. 24 Apr.-2 May, S. K. Zimmerman (2n).
- Grapholita packardii* (Zeller)
Pyracantha sp. (Rosaceae)—TEXAS: Jefferson Co., Beaumont, 8-15 Jan. (2n).
- Grapholita vitrana* (Walsingham)
Astragalus sp. (Fabaceae)—CALIFORNIA: San Diego Co., Otay, 12 Mar. 1948, E. D. Algett (5n).
- Satronia tantilla* Heinrich
Pinus elliottii Engelm. (Pinaceae)—FLORIDA: Baker Co., em. 16 Apr., Hopk. #40169, B. H. Ebel, on male flowers (3n).
Pinus sp.—ARKANSAS: Johnson Co., "RP," em. 4 Apr. 1967, I. Brown on male flowers (2n).

OLETHREUTINI

- Episimus tyrius* Heinrich
Prunus caroliniana (Mill.) Ait. (Rosaceae)—FLORIDA: Alachua Co., Gainesville, 21 May 1973, em. 11 Jun. 1973, D. H. Habeck (1n); 30 Jul. 1980, em. 16 Aug. 1980 (1n), FSCA.
- Larisa subsolana* Miller
Carya illinoensis (Wangenh.) C. Koch (Juglandaceae)—TEXAS: Brown Co., Brownwood, 26 May 1919, A. T. Fabis, Quaintance No. 18829 (1n); Menard Co., Ft. McKavett, em. 26 Jun. 1919, A. T. Fabis, Quaintance No. 188828 (1n).
- Zomaria andromedana* (Barnes and McDunnough)
Lyonia ferruginea (Walt.) Nutt. (Ericaceae)—FLORIDA: Marion Co., 11 mi. E Lynne, 17 Sept. 1980, em. 29 Sept.-13 Oct. 1980, D. H. Habeck, A-2684f, FSCA.
- Zomaria interruptolineana* (Fernald)
Befaria racemosa Venten. (Ericaceae)—FLORIDA: St. Johns Co., St. Augustine, 17 Jan. 1968, A. E. Graham, FSCA (1n).

- Bumelia lanuginosa* (Michx.) Pers. (Sapotaceae)—FLORIDA: Columbia Co., Ichetucknee Springs St. Pk., em. 12 Jun. 1973, D. H. Habeck, FSCA (1n).
- Leucothoe populifolia* (Lam.) Dipp. (Ericaceae)—FLORIDA: Marion Co., Juniper Springs, 30 Mar. 1979, D. H. Habeck, A-2349a, FSCA (1n).
- Vaccinium arboreum* Marsh.—FLORIDA: Columbia Co., Santa Fe River, 8 mi. S Ft. White, c. 6 Apr. 1974, p. 9 Apr. 1974, em. 15 Apr. 1974, D. H. Habeck, FSCA (2n).
- V. stamineum* L.—FLORIDA: Alachua Co., Gainesville, 30 Apr. 1972, em. 17 May 1972, D. H. Habeck, FSCA (2n).
- Zomaria rosaochreana* (Kearfott)
- Lyonia lucida* (Lam.) C. Koch—FLORIDA: Glades Co., Palmdale, 13 Mar. 1973, D. H. Habeck, FSCA (3n); Alachua Co., Gainesville, 13 Aug. 1972, D. H. Habeck, FSCA (40n).

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NEW WISCONSIN BUTTERFLY RECORDS

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ABSTRACT. Numerous new county records have increased the known range and relative abundance of many of Wisconsin's butterflies (Rhopalocera). A number of species new to the state have been uncovered and several old records have been confirmed. The records were obtained from resident and non-resident collectors, published literature, university and natural history museum collections, and the author's collection.

Since the publication of *Butterflies of Wisconsin* (Ebner, 1970), I have maintained a list of all Wisconsin butterfly records. To date thirteen new state records, six species of questionable occurrence and over 1500 new county records have been added to this list. This brings the state total of confirmed butterfly species to 146.

These records have come from much field work by resident collectors, various publications and field trips by myself. Collecting by George Balogh of St. Louis, Missouri, Robert J. Borth of Milwaukee, and Leslie A. Ferge of Middleton, particularly in prairies in the southern half of the state, in sphagnum-heath bogs in the north, and in oak-pine barren and bracken-grassland ("stump prairie") areas, has accounted for many new county records. Fay H. Karpuleon of Eau Claire and John H. Masters of California have added many new northern records. It should be noted that this intensive and widespread collecting has shown the ranges and relative abundance of many of Wisconsin's butterflies to be much greater than is indicated in *Butterflies of Wisconsin* (Ebner, 1970).

In addition to the new state records, noted with a double asterisk (**), and confirmation of very old records, noted with an asterisk (*), only those new county records which are notable range extensions or relate to scarce or local species are mentioned in this supplement.

Information regarding any Wisconsin butterfly records of which I am not aware would be greatly appreciated.

All the species mentioned are single brooded in Wisconsin, except for those noted otherwise. A few species are also noted as representing strays due to their infrequent occurrence, undoubtedly from populations to the south.

The nomenclature and arrangement follow that of Ebner's checklist (1970) but with some of the changes noted by Kuehn and Masters (1972).

HESPERIIDAE

*****Lerodea eufala*** (Edwards). Door, Douglas, Jefferson, Juneau, Milwaukee Counties, 5 August-1 October. A small female in good condition was collected on 28 August 1966 in Douglas County by Jackson L. Boughner and is now in the Milwaukee Public Museum

collection (Ms. Susan Borkin, pers. comm.). Since then two more specimens, also in good condition, were collected by George Balogh. The determination of these specimens was confirmed by Mogens C. Nielsen. Another specimen, a fresh female, was taken in Juneau County by Tom W. Kral. A fifth specimen was collected by William E. Sieker in Door County in the 1930's. This skipper could occur as a stray throughout Wisconsin, as it has been found as far north as the Upper Peninsula of Michigan (Nielsen, 1970). Because of its drab color and late flight period, *eufala* could be easily overlooked. It should be looked for in dry, open fields in fall.

****Atrytonopsis hianna*** (Scudder). Adams, Burnett, Douglas, Eau Claire, Grant, Juneau, Wood Counties, 14 May–28 June. Found in the oak-pine barren areas of western and central Wisconsin, *hianna* flies with *Lycaeides melissa samuelis* Nabokov. Although widely distributed, it has not been taken in large numbers. This skipper was said to have been common in the Racine County area (southeastern Wisconsin) prior to the turn of the century (Hoy, 1883). There have been no subsequent records from this area.

Euphyes conspicua (Edwards). 1 July–10 August. Twenty scattered new county records indicate that this skipper should be found statewide in sedgy meadow or marsh habitats and not only in those counties near Lake Michigan as suggested by Ebner (1970). In its habitat *conspicua* can be moderately common.

Euphyes bimacula (Grote & Robinson). Barron, Chippewa, Douglas, Florence, Forest, Iowa, Juneau, Kenosha, Marinette, Racine, Vilas, Waukesha Counties, 25 June–30 July. These widely scattered new county records indicate a statewide distribution for *bimacula*. It is very local and never common in sedgy meadow or marsh habitats.

Poanes viator (Edwards). 4 July–7 August. While generally scarce, this species has been found to be locally abundant at times in Dodge and Ozaukee Counties.

*****Problema byssus*** (Edwards). Grant County, 12 July 1981. Two males and a female, all fresh, were taken in prairie habitat in extreme southwestern Wisconsin by George Balogh and Robert J. Borth; another female was taken by James C. Parkinson in the same area on 11 July 1982. This species occurs in Iowa and throughout much of Illinois in areas on or near major rivers (Irwin & Downey, 1973). Thus it could also be expected in similar areas of southern Wisconsin.

Atalopedes campestris (Boisduval). Brown, Dane, Eau Claire, Grant, Green, Jefferson, Juneau, Polk, Rock, Winnebago Counties, 12 August–20 October. New county records from Polk County in the northwest to Winnebago County in the east and Jefferson County in the south show that this skipper strays throughout the southern two-thirds of Wisconsin, especially during late summer and fall.

Pompeius verna (Edwards). Brown, Dane, Douglas, Dunn, Grant, Iowa, Marathon, Milwaukee Counties, 23 June–31 July. The distribution of *verna* may well be statewide based on these widely scattered new county records.

****Polites origenes*** (Fabricius). Adams, Dane, Chippewa, Eau Claire, Grant, Green, Iowa, Juneau, Monroe, Pierce, Sauk, Waukesha Counties, 25 June–29 July. Records for *origenes* show it to be found at least through the southern half of Wisconsin. It flies in the same open, grassy fields as the similar and generally more common *Polites themistocles* (Latreille) with which, at first glance, it can easily be confused. This may be the reason that its presence in Wisconsin has gone unnoticed since the turn of the century (Rauterberg, 1900). In dry prairie habitats, such as those found in Grant, Green and Sauk Counties, *origenes* often outnumbers *themistocles*.

Hesperia metea Scudder. Adams, Brown, Douglas, Florence, Juneau, St. Croix Counties, 12 May–1 June. The Adams and Juneau County records show that this skipper occurs as far south as central Wisconsin in oak-pine barren areas. It can be easily missed as the flight period is very short.

Hesperia ottoe Edwards. Crawford, Dane, Grant, Green, Sauk, Waushara Counties, 24 June–26 August. Found in modest numbers in the southwestern portion of the state, *ottoe* is restricted to dry prairie habitat.

Hesperia sassacus Harris. 15 May–29 July. Well over a dozen new county records show this skipper to be a resident of all but the most extreme southern counties of Wisconsin, having been found as far south as Iowa County.

Hesperia leonardus Harris. Brown, Chippewa, Columbia, Dane, Douglas, Eau Claire, Florence, Green, Juneau, Langlade, Marathon, Oconto, Sauk, Shawano Counties, 4 August–10 September. While typical *leonardus* occur in northeastern Wisconsin, specimens from the western and southern portions of the state are part of a blend zone between *leonardus* to the east and *Hesperia leonardus pawnee* Dodge to the west (Dr. William W. McGuire, pers. comm.). The southernmost records (Green County) are of specimens showing varying degrees of transition between *leonardus* and *pawnee*; here they are found in dry prairie habitat.

Hylephila phyleus (Drury). Dane, Grant, La Crosse, Manitowoc, Portage, Waukesha Counties, 2 August–15 October. These new county records indicate that *phyleus* strays throughout the southern half of Wisconsin as far north as Portage County (Johnson & Malick, 1972); it is seldom common.

Thymelicus lineola (Ochsenheimer). Dane, Kenosha, Marinette, Ozaukee, Sheboygan, Vilas, Washington, Waukesha Counties, 16 June–21 July. This species is now common in the Milwaukee County and Dane County (Madison) areas and appears to be extending its range throughout eastern Wisconsin.

**Oarisma poweshiek* (Parker). Walworth, Waukesha Counties, 27 June–16 July. Two strong colonies of this skipper were discovered by George Balogh in low prairie areas on 4 July 1978 in Waukesha County. Since then another locality may have been found when Leslie A. Ferge and James C. Parkinson, collecting in Walworth County, took a single specimen. Both of these counties are in southeastern Wisconsin. The last report of *poweshiek* in Wisconsin was by Fernekes (1906) in Milwaukee County.

***Nastra lherminier* (Latreille). Green County, 26 August 1979. A single female of this species was taken by George Balogh in a dry, upland prairie. This specimen was examined by me and, as *lherminier* has been reported from northcentral Minnesota (Azevedo, Jr., 1970) and central Illinois (Irwin & Downey, 1973), it is likely this skipper will be found on occasion in Wisconsin.

Carterocephalus palaemon mandan (Edwards). 20 May–5 July. Numerous new county records indicate that this species occurs in all but the southern quarter of the state, and it has been found as far south as Dodge and Washington Counties.

Erynnis icelus (Scudder & Burgess). 6 May–8 July. Almost three dozen new county records show *icelus* to be common throughout Wisconsin.

Erynnis brizo (Boisduval & Leconte). 24 April–14 June. Over a dozen new county records indicate that *brizo* is also found statewide, but it tends to be less common than *icelus*.

**Erynnis persius* (Scudder). Adams, Burnett, Eau Claire, Juneau, Monroe, Polk, Wood Counties, 11 May–8 June. Not reported since before the turn of the century (Hoy, 1883), *persius* is seldom common in the oak-pine barren areas of central and western Wisconsin. It is associated with *Lupinus perennis* (blue lupine) and is found in company with *Atrytonopsis hianna* and *Lycaeides melissa samuelis* Nabokov (Lycaenidae). The Eau Claire County specimens were reared from ova found on *L. perennis* by Fay H. Karpuleon and identified by Mogens C. Nielsen. Some of the Adams, Burnett and Wood County specimens were determined by Dr. John M. Burns.

Erynnis lucilius (Scudder & Burgess). 9 May–25 September. Seventeen new county records for this skipper show it to be well distributed within the southern half of Wisconsin as far north as Chippewa County. Some late capture dates would indicate that a partial third brood occurs.

Erynnis baptisiae (Forbes). Iowa, Iron, Juneau, Polk, Wood Counties, 3 July–5 September. Robert P. Dana took several examples of this species in Polk County in 1973, and

also obtained some adults from larvae found on *Astragalus canadensis* (milk-vetch). The Iron and Wood County records and identification of the Polk County specimens were obtained from Dr. John M. Burns. A single specimen taken by George Balogh in Iowa County was determined by Richard Heitzman; a specimen also has been taken in Juneau County by Tom W. Kral. Dates for the few specimens taken in Wisconsin indicate a single brood.

Erynnis martialis (Scudder). Burnett, Douglas, Eau Claire, Juneau, Waukesha Counties, 15 May–18 August. These widely scattered records indicate that *martialis* may be found over much of southern and western Wisconsin. It is double brooded and common at times.

Thorybes bathyllus (J. E. Smith). 6 June–19 July. Almost a dozen new county records indicate that this species is found throughout the southern half of Wisconsin. It had previously appeared to be limited to the southeastern portion of Wisconsin (Ebner, 1970).

**Achalarus lyciades* (Geyer). Buffalo County, 10 July 1956. Reported long ago by both Hoy (1883) and Rauterberg (1900), this single specimen is the only remaining known record from Wisconsin. Taken by Dr. John S. Nordin, he reported the species as being moderately common in clearings in wooded bluffs along the Mississippi River.

PIERIDAE

Artogeia virginiensis (Edwards). Florence, Langlade, Lincoln, Marathon, Oconto, Oneida Counties, 4 May–2 June. Apparently confined to the northeastern quarter of Wisconsin, *virginiensis* occurs as far south as Marathon County. It is quite local and generally not too common in beech-maple forests.

Colias interior Scudder. 4 June–31 August. This species occurs as far south in central Wisconsin as Juneau, Monroe and Waushara Counties. Fresh specimens taken on 19 August 1971 and 22 August 1974 in Marathon County suggests that an occasional partial second brood occurs.

Phoebis sennae eubule (Linnaeus). Grant County, 31 August 1975 (leg. Leslie A. Ferge), 7 & 10 September 1931. Each date represents the capture of a single specimen. S. E. Ziemer (pers. comm.) reports that this species was regularly sighted in the 1930's in Kewaunee County. Since the middle 1950's, none has been seen there.

Phoebis philea (Johansson). One perfect male was taken by S. E. Ziemer in Kewaunee County on 20 September 1930. More recently, a male in good condition was taken by Mrs. Kathleen Lukasavitz near Hartford, Washington County on 18 August 1979. This specimen was caught by using a small fruit basket in a flower garden!

***Phoebis agarithe* (Boisduval). Eau Claire County, 5 August 1979. A single, slightly worn male was taken by Fay H. Karpuleon in a gravel pit filled with grasses, weeds and wildflowers near the Chippewa River. As with the other members of the genus *Phoebis* mentioned, this specimen obviously represents a rare straggler in Wisconsin.

Eurema mexicana (Boisduval). On 24 June 1977 a single male was collected in Sauk County. The specimen's near perfect condition suggests that it may represent the offspring of a migrant parent (James C. Parkinson, pers. comm.). There is also an example of this species from Wausau, Marathon County (no date) in the collection of Julia Wood (Russell A. Rahn, pers. comm.).

Falcapica midea annickae dos Passos & Klots. Waukesha County, 14–27 May. A single colony of this butterfly was located by Charles A. Kondor, Sr. in 1980 and eight specimens were taken. Additional specimens were observed and collected in 1981. Found only in very limited numbers, *annickae* occurs only in the immediate area of a small, dry, sandy wash with scattered oaks (*Quercus* sp.).

As subsequent visits to the area by a number of collectors in 1982 and 1983 failed to locate additional specimens, the present status of this species in Wisconsin is uncertain.

RIODINIDAE

Calephelis muticum McAlpine. Dane, Fond du Lac, Sauk, Walworth, Waukesha Counties, 11 July–17 August. This species should be found in the southern third of Wisconsin in marshes and wet prairies where *Cirsium muticum* (swamp thistle) occurs. It is at times moderately common, but extremely local.

LYCAENIDAE

***Satyrium caryaevorum* (McDunnough). Adams, Dane, Douglas, Grant, Green, Green Lake, Iowa, Juneau, Lincoln, St. Croix, Waushara Counties, 27 June–2 August. These few records by several different collectors indicate that this hairstreak is found statewide but it is local and uncommon. Its similarity to the common *Satyrium calanus falacer* (Godart) undoubtedly has caused the misidentification of many specimens of *caryaevorum*.

Incisalia polios Cook & Watson. Adams, Bayfield, Burnett, Douglas, Eau Claire, Florence, Juneau, Marathon, Oneida, Washburn, Vilas Counties, 6–31 May. Based on these widely scattered new county records, this elfin should be found throughout the northern half of Wisconsin. It is often common but local on sandy, barren grasslands and oak-pine barrens.

***Incisalia irus* (Godart). Adams, Juneau Counties, 4–29 May. One female was collected by George Balogh on 21 May 1977; the determination was by Patrick J. Conway. Since then well over a dozen specimens have been taken here, in another nearby locality in Adams County and in adjacent Juneau County (leg. Robert J. Borth, Leslie A. Ferge, Tom W. Kral, Roger M. Kuehn and James C. Parkinson). The habitat is sandy, open woods with *Lupinus perennis* (blue lupine), typical of Wisconsin's oak-pine barren areas.

Incisalia henrici (Grote & Robinson). Chippewa, Juneau, Langlade, Oneida, St. Croix Counties, 1 May–6 June. Apparently quite local and not too common, *henrici* could be expected throughout northern Wisconsin, especially in the northwest quarter. In Burnett County it is moderately common in brushy, sandy oak-pine barren areas.

Incisalia augustus (Kirby). 8 May–17 June. Over a dozen new county records show *augustus* to be found throughout the northern portion of the state and as far south as Adams County in central Wisconsin. It is fairly common throughout its range, especially in bogs.

***Erora laeta* (Edwards). Menominee County, 11 & 22 May 1968. Two specimens of this rare butterfly were reported by Richard A. Bailowitz (pers. comm.). As it has been taken in the Upper Peninsula of Michigan (Oosting, 1979), *laeta* should be looked for, but not necessarily expected, in Canadian Zone forest throughout northern Wisconsin.

Epidemia dorcas (Kirby). Langlade, Lincoln, Marathon, Oneida, Rusk, Sawyer, Vilas Counties, 2 July–2 August. Distributed throughout much of the northern half of Wisconsin, *dorcas* is often moderately common but local. It occurs in and near marsh or bog habitats where *Potentilla fruticosa* (shrubby cinquefoil) is found.

Epidemia epixanthe michiganensis (Rawson). 21 June–15 September. Thirteen new county records indicate that while *michiganensis* occurs mainly in northern Wisconsin, it is found as far south as Juneau, Monroe and Sheboygan Counties. It is at times very common in open bogs.

**Leptotes marina* (Reakirt). Grant County, 16 July 1978. Two specimens were taken in extreme southwestern Wisconsin; their fresh condition made them appear to be newly emerged (Robert J. Borth, pers. comm.). These most likely represent the offspring of migrants, as this blue is seldom encountered to the south in Illinois (Irwin & Downey, 1973). This butterfly had been reported from Milwaukee County many years ago (Fernekes, 1906).

Hemiargus isola (Reakirt). Eau Claire, Grant, Price, Sawyer, Trempealeau Counties, 21 June–21 August. These records indicate the sporadic occurrence of *isola* in western Wisconsin.

Lycaeides argyrognomon nabokovi Masters. 29 June–15 July. This species appears to be limited to the northeastern corner of the state with only Florence and Langlade Counties being new records. It is still present in the Waubesa Lake area (George Balogh, pers. comm.) from which it was first reported by Louis Griewisch (1953). As Ebner (1970) was unaware that *Lycaeides melissa samuelis* occurred in Wisconsin, the true identity of specimens referred to from Brown and especially Burnett and Waupaca Counties is in doubt. *L. a. nabokovi* is common at times, but is extremely local in and near barren grassland openings on sandy soil in Canadian Zone forest. The foodplant in Wisconsin is *Vaccinium caespitosum* (dwarf bilberry) (Nielsen & Ferge, 1982).

*****Lycaeides melissa samuelis*** Nabokov. Adams, Burnett, Clark, Douglas, Eau Claire, Jackson, Juneau, Menominee, Monroe, Polk, Portage, Shawano, Waushara, Wood Counties, 21 May–26 August. This blue is locally common in the oak-pine barren areas of central and western Wisconsin where its foodplant, *Lupinus perennis* (blue lupine), occurs (Masters & Karpuleon, 1975). There are two broods in Wisconsin. A superficial resemblance to *L. a. nabokovi* has probably led to the misidentification of specimens in the past. A female specimen from Portage County plated by Johnson and Malick (1972) as *nabokovi* is more likely referable to *samuelis* based on appearance and locality.

*****Everes amyntula* ssp.** (Boisduval). Burnett, Douglas, Washburn Counties, 22–28 May. Several examples of this western blue were taken on 27 May 1979 in sandy, oak-pine barren areas in Burnett County in extreme northwestern Wisconsin. Specimens of *Everes comyntas* (Godart) were also taken in the same areas. The identification of the Burnett County specimens (leg. George Balogh, Robert J. Borth & Leslie A. Ferge) was by Mogens C. Nielsen. As *amyntula* has been reported from central and northern Minnesota and the Upper Peninsula of Michigan (Mogens C. Nielsen, pers. comm.), it could possibly be found in Wisconsin's northernmost counties.

NYPHALIDAE

*****Polygonia satyrus neomarsayas*** dos Passos. Douglas, Florence, Forest, Iron, Marathon, Marinette, Oneida, Sawyer, Vilas Counties, 2 June–3 September. These scattered records show that *neomarsayas* should be expected throughout northern Wisconsin. Found in company with *Nymphalis vau-album j-album* (Boisduval & Leconte) and *Polygonia faunus* (Edwards) in Canadian Zone forest, it has been taken in moderate numbers.

Charidryas gorgone carlota (Reakirt). 15 May–15 September. Twenty-two new county records show *carlota* to be found statewide, except for the north central part of Wisconsin. Common at times, it is found in sandy, oak-pine barren areas in the western portion of the state and in dry prairies in southern Wisconsin. Fresh specimens taken in September indicate that there are two broods in Wisconsin; the foodplant is *Helianthus* sp. (sunflower) (Wayne Duesterbeck, pers. comm.).

*****Phyciodes pascoensis*** Wright. Florence, Fond du Lac, Forest, La Crosse, Marathon, Marinette, Oneida, Waukesha Counties, 11 June–5 August. As more resident collectors become aware of the presence of *pascoensis* and learn to distinguish it from the similar *Phyciodes tharos* (Drury), its range within Wisconsin will become much clearer. From the few reliable county records for *pascoensis*, it appears to occur in all but the southern quarter of Wisconsin. More attention will be required when collecting *tharos* and *pascoensis* regarding flight dates, number of broods and type of habitat; their ranges may overlap in the Washington and Waukesha County areas. All determinations were made by Dr. Paul A. Opler.

Phyciodes batesii (Reakirt). 30 May–2 August. Although found as far south as Adams and Juneau Counties, *batesii* is found mainly in the northern third of Wisconsin. It is occasionally found in moderate numbers in sandy, barren grassland habitat.

Clossiana bellona (Fabricius). 8 May–29 September. Dozens of new county records show *bellona* to be found throughout Wisconsin, but it becomes less common and much more local southward in the state. Specimens from extreme northern Wisconsin are the subspecies *Clossiana bellona toddi* (Holland).

*****Clossiana frigga* ssp.** (Thunberg). Bayfield, Forest, Iron, Langlade, Lincoln, Oneida, Vilas Counties, 14 May–17 June. This species was discovered by four different collectors during the last week of May 1975 (Ferge & Kuehn, 1976). Although the records for *frigga* are concentrated in the north central portion of the state, it should be found throughout the northern third of Wisconsin in suitable bogs. Found in very wet, open, sedge sphagnum-moss bogs, it is moderately common but the flight period is quite short.

Clossiana freija ssp. (Thunberg). Bayfield, Langlade, Lincoln, Price, Vilas Counties, 10 May–6 June. Restricted to the northern third of the state, *freija* is very local and generally uncommon in open sphagnum bogs.

Proclassiana eunomia dawsoni (Barnes & McDunnough). Chippewa, Iron, Langlade, Lincoln, Marathon, Oneida, Price, Rusk, Sawyer, Vilas Counties, 23 May–27 June. First collected in a Price County bog by John H. Masters (Masters, 1971), *dawsoni* has been found in several north central Wisconsin counties. It is likely to be found throughout northern Wisconsin.

HELICONIIDAE

Agraulis vanillae nigrilor Michener. Portage County, 12 May 1963. A second record of this species was reported from Wisconsin by Johnson and Malick (1972). There are also old reports from Milwaukee County (Muttkowski, 1907).

SATYRIDAE

*****Satyroides appalachia leeuwi*** (Gatrelle & Arbogast). Adams, Brown, Dane, Florence, Fond du Lac, Green Lake, Jefferson, Juneau, Manitowoc, Marathon, Marinette, Oconto, Ozaukee, Racine, Sauk, Walworth, Washington, Waukesha Counties, 23 June–21 August. This recently described subspecies (Gatrelle & Arbogast, 1974) has been found throughout southern Wisconsin and in scattered colonies in the northern portion of the state. As elsewhere, *leeuwi* occurs in both deciduous and tamarack swamps and forest-edge habitat adjacent to open marshes. Additional data is still required to determine the full extent of its range in Wisconsin.

Coenonympha inornata Edwards. Ashland, Bayfield, Douglas, Iron Counties, 6 June–21 July. At present, the range of this Ringlet appears to be limited to the extreme northwest corner of the state. It is found along roadsides and in open, grassy fields often in the late afternoon or early evening.

Oeneis chryxus strigulosa McDunnough. Douglas, Florence, Langlade, Oneida, Vilas Counties, 14–31 May. These records indicate that *strigulosa* should be found throughout the northernmost third of Wisconsin. Found in jack pine barrens and bracken-grasslands ("stump prairies"), it is generally distributed and abundant at times.

Oeneis jutta ascerta Masters & Sorensen. 14 May–27 June. Eighteen new county records show *ascerta* to be concentrated in north central Wisconsin, although it has been found as far south as Monroe and Juneau Counties. It should be found throughout most of northern Wisconsin in black spruce/sphagnum-moss bogs. The more southern colonies in west central Wisconsin are in tamarack/sphagnum-moss bogs and represent the southern most records for this species in eastern North America. *ascerta* is the most often encountered bog-related butterfly; the heaviest flights occur in odd-numbered years.

Erebia discoidalis (Kirby). Iron, Langlade, Lincoln, Price, Vilas Counties, 14 May–6 June. As with many of northern Wisconsin's bog-restricted species, *discoidalis* may or may not be present in any one particular bog. Found throughout the northern third of the state, it is very local but moderately common at times.

DISPOSITION OF SPECIMENS

All specimens are presently retained by their respective collectors, except as noted below.

- Lerodea eufala* leg. George Balogh, Roger M. Kuehn coll. (one specimen); leg. William E. Sieker, University of Wisconsin-Madison coll.
- Erynnis baptisiae* leg. Robert P. Dana, National Museum of Natural History coll. (one specimen); Roger M. Kuehn coll. (one specimen).
- Achalarus lyciades* leg. Dr. John S. Nordin, Roger M. Kuehn coll.
- Phoebis sennae eubule* leg. unknown, University of Wisconsin-Platteville coll. (two specimens).
- Phoebis philea* leg. Mrs. Kathleen Lukasavitz, Milwaukee Public Museum coll.
- Falcipica midea annickae* leg. Charles A. Kondor, Sr., James A. Ebner coll. (two specimens); Philip A. Holzbauer coll. (two specimens); Roger M. Kuehn coll. (two specimens); Milwaukee Public Museum coll. (two specimens).

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PUPAL COLOR DIMORPHISM IN CALIFORNIA
BATTUS PHILENOR (L.) (PAPILIONIDAE): MORTALITY
FACTORS AND SELECTIVE ADVANTAGE¹

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ABSTRACT. Estimates of *Battus philenor* (L.) pupal mortality were made in central California. Summer mortality of first and second generation pupae from unspecified causes ranged from 9-20%. *Brachymeria ovata* (Say) (Hymenoptera: Chalcididae) attacked and killed *B. philenor* in the pupal stage. Rates of parasitism varied between populations but not between pupae on narrow twigs or broad tree trunk habitats.

A field experiment was conducted in a natural habitat of *B. philenor* to determine the selective advantage of pupal color dimorphism. Cryptic and non-cryptic pupae were affixed, in pairs, to narrow twigs in foliage or tree trunks and exposed to predators. Non-cryptic pupae in each pupation habitat suffered relatively more predation and lower survivorship. The extent of selective advantage conferred by cryptic coloration varied according to pupation substrate and season. Predation was greatest during the summer and on exposed tree trunks. The results indicate that *B. philenor* has greater survival on the pupation sites most frequently used in nature.

The pupae of *Battus philenor* (L.) are dimorphic, being either green or brown with rare intermediates. In the central Appalachian Mountains of Virginia, *philenor* pupates off the ground on broad exposed surfaces such as tree trunks and cliffs (Hazel & West, 1979). These pupae are almost always brown. California *philenor* also pupate off the ground but much more frequently on narrow twigs within green foliage (Sims & Shapiro, 1983). Two-thirds ($n = 1172$) of the California pupae found on narrow twigs (≤ 6 mm) are green. Pupae found on broad substrates such as grey concrete and brown tree trunks are predominantly (92%, $n = 283$) brown.

West and Hazel (1982) have shown higher survivorship of Virginia *philenor* pupae on the broad surfaces where they normally occur than on unutilized ground-level pupation sites in forest leaf litter. The difference in mortality between the two types of sites was attributed to the relative palatability of pupae to different predators. Birds hunting above ground level probably learned to avoid the distasteful pupae; whereas, the greater palatability of pupae to small mammals hunting at ground level may have led to the formation of search images.

The different pupation site distribution and color response of California *philenor* suggests that the selective mortality factors operating on apparent cryptic and non-cryptic pupae (background matching or

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contrasting respectively) are distinct from those of the eastern United States populations (Sims & Shapiro, 1983). This is not surprising considering differing factors in western areas such as the Mediterranean climate, riparian habitat of the foodplant (*Aristolochia californica* Torr.), evergreen nature of many associated dominant trees and shrubs, and probable differences in the species composition and predation pressure exerted by avian and other predators.

Since present "non-preference" for certain available pupation sites is possibly due to continuing selection against individuals with this behavior (see Clarke & Sheppard, 1972 for evidence for a genetic basis of pupation site choice in *Papilio polytes* L.), we tested the hypotheses that 1) greater survival of both cryptic and non-cryptic pupae occurs on "preferred" twigs, and 2) cryptic pupae have a selective advantage on twigs as well as on broad tree trunk environments.

Predation is not responsible for all mortality of *philenor* pupae. Pupae may be parasitized or die from undetermined causes. In this study we determined the percentage of pupae parasitized and compared rates of parasitization between pupae on narrow and wide substrates. We also estimated pupal death from undetermined causes over summer and winter.

METHODS AND MATERIALS

We studied parasitization and other mortality patterns of *philenor* pupae at Goethe Park, Sacramento Co., CA (Latitude 38°40'N) (GP) and Bidwell Park, Chico, Butte Co., CA (39°45'N) (BP). Parasite data was also collected on larvae from the Vaca Mountains (from Mix Canyon to Solano Lake, approximately 7 km SW Winters), Inner Coast Range, Solano Co., CA (38°25'N) (VM).

B. philenor pupae from GP were collected on twigs and tree trunks in an area adjacent to a 1 km stretch of the American River on seven sample dates from 25 January to 5 March 1974. The vegetation at GP is an oak-dominated riparian forest. The most common tree and shrub species are live oak (*Quercus agrifolia* Nee.), elderberry (*Sambucus mexicana* Presl.), redbud (*Cercis occidentalis* Torr. ex Gray), coffeeberry (*Rhamnus californica* Esch.), and the larval host, Dutchman's pipevine (*Aristolochia californica*).

BP is also a riparian habitat dominated by oak. Pupae here were sampled from either twigs of the host plant growing on concrete supports beneath a highway overpass or from the concrete itself.

Mortality in some *philenor* pupae is manifested by external discoloration and subsequent desiccation. This may result from disease, but the pathogen(s) remains undetermined. We estimated the magnitude of this type of mortality by collecting final instar larvae from VM and

BP and allowing them to pupate and remain within outdoor cages in a sheltered location in Davis, Yolo Co., CA.

We tested the selective advantage of cryptic pupal coloration on a 0.5 km stretch of south-facing slope in Mix Canyon (VM population) at an elevation of 100 m. Both *Aristolochia* and *philenor* are common in this area. Diapause pupae used in this test had been field-collected on 11 June 1976 at BP. They were affixed to tree trunks and narrow twigs using clear silicone rubber sealant. On 8–9 July 1976, 64 pairs of green and brown pupae were attached to opposite sides of individual *Q. agrifolia* tree trunks at heights of from 1 to 2 meters. An additional 40 pairs were attached to narrow (≤ 6 mm) twigs at similar heights in foliage of *Q. agrifolia*, *Heteromeles arbutifolia* M. Roem. (toyon), and *Umbellularia californica* (H. & A.) Nutt. (California bay). Pairs of pupae on twigs were separated by 30–40 cm. The location of pupae was marked by a stake at the base of the tree or shrub. Pupae were checked twice during the summer and once the following spring.

West and Hazel (1982) recognized several possible fates for individual pupae which are applicable here. A pupa may be: 1) alive and intact, 2) dead but intact, 3) attacked by a predator, remains visible, 4) gone and presumably predated, 5) eclosed. We assume that missing pupae are most likely predated and combine categories 3 and 4. The former position of pupae completely removed could generally be determined from the remaining traces of glue. The specific identities of probable predators were not determined in this study, although the visible remains of some predated pupae showed beak marks characteristic of birds.

RESULTS

The summer "disease" mortality, from June–September, of VM individuals pupating during June in 1975 and 1976 was 20.3% (total $n = 79$) and 15.2% ($n = 171$), respectively. BP had 8.6% "disease" mortality ($n = 558$) during the summer of 1976. The incidence of the "disease" may be higher in summer than during the following fall-winter and spring. For example, a sample of BP pupae collected on 25 January 1975 and monitored outdoors in Davis until emergence in March–April had only 4.6% ($n = 195$) dead pupae with these symptoms. This may be variable from year to year. In warm and wet years (such as 1981–1982) fungal attack may be a significant cause of death in overwintering pupae. In later winter, pupae so attacked show mildew in their spiracles and intersegmental membranes, but this is rarely recognizable by late spring.

During January–March 1974, 551 pupae were collected at GP. Most

pupae were found on stems and trunks of live oak, pipevine, redbud, and elderberry. Of 551 pupae, some appearing more than one year old, 427 (77.5%) were dead; 351 (82.5%) of the dead pupae had a 2–3 mm diameter circular opening in either the wing case or dorsum of thorax or abdomen suggesting a parasitoid emergence hole. Among dead individuals collected on narrow (≤ 6 mm) twigs, 79% ($n = 228$) had “parasite” holes while 86% ($n = 199$) of dead pupae on broad tree trunks (≥ 20 mm) had holes. These values are statistically similar ($\chi^2_1 = 3.54$, $P < 0.10$).

No parasitoids emerged the following spring from >1000 diapausing winter-collected pupae (GP 1974; BP 1975, 1976), nor were any parasitoids obtained from field-collected ova (>500 ova, VM 1973, 1974), 3rd instar larvae (>100 larvae, VM 1974), or final instar larvae (>400 larvae, VM 1974–1976; >200 larvae, BP 1975, 1976).

Of 755 pupae collected 24 June 1975 at BP, 3.4% produced adult *Brachymeria ovata* (Say) (Hymenoptera: Chalcididae). All parasitoid emergence was completed by 12 July. On 11 June 1976, a sample of 558 pupae had no parasitoids. Exit holes left by parasitoid adults from BP were identical to those seen in the GP pupae. *B. ovata* attacks and emerges from the pupal stage of many species of Lepidoptera (Harville, 1955; Peck, 1963).

The fate of green and brown pupae on narrow twigs and broad trunks is shown in Table 1. We compared the survivorship of cryptic vs. non-cryptic pupae between sites by combining the number of successful adult emergences over the summer with the number of surviving overwintering pupae. These comparisons are presented in Table 2. Most pupal mortality occurred during the summer, especially the first month following initiation of the experiment (Table 1). Green pupae on twigs and brown pupae on tree trunks suffered less predation than their alternate color forms but the differences were small (Table 2). The survivorship advantage of apparent cryptic coloration within sites in this study was largely due to greater adult emergence and lower non-predation mortality among the cryptic forms (Table 1). Our data suggests a lower survivorship of non-cryptic green pupae on tree trunks compared to brown pupae on twigs. Brown, and especially green pupae on tree trunks are quite conspicuous to the human observer and may be so to visually hunting predators. There was significantly reduced survivorship and increased predation on tree trunk pupae (combined green and brown) compared to twig sites (Table 2).

We did not identify any of the predators of *philenor*, but the few remaining predated pupae had beak mark damage characteristic of birds. Most pupae were removed completely or with only a bit of the abdomen and cremaster remaining.

TABLE 1. Survival of *B. philenor* pupae through the summer and winter of 1976-1977.

	Twigs						Tree trunks									
	Green pupae			Brown pupae			Green pupae			Brown pupae						
	Dead	Emerged	Predated	Alive	Dead	Emerged	Predated	Alive	Dead	Emerged	Predated	Alive				
10 July	—	—	—	40	—	—	—	—	—	—	—	64	—	—	—	64
10 Aug.	5	15	3	17	9	12	6	13	13	5	35	11	3	8	30	23
15 Sept.	1	9	—	7	1	7	—	5	1	4	3	3	2	10	3	8
10 Mar.	—	—	—	7	—	—	—	5	—	—	—	3	—	—	2	6
Totals	6	24	3	—	10	19	6	—	14	9	38	—	5	18	35	—

TABLE 2. Survivorship (number of emerging adults during the year of the experiment + number of pupae alive the following spring) and predation of *B. philenor* pupae.

Pupal color and substrate	Survivors	Predated	χ^2 (1)	P
Green pupae on twigs	31	3	1.65	>0.10
Brown pupae on twigs	24	6		
Green pupae on tree trunks	12	38	3.40	<0.10
Brown pupae on tree trunks	24	35		
Total pupae on twigs	55	9	45.28	<0.01
Total pupae on tree trunks	36	73		

DISCUSSION

In this study we determined the magnitude of some *philenor* mortality factors in central California and the survivorship of cryptic and non-cryptic pupae on substrates which are most frequently used as natural pupation sites.

An estimated 9–20% of intact pupae die from unknown, possibly pathogenic, agents during the summer months. One sample indicated that winter mortality of pupae with disease symptoms is somewhat lower than summer, but this may vary from year to year.

The pupal-pupal parasitoid *Brachymeria ovata* attacks pupae in spring and summer. A single parasitoid is produced from each pupa, which is killed in the process. The parasitoids do not overwinter in diapause *philenor* pupae but probably overwinter as adults in a manner similar to other *Brachymeria* species (Clausen, 1940). Our determinations of percent parasitization may not accurately estimate the seasonal rate since we took only one sample each year per population. However, the rate of parasitization appeared low in the BP population, especially compared to the much higher estimate at GP. The determination of annual percent parasitization at GP is complicated by our inability to determine what proportion of the dead pupae in our samples represents individuals more than one year old. Thus, we have only an average estimate of parasitoid-caused annual mortality.

It is possible that synchronization between parasitoid activity and the months of greatest *philenor* pupation (May–June) influences parasitization rate. Individuals may not be “at risk” during their entire pupation period, since *Brachymeria* prefers to oviposit in newly-formed pupae (Clausen, 1940).

B. ovata has been observed to search randomly for host pupae in California habitats similar to those studied here (Harville, 1955). Random searching and host finding is reflected in the similar rates of parasitization of pupae on narrow and wide substrates. However, one

of us (AMS) has observed a parasitization rate in excess of 90% in each of four years at a site (Rossmoor Bar, not far from GP) where a great many pupae are formed in the open on whitewashed fence posts; no data are available for pupae from more natural substrates.

The primary pupal predators of California *philenor* remain undetermined. Several local nocturnal animals such as the opossum (*Didelphis virginiana*) and deer mouse (*Peromyscus* sp.) are possible candidates since they are often both arboreal and insectivorous (J. Harris, pers. comm.; Landry, 1970). Odor might be at least as important to these animals as visual cues. *B. philenor* adults are distasteful to some birds (Brower, 1958). Larvae are aposematically colored and it is likely that pupae possess alkaloids and aristolochic acid similar to those found in adults (Rothschild et al., 1970). We found some evidence for the unpalatability of pupae to birds since 5 of 82 pupae predated were clearly damaged by a bird's beak but were left uneaten. Similarly, West and Hazel (1982) observed 13 of 139 damaged but uneaten *philenor* pupae on tree trunks over a two year period in Virginia.

The significantly reduced predation pressure among narrow pupation substrates is correlated with the high percentage (33% of total) of brown pupae there. This suggests that brown pupae are as cryptic or otherwise protected as green pupae on twig sites and indicates the variability of the color-influencing stimuli of twigs. Tree trunks produce less ambiguous color-determining cues. Only 8% of the pupae on broad exposed sites are non-cryptic green (Sims and Shapiro, 1983).

Evidence is beginning to accumulate that a distinct selective advantage is accorded to individuals of dimorphic Lepidoptera species that choose an appropriate pupation site and have a cryptic pupal color response (Hidaka et al., 1959; Baker, 1970; Wiklund, 1975; West & Hazel, 1982). The choice of pupation site and ability of individuals to show a cryptic color response to the site's color and texture varies in different *philenor* populations (West & Hazel, 1979; Sims & Shapiro, 1983). We believe that this variability is related to a combination of the structure and seasonal phenology of the pupation-habitat coloration and the intensity of predation pressure. The latter is partly determined by predator species composition and density. In the deciduous forest of Virginia, most *philenor* pupae show a preference for rough exposed surfaces above ground level, are especially sensitive to the textural-optical qualities of these sites and, thus, pupate brown (West & Hazel, 1979; Hazel & West, 1979). In the partly evergreen habitat determined by central California's Mediterranean climate, narrow twigs in leafy areas are more frequently chosen, pupae are less sensitive to brown-producing stimuli, and more pupae are green (Sims & Shapiro, 1983). This study lends support to the hypothesis that pupation site preference

has evolved under differential selection by predators (West & Hazel, 1982). The highest summer and overwinter survival and least predation occurred on the narrow pupation sites most frequently used by *philenor* in nature.

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A NEW SUBSPECIES OF *SPEYERIA ATLANTIS*
(EDWARDS) (NYMPHALIDAE) FROM THE
GREAT BASIN OF NEVADA

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ABSTRACT. A new subspecies of *Speyeria atlantis* (Edwards) of the unsilvered northern Great Basin cline from northeastern Nevada is described. This is the palest of the cline and occurs in an area known for pallidity in other *Speyeria* taxa.

A number of new taxa of butterflies have been discovered and named from the more remote regions of the Great Basin over the past several years (Bauer, *in* Howe, 1975; Brown, 1975; Emmel & Emmel, 1971a, b; Emmel & Mattoon, 1972; Herlan, 1970; Howe, 1975; Scott, 1981; Shields, 1975). A distinct fritillary of the unsilvered, northern Great Basin cline of *Speyeria atlantis* (Edwards) has been known by a few collectors to occur in the Jarbidge and Independence ranges of northeastern Nevada for about 20 years. The cline involved is largely unsilvered, running from *tetonia* dos Passos and Grey from Wyoming through *viola* dos Passos and Grey in Idaho to *dodgei* (Gunder) in Oregon and ending in *irene* (Boisduval) in the Sierra Nevada of California (see Moeck, 1957). The Nevada phenotype has usually been designated *Speyeria atlantis* near *dodgei*. It is, however, distinct enough to warrant recognition.

***Speyeria atlantis elko*, new subspecies**
(Figs. 1 and 2)

Description. Male, dorsal surface—Primaries and secondaries deep fulvous with the usual speyerian black markings moderately developed. Marginal band of primaries black with narrow lines of fulvous in each cell. Basal suffusion light to moderate on both wings. No lightening of ground color indicating positions of ventral surface pale markings. Ventral surface—Primaries basically pale tan with slight basal flush of fulvous. Markings of apical area and suffusion within marginal band a warm, slightly reddish, brown. On secondaries, all pale areas of same tan color as on primaries. Normal discal spots large and prominent. Narrower streaks of tan occur in median area of most or all cells. Disc pale brick red. Discal pale spots bordered basally with black; submarginal spots narrowly bordered distally with black. Basal spots in discal cell and cell Cu_2 usually completely encircled with black. Remaining dark areas of secondaries (marginal suffusion, basal border of submarginal spots) of same brown as markings of apical area of primaries. No silvering of any ventral spots. Size (all measurements of right primary along costal margin to furthest extent of apex)—Holotype = 27 mm, paratypes = 25-28 mm (N = 16). Material examined—Holotype and 28 paratypes.

Female, dorsal surface—Ground color of primaries and secondaries of paler fulvous than male; black markings usually slightly less well developed. Marginal band of primaries tends to be filled completely with black apically but shows the fulvous ground, as in male posteriorly. Basal suffusion as in male. Ground color slightly lighter above positions of ventral pale spots. Ventral surface—Basic coloration similar to that of male

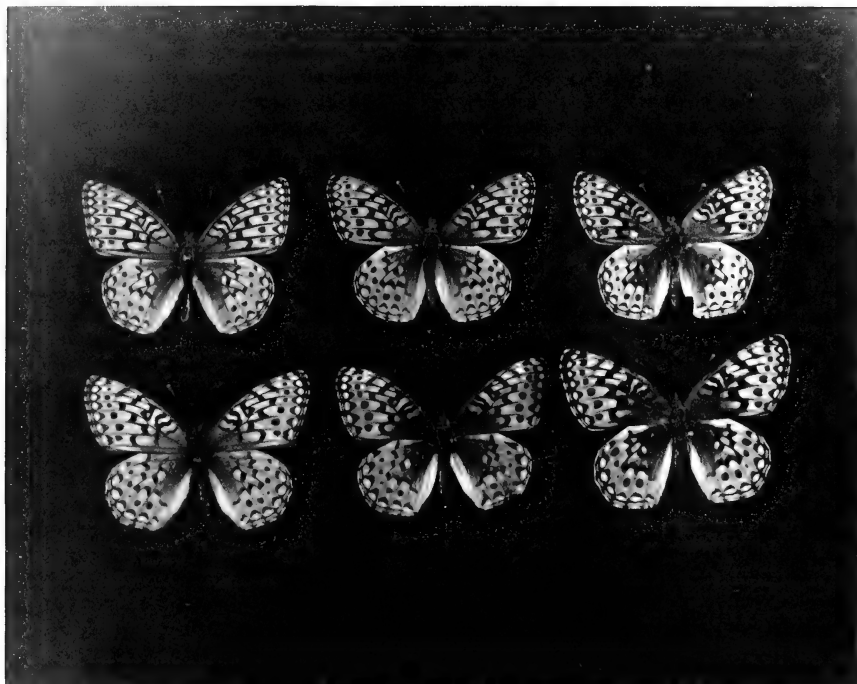


FIG. 1. *Speyeria atlantis* subspecies dorsal surface. **Top row, males:** **left, *elko***, holotype, NV: Elko Co.; Owyhee R. Valley, Wildhorse Creek Campgr., ca. 10 mi. S Mountain City, 8 July 1978, leg. G. T. Austin. **Center, *irene***, CA: Nevada Co.; nr. Norden Lake, 6700', 26 July 1976, leg. C. Hageman. **Right, *dodgeti***, OR: Dead Indian Rd., 22 June 1934, coll. unknown. **Bottom row, females:** **left, *elko***, allotype, same data as holotype. **Center, *irene***, CA: Nevada Co.; Soda Springs, 12 Aug. 1977, leg. B. O'Hara. **Right, *dodgeti***, CA: Siskiyou Co.; Methodist Camp, Castle Lake Rd., 27 July 1972, leg. L. P. Grey.

but fulvous flush of primaries extending more into discal cell and noticeably to outer margin posteriorly. Pale spots of primaries and secondaries proportionally larger than those of males. Size—Allotype = 29 mm, paratypes = 28–30 mm (N = 10). Material examined—Allotype and 15 paratypes.

Types and type locality.* Holotype: NEV(ada): Elko Co(nty); Owyhee R(iver) Valley, Wild Horse Creek Campg(round), ca. 10 mi(les) S(outh) (of) Mountain City, 8 July 1978, leg. G. T. Austin. Paratype males: six with same data as holotype; two with same data except collected on 2 July 1980; one with same data except collected on 24 June 1981; six from Pine Creek, (Jarbidge Mountains) Elko Co(nty), Nevada, Jul(y) 10 (19)'72, leg. P. Herlan; three from Sawmill Creek, (Jarbidge Mountains) Elko Co(nty), Nevada, Jul(y) 8, (19)'74, leg. P. Herlan; one from same location, 7 (=July)-18-(19)76, leg. P.

* Data on types are as indicated on specimen labels; parenthetical data correct errors or clarify label data; all from Nevada.

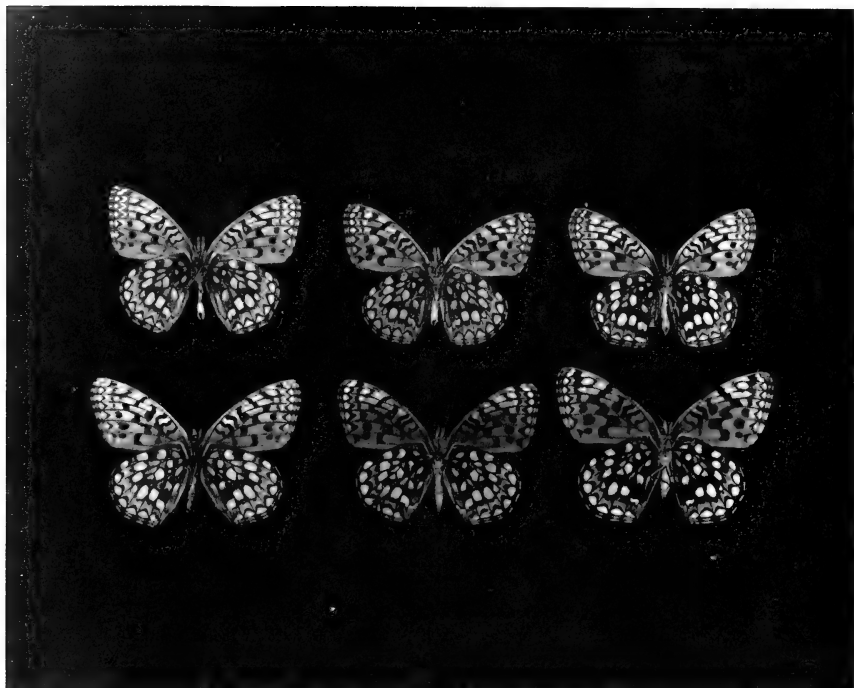


FIG. 2. *Speyeria atlantis* subspecies ventral surface. Same specimens as in Fig. 1 (note especially the paleness and large spots of *elko*).

Herlan; two from Elko Co(nty); Indep(ependence) Range, Bull Run M(oun)t(ain)s, slope and summit of Porter Peak, 5 mi(les) W(est) of Maggie Summit, N(e)v(ada State Route) 11A, 8000-9265', 11 July 1982, leg. S. Mattoon; one from Elko Co(nty); Indep(ependence) Range, N(e)v(ada State Route) 11A, Bull Run Basin to Columbia Basin at Aura Hist(orical) site, 6-10 mi(les) NNE H(igh)w(ay) 11, Deep Cr(eek) J(unc)tion, 6000-6300', 11 July 1982, leg. S. Mattoon; four from Elko Co(nty); Indep(ependence) Range, Bull Run M(oun)t(ain)s, N(e)v(ada State Route) 11A, vic(inity) Maggie Summit, 6500', 20 July 1973, leg. S. Mattoon; two from Elko Co(nty); Indep(ependence) Range, Bull Run M(oun)t(ain)s, N(e)v(ada State Routes) 226 and 11a, Jack Cr(eek) Campg(round) to Maggie Sum(mit), 5500-6619', 10 July 1982, leg. S. Mattoon.

Allotype: NEV(ada): Elko Co(nty); Owyhee R(iver) Valley, Wild Horse Creek Campg(round), ca. 10 mi(les) S(outh) (of) Mountain City, 8 July 1978, leg. G. T. Austin. Paratype females: two with same data as allotype; one from Jarbidge, (Jarbidge Mountains) Elko Co(nty), Nev(ada), Aug(ust) 11, (19)63, leg. P. Herlan; one from Jarbidge, (Jarbidge Mountains) Elko Co(nty), Nevada, Jul(y) 10, (19)72, leg. P. Herlan; 11 from Elko Co(nty), Independence Range, Nev(ada State Route) 11A, 0.5 mi(les) E(ast) (of) Maggie Summit, 28 July 1981, leg. G. T. Austin.

Due to the small number of specimens from any one specific location, the type series includes all specimens from Elko Co., Nevada, at hand. They were taken essentially from three colonies within 60 km of each other, one in the Jarbidge Mountains near Jarbidge, one in the Independence Range near Maggie Creek and the other along Wild Horse Creek, 6400', in the Owyhee River Valley (R54E T44N S16). The latter was chosen as the type locality. The type locality is a creek bottom along which the males patrol. The surrounding area consists of low hills with sagebrush (*Artemisia*) as the predominant

vegetation. The new taxon flies with five other *Speyeria*: *coronis snyderi* (Skinner), *zerene gunderi* (Comstock), *callippe harmonia* dos Passos & Grey, *egleis linda* (dos Passos & Grey), *mormonia artonis* (Edwards).

Deposition of types. The holotype, allotype, 10 male and seven female paratypes are deposited in the Nevada State Museum, one male paratype is deposited in the collection of C. S. Lawson in Las Vegas, Nevada, nine male paratypes are deposited in the collection of S. Mattoon, Chico, California, and the remaining paratypes are in the author's personal collection.

Other records. All NEVADA: Elko Co. (specimens not seen): Jarbidge Mts., Pine Creek, 9 July 1964 (J. Lane *vide* L. P. Grey); same location, 11 July 1972 (D. Bauer); same location, 10 Aug. 1967 (J. F. Emmel); Jarbidge Mts., Jarbidge-Charleston Road, 8 mi. S. of Jarbidge, 9 Aug. 1967 (J. F. Emmel); Jarbidge River, 12 and 31 July 1974 (C. Ferris *vide* L. P. Grey); Rt. 11A, Maggie Creek, 21 July 1973 (L. P. Grey, Mattoon, *vide* L. P. Grey); same location, 21 July 1976 (L. P. Grey).

Etymology. This subspecies is named after Elko County, Nevada, its type locality and only presently known range.

Diagnosis. This new taxon is immediately recognizable from any other *atlantis*. The dorsal ground color is paler and the black patterning is finer than in *tetonia*, *viola* and *dodgei*. The males of those three subspecies tend to have the marginal area of the primaries largely black which is not the case in *elko*. In color, *elko* is similar to *irene* but the pattern is finer, especially on the secondaries, of *elko*. The ventral surface is particularly distinctive. The reddish brown is paler in *elko* than in all the above-named taxa. The palest (aside from *elko*), *irene*, still shades towards a deeper brick red color which becomes progressively darker eastward. The submarginal band is wider, and the spots of the secondaries are larger than in any of the conspecifics, and the tan coloration of these gives the ventral surface of *elko* an almost yellowish appearance, an aspect not attained by any other taxon.

Discussion

Geographically, the paleness of *elko* corresponds closely with pallidity exhibited by other *Speyeria* of this same general region of the Great Basin (i.e., *S. atlantis greyi* Moeck, *S. mormonia artonis*, *S. zerene gunderi*). It is interesting that two very different clines of western *atlantis* coming from two directions terminate in extremes of pallidity within 80 km of each other. The populations of *greyi* in the Ruby Mountains and East Humboldt Range, Elko Co., Nevada may represent the western pallid extreme of the *chitone* (Edwards) and *wasatchia* dos Passos and Grey cline, while the taxon described herein is the pallid extreme of the northern Great Basin-Sierra Nevada cline which apparently colonized Nevada from the north. This situation approaches that shown by another pair of *atlantis* subspecies, *hollandi* (Chermock & Chermock) and *dennisi* (Gunder), which fly together in the Black Hills (Grey et al., 1963) and by a pair of *S. zerene* (Boisduval) subspecies, *zerene* and *gunderi*, which overlap in northeastern California (Grey & Moeck, 1962).

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THE LARVA OF *SIDERIDIS MARYX* (GUENÉE) (NOCTUIDAE)

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ABSTRACT. The mature larva of *Sideridis maryx* (Guenée) (Noctuidae) is described and illustrated.

The noctuid genus *Sideridis* (Hübner) (Hadeninae) is represented in eastern North America by three species, *S. rosea* (Harvey), *S. congermana* (Morrison), and *S. maryx* (Guenée) (Forbes, 1954). Of the three species, *S. rosea* is the most common, and the immature stages are best known; they were most recently described and illustrated by Godfrey (1972) who listed grass, dandelion, *Elaeagnus angustifolia* L., *Ribes* sp., *Shepherdia* sp., and *Salix* sp. as host plants. *S. congermana* and *S. maryx* are generally considered to be uncommon to rare throughout eastern North America (Forbes, 1954; Rockburne & Lafontaine, 1976). Dyar (1899) briefly described the mature larva of *S. maryx* (= *Mamestra rubefacta* Morrison) based on preserved material. The larva of *S. congermana* and the natural host plants of all three species of *Sideridis* are unknown.

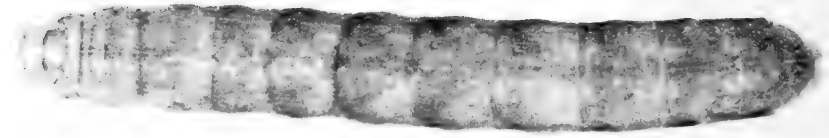
This paper describes the mature larvae of *S. maryx* reared from ova obtained from a female taken on 11 June 1979 at Belliveau Cove, Digby Co., Nova Scotia. Larvae were fed an artificial diet based on that of Hinks and Byers (1976). They grew quickly and pupated by 7 August. Adults emerged 10-15 September 1979. Throughout its range, *S. maryx* is single brooded, overwintering as a pupa, with adults emerging in late spring and early summer.

The terminology and abbreviations used here follow Godfrey (1972). The illustrations which accompany the description of the last larval instar were drawn to scale using a camera lucida and stereomicroscope.

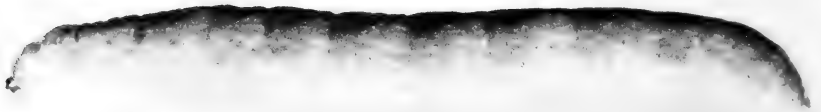
Sideridis maryx (Guenée)

General. Head 3.5-4.0 mm wide. Total length 40.0-49.5 mm. Head and body smooth. Prolegs present on Ab3-6, size increasing posteriorly on Ab3-6, those on Ab3 slightly more than ½ the size of those on Ab6. Crochets uniordinal, 19-22 per third abdominal proleg, 21-25 per fourth, 26-29 per fifth, 27-30 per sixth. All simple.

Coloration (living material). Head (Fig. 3): yellowish brown with darker reddish brown coronal reticulations and coronal stripes. Body (Figs. 1, 2): red; dorsal and subdorsal areas with numerous greyish flecks, flecks heaviest at edges of middorsal line; middorsal and subdorsal lines narrow and poorly defined, the middorsal line more well defined on T1-3; lateral and ventral areas translucent red, lacking greyish flecks. Spiracles yellowish brown with black peritremes. Lateral shields of prolegs and thoracic legs yellowish brown, both darker basally. Prothoracic shield orange brown.



1



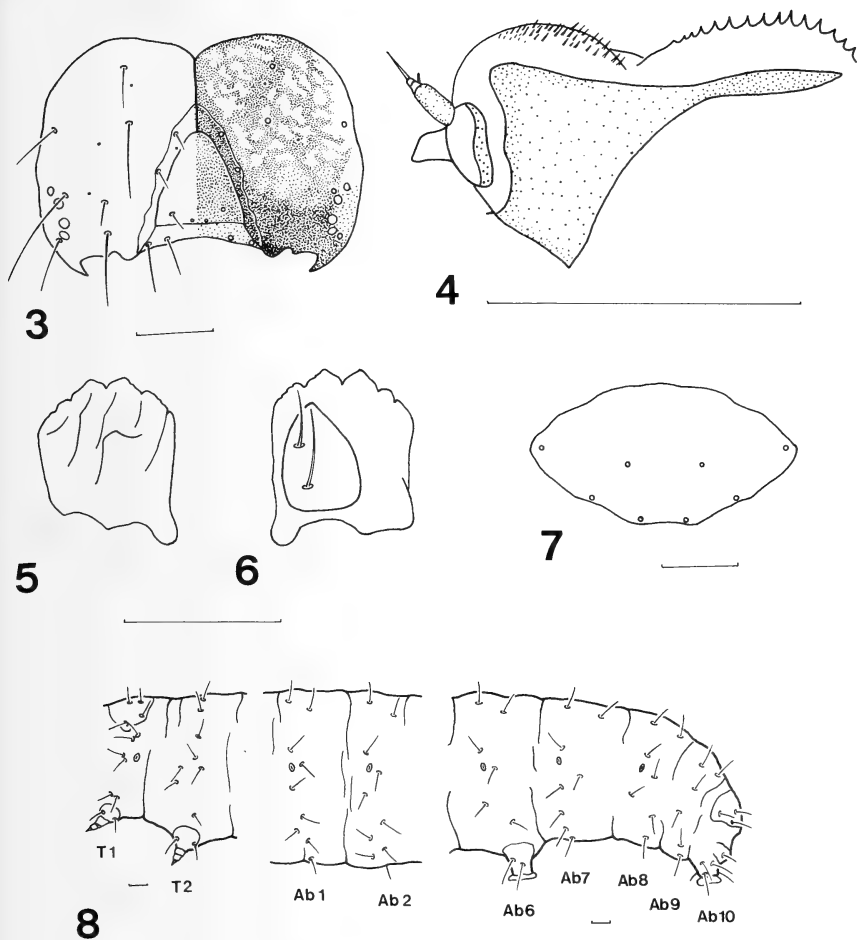
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FIGS. 1 & 2. *Sideridis maryx*, sixth instar larva ($\times 3$): 1, dorsal view; 2, lateral view.

Head (Fig. 3). Epicranial suture 0.92–1.05 mm long; height of frons (apex to Fa's) 1.03–1.05 mm; distance from F1 to anterior edge of clypeus 0.33–0.35 mm; interspace between F1–F1 0.45–0.47 mm; aFa anterior and Af2 posterior to apex of frons; A1–A3 forming an obtuse angle at A2; P1–P1 1.54–1.56 mm; P2–P2 1.70–1.72 mm. Distance from P1 to epicranial suture less than that from P1 to L; L cephalad of juncture of adfrontal ecdysial line. Ocellar spacing: Oc1–Oc2 0.07–0.09 mm; Oc2–Oc3 0.10–0.12 mm; Oc3–Oc4 0.05–0.06 mm.

Mouthparts. Hypopharyngeal complex (Fig. 4): spinneret short and broad, subequal to Lps1; Lps1 longer than Lp2; stipular setae short, about $\frac{1}{8}$ the length of Lps1, slightly shorter than Lp1, and about $\frac{1}{8}$ the length of Lp2; Lps2 subequal to Lp1; distal and proximal regions of hypopharyngeal complex separated by a distinct medial transverse cleft; distal region with distal $\frac{1}{2}$ bare, remainder with short thin spines becoming longer and slightly more robust proximally; proximolateral region with 15–20 stout spines. Mandible (Figs. 5 & 6): two well-separated outer setae present; inner surface with ridges and tooth; inner tooth prominent, base broad, apex truncate; first outer tooth well developed, serrated on outer side; second outer tooth serrated on side opposite outer tooth; third and fourth outer teeth acutely angular; fifth outer tooth wide and flat with outer margin serrated.

Thorax. Segment T1 (Fig. 8): prothoracic shield weakly sclerotized; SD1 and SD2 setal insertations well separated from shield; interspace D1–D1 about 0.65 XD1–XD1; D2–SD-2 about 1.41 SD2–XD2; spiracle elliptical, 0.44–0.48 mm high, 0.27–0.29 mm wide;



FIGS. 3-8. *Sideridis maryx*, larva: **3**, frontal view of head capsule; **4**, left lateral view of hypopharyngeal complex; **5**, oral surface of left mandible; **6**, outer surface of left mandible; **7**, dorsal view of anal shield; **8**, dorsolateral chaetotaxy of prothoracic (T1), mesothoracic (T2), and abdominal segments (Ab1-2, Ab6-10). Scale lines equal 1.0 mm.

peritreme wider laterally. T2 (Fig. 8): D1-D2 about 0.69 D2-SD2; all setae thin and hairlike, tapering and sharply pointed distally; coxal bases narrowly separated.

Abdomen. Dorsal and lateral chaetotaxy of Ab1-10 as in Fig. 8. Ab1 with 2 SV setae, Ab2-6 with 3 SV setae, Ab7-8 with 1. Ab9: SD1 much finer than D1 and D2. Ab10: Anal shield as in Fig. 7. Dorsal margin convex, posterior margin entire. Length of D1 on Ab6-7 0.49-0.53 mm; D2 0.56-0.60 mm. Asp7 0.36-0.37 mm high, 0.21 mm wide; Asp8 0.49-0.50 mm high, 0.27 mm wide.

Material examined. 4 specimens: Belliveau Cove, Digby Co., Nova Scotia. Reared on artificial diet (Hinks & Byers, 1976) from ova obtained from a female taken on 11 June 1979. Adults emerged 10-15 September 1979. Moth collected, determined, and larvae reared by K. A. Neil.

Remarks. Based on the larval description and illustrations of *S. rosea* given by Godfrey (1972), *S. maryx* can easily be distinguished from that species by the truncate inner mandibular tooth, the short, stout spinneret which is only about $\frac{1}{2}$ the length of the spinneret of *S. rosea*, and by the wider F1-F1 interspace.

ACKNOWLEDGMENTS

I thank Dr. G. L. Godfrey of the Illinois Natural History Survey for reviewing this manuscript and Ronald Long of Simon Fraser University for photographing the illustrations.

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GENERAL NOTES

COLLECTION RECORDS OF BUTTERFLIES FROM NYANGEZI, ZAIRE, AFRICA¹

Beginning in 1977, while working in the Peace Corps as a science teacher, I studied and collected butterflies from the small village of Nyangezi, in eastern Zaire, Africa, for approximately 20 months.

Zaire is centrally located in Africa. It is bordered by the People's Democratic Republic of the Congo on the west, Central African Republic and Sudan on the north, by Uganda, Rwanda, Burundi and Tanzania on the east and on the south by Zambia and Angola. The province of Kivu is in the eastern portion of the country, and the village of Nyangezi is in the southern third of Kivu, along the Rwanda and Burundi borders.

Nyangezi is in the midst of montane highlands having an altitude of approximately 1600-2000 m. It is partly located in a large interpluvial forest and has a very moist climate. The combination of the climate and altitude produces a constant temperature of approximately 24°C. The region was once richly endowed with native tropical flora but today introduced cypress, eucalyptus and various citrus species, as well as many agricultural plants, predominate. The village of Nyangezi would thus be termed a disturbed site for collecting butterflies.

The families of Lepidoptera found in the village included: HesperIIDae, PapilionIDae, PierIDae, DanaIDae, NymphalIDae, AcraeIDae and SatyrIDae. Unlike Rogers and van Someren (1925, E. Afr. Nat. Hist. Soc. J. 6:22-43), who treated these taxa as subfamilies, I assigned family rank, following the precedence of Williams (1969, A Field Guide to the Butterflies of Africa, Collins, London). The following species, arranged by family, were collected.

HESPERIIDAE

I collected only one specimen of *Calaenorrhinus galenus* (Fab.) although I observed others.

PAPILIONIDAE

Graphium simoni Aurivillius, *Papilio cynorta* Fabricius, *P. dardanus* Brown, *P. demodoceus* Esper, *P. echerioides* Trimen, *P. nireus* L., *P. zenobia* and *P. zoroastres* Druce.

PIERIDAE

Belenois aurota Fabricius, *B. zochalia* Boisduval, *Catopsilia florella* Fabricius, *C. thauruma* (Reak.), *Eurema brigitta* Cramer, *Nepheronia thalassina* Boisduval.

DANAIDAE

Amauris albimaculata Butler, *A. echeria* Stoll, *A. niavius* L., *A. ochlea* Boisduval, *Danaus chrysipus* L., *D. limniace* Cramer.

NYMPHALIDAE

Byblia acheloia Wallengren, *Cataeroptera cloanthe* Cramer, *Charaxes fulvescens* Aurivillius, *Cymothoe theobene* Doubleday, *Euphaedra spatiosa* Mabilie, *Eurytela dryope* (Cramer), *Hamanumida daedalus* Fabricius, *Hypolimnias dinarcha* Hewitson, *H. missippus* L., *Neptidopsis ophione* (Cramer), *Neptis nemetes* Hewitson, *N. saclava* Boisduval, *N. seeldrayeri* Aurivillius, *Phalanta phalantha* Drury, *Precis hierta* Fabricius, *P. natalica* Felder, *P. octavia octivia* Cramer, *P. oenone* L., *P. sophia sophia* Fabricius, *P. terea terea* Drury, *Pseudacraea eurytus* L., *Pseudargumnis hegemon* Godart, *Salamis anacardi* Trimen, *S. parhassus* Drury.

¹ Approved by the Director of the North Dakota Agricultural Experiment Station as Journal Paper No. 1298.

ACRAEIDAE

Acraea asbolophintha (Karsh.), *A. egina* Mabille, *A. uvui* Grose-Smith, *Bematistes macarioides* Aurivillius, *B. poggei* Dewitz.

SATYRIDAE

Mycalesis chapini Holland, *M. langi* Holland, *M. saussure* Dewitz, *Ypthima albida* Butler, *Y. doleta* Kirby.

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NOTES ON THE GENUS *IMELDA* (RIODININAE)

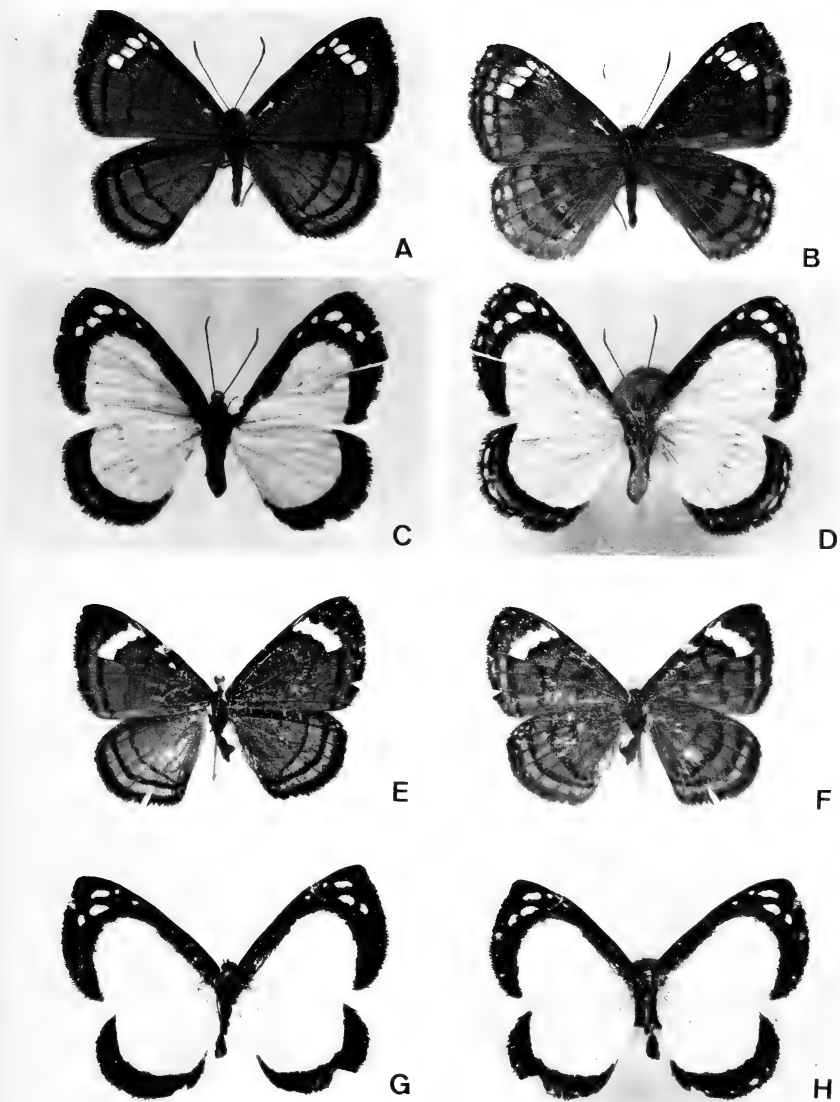
In "Illustrations of the Diurnal Lepidoptera," volume 5(3), Hewitson described the riodinid butterfly *Nymphidium mycea* from a female received from "New Granada," an area covering present-day Colombia, Venezuela, and Panama. His description reads as follows: "Upperside pale yellow, with the margins broadly dark brown; the outer margin of both wings transversed by a rufous band. Anterior wing with three white spots near the apex."

In 1879, Hewitson described a second butterfly based on a male from Ashpiyaco, Ecuador, which he named *Imelda glaucosmia* and designated it as the type of the genus *Imelda*, which was described in the same article. He later illustrated it in "Illustrations," volume 4(5), plate 24, figure 5, repeating the original description, as follows: "Upperside of male glossy dark blue, slightly tinged with green. Both wings crossed beyond the middle by a narrow linear black band scarcely visible on the anterior wing; both with a submarginal band and the outer margin (which is broad) black. Anterior wing with the costal margin brown; crossed by a subapical broad band of white bordered with black. Underside as above, except that it is grey-brown, that each wing has two subbasal spots and a linear spot at the end of the cell of dark brown, and that the inner black band is much broader."

Thieme (1907, Berlin Ent. Zeitschrift 52:1-16) designated *mycea* as the female of *glaucosmia*, using the name *mycea* to refer to *glaucosmia* specimens from Colombia. H. Stichel (1910, Berlin Ent. Zeitschrift 55:9-103) erected a new subspecies, *terpna*, to refer to the male designated by Thieme as that of *mycea*. Stichel rejected the idea that *mycea* was the female of *terpna*, claiming that the dimorphism between the two was too great for them to be conspecific. He maintained this position in the Catalogus (Stichel, 1930, in Junk, Lepidoptorum Catalogus, Vol. 44, Berlin).

Because the most recent revision of a taxonomic group usually takes precedence over previous revisions, Stichel's conclusions determine the present status of these butterflies. However, as both Thieme's and Stichel's conclusions were reached without the help of field observations, the matter is worth reopening in light of data I gathered in the field.

My first experience with *glaucosmia* came during a collecting trip to a locality about 14 km to the west of Arcabuco, Boyacá, Colombia, in July 1981. The altitude of this area is 2000 m and lies in a transition zone between Very Humid Low Montane Forest and Premontane Very Humid Forest. Rainfall is about 2000 mm per year (1977, Anonymous, Zonas vegetales de Colombia, IGAC). Although much of the vegetation has been cleared for cattle raising, forested areas may be found along the streams. The general aspect of the forest is like other subtropical montane forest areas throughout the neotropical region. The trees reach a height of 10 m and support many bromeliads and other epiphytic plants growing from the branches, and are interspersed with bamboos and tree ferns.



FIGS. A-H. *Imelda mycea* ssp. (dorsal and ventral views): A & B, male *I. m. mycea* Hewitson, ♂ & ♀ from Arcabuco, Boyaca, 2000 m, Colombia; C & D, female *I. m. mycea*; E & F, male *I. m. glaucosmia* Hewitson, ♂ & ♀ from Rio Topo, 1500 m, Tungurahua, Ecuador; G & H, female *I. m. glaucosmia*.

At 1245 h while collecting in a small forest clearing by a stream, I noticed a small blue riordinid butterfly resting beneath a leaf with wings outspread at the edge of the clearing about 3 m above the ground. I had barely captured this butterfly when another identical individual alighted on the same spot. This butterfly was also caught. Moving along the edge of the clearing, I captured another riordinid butterfly, this time a yellow one, resting under another leaf about 4 m off the ground. All this took place within a 5 minute period. The behavior exhibited by these butterflies was typical of perching, a form of mate locating behavior employed by members of the subfamily Riordininae, in which the butterflies wait for mates at certain localities and during certain hours of the day (Callaghan, in prep.).

During a subsequent visit to the same locality on 16 September 1982, four additional males and one female were captured between the hours of 1136 and 1320. All were frequenting the same microhabitat and exhibiting the same behavior as on the previous visit.

Through consulting the descriptions and references above, I determined the butterflies to be *Imelda glaucosmia terpna* Stichel and *Imelda mycea* Hewitson.

In view of the behavior observed and the morphology of the butterflies, I conclude that *terpna* and *mycea* are male and female of the same species. First, my studies of the perching habits of riordinid butterflies have shown that the frequenting of similar perching sites at the same time by closely related male and female phenotypes is a strong indication that the two are conspecific. Secondly, there is enough similarity in the morphology of *glaucosmia terpna* and *mycea* to suggest that they are conspecific. The general pattern with the white spots on the apex of the forewing and the placement of the submarginal bands on both, as well as the marginal row of white spots on the underside of both wings is sufficient indication that the two are indeed conspecific as indicated by Thieme.

In conclusion, the name *Imelda mycea mycea* (Hewitson, 1865, [1852-1878], Illustrations of Diurnal Lepidoptera, vol. 1-5) refers to central Colombian material, illustrated in Figs. A, B, C and D, for which the name *terpna* Stichel is a synonym. The name *Imelda mycea glaucosmia* (Hewitson, 1870, Ecuatorial Lepidoptera, Part IV) is the designation for material from Ecuador to Southern Colombia (Huila), illustrated in Figs. E, F, G and H.

I wish to thank Dr. Keith Brown for his comments on the paper.

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NEW AND UNUSUAL BUTTERFLY RECORDS FROM KANSAS

In June 1979, my colleagues and I (senior author) began an intensive, statewide survey of the butterflies of Kansas. Our third season (1981) was marked by an influx of immigrant species and the collecting of two species (*Pyrisitia proterpia* and *Speyeria edwardsii*) not previously reported from Kansas. Observations and collections were also made for *Thesalia fulvia* and *Vanessa annabella*, both considered "unusual" for Kansas.

Pyrisitia proterpia (Fabricius).—Labeledz took a single female (nearly perfect condition) on the Fort Hays State University campus, Hays, Ellis County on 20 October 1981. This individual was taken on a purple-flowered, ornamental *Amaranthus* sp. at about 1445 h. The temperature was about 70°F with a light wind and the sky was clear. Upon seeing this specimen, Rolfs recalled collecting a similar one on 3 October and of seeing

a second "a few days later" (about 7 October). These two individuals were over a vegetable and flower garden in north Hays. No additional specimens were found despite an extensive search on following days. William Howe (pers. comm.) captured a tattered vagrant in Franklin County in October 1971 (now at LACM). These are the first reported specimens from Kansas.

Speyeria edwardsii (Reakirt).—Ely collected a male in perfect condition in Atwood, Rawlins County on 5 June 1981. It was feeding in a small patch of alfalfa (*Medicago sativa* L.) growing at the edge of a paved street at the edge of town. Nine other species were collected at this site, and we spent about 30 minutes searching, in vain, for another specimen. The weather was sunny and warm (late afternoon) with a light wind. This is the first reported Kansas specimen. The only other unusual species seen in Rawlins County on this date was a single *Danaus gilippus* which narrowly evaded capture at another locality.

Thessalia fulvia (W. H. Edwards).—Field (1938, A manual of the butterflies and skippers of Kansas, Bull. Univ. Kansas 39:328 pp.) reported a specimen from Rush County on 28 June 1912. Marvin D. Schwilling (pers. comm.) took three specimens (now in his private collection) in Barton County during the 1960's. Ely took a fresh but slightly damaged specimen from a truck radiator on 14 June 1980. This specimen must have been hit between Holcomb (Finney County) and Hays and we suspect closer to the latter. This was followed by multiple finds by Ely in Ellis County.

On 15 June while on a class field trip to the FHSU pasture about one mile south of Hays, he collected a single male (by hand) in moderately grazed mixed grass prairie. Next morning on a similar trip he saw several others in a nearby area, so returned after class for a more extensive search. Between 1020 h and 1100 h, seven of the 15 individuals seen along a white chalk road through the prairie were collected. They appeared to be attracted to the road since only three were found on a similar intersecting road nearby and none was seen in adjacent prairie. All seemed to be males and some seemed "territorial" in that each repeatedly returned to its same spot after being flushed. All alighted on the ground rather than on vegetation and no feeding was observed. The area was rich in flowering forbs and pioneer plants. The weather was warm and without wind.

Ely next visited the area on the 17th (1400–1420 h), a warmer day with moderate wind, and failed to find even one individual. A careful examination of the *Castaleja* plants in the vicinity failed to locate any larvae. On the 24th he again visited the area during mid-morning (1000–1010 h) and saw at least 10 individuals, including one feeding on *Houstonia nigricans* (Lan.) Fern. The area was last visited on 4 July but no *fulvia* were found. During this entire period all individuals were within an area of approximately 10 m × 100 m. One other specimen was taken in 1980, in similar prairie about 12½ miles north of Hays. It was in a disturbed area where numerous chalk fragments were scattered about the surface.

On 26 May 1981 while collecting in southcentral Kansas, Ely and Rolfs found this species to be common in the sagebrush and sandsage prairie habitats at numerous localities in Comanche, Clark and Ford Counties. In sagebrush south of Clark State Fishing Lake (13 miles north of Ashland), it was exceeded in numbers only by *Nathalis iole*. A good series was collected, most of them as they fed at various species of yellow-flowered composites. The only specimen taken in Ellis County during 1981 was a single taken in the FHSU pasture by Guy Ernsting on 29 June.

Vanessa annabella (Field).—Field (op. cit.) reported one from Scott County on 28 October 1935. Ely collected single individuals over flower beds on the FHSU campus on 6 October 1980 and 19 October 1981. Other immigrant species recorded at Hays during summer 1981 included *Mestra amydone* (2), *Chlosyne lacinia* (15+), *Agraulis vanillae* and *Phoebis sennae* (4).

We wish to thank William H. Howe, who confirmed the identifications of the two state records and reviewed the manuscript.

ABERRANT *GLAUCOPSYCHE LYGDAMUS COUPERI* GRt. (LYCAENIDAE)

On 11 June 1977, an aberrant female *Glaucopsyche lygdamus couperi* Grt. was collected at Mer Bleue Bog, near Ottawa, Ontario. This species is common in open areas throughout the Ottawa area wherever the hostplant, common vetch (*Vicia* spp.), grows. The specimen was collected in a field bordering the bog while it rested on the underside of a vetch leaf.

Figs. 1, 2 show the ventral surfaces of a normal (Fig. 2), and the aberrant specimen (Fig. 1). In the aberrant specimen, the normal ventral postmedian row of spots is elongated, especially on the secondaries, where they form a series of roughly rectangular bars, as compared to the round or oval spots of the usual form. The specimen has been deposited in the Nova Scotia Museum collection, Halifax, Nova Scotia. I would like to thank Mary Primrose of Dalhousie University, Halifax, Nova Scotia, for photographing specimen.

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FIGS. 1 & 2. Females of *Glaucopsyche lygdamus couperi*, ventral surface: 1, aberrant specimen; 2, normal specimen.

BOOK REVIEW

LARGE WHITE BUTTERFLY: THE BIOLOGY, BIOCHEMISTRY AND PHYSIOLOGY OF *PIERIS BRASSICAE* (LINNAEUS). By John Feltwell. W. Junk Publishers, The Hague. Series Entomologica, vol. 18. 542 pp. 1981. \$98.00.

Large White Butterfly—it sounds like it is missing a “The” in front—is a very peculiar book. It attempts to be a complete, or nearly complete, literature survey of a very extensively studied animal, *Pieris brassicae*. It probably isn't complete, but I failed to turn up any references in my own files that weren't in it—down to Akhmedov's 1967 paper in the proceedings of the Azerbaijanian Academy of Sciences on photoperiodic reactions of Tashkent stocks, or Fernando's in *Spolia Zeylandica* on host plant selection. One can't get much more arcane than those.

Why do a compilation like this? As Miriam Rothschild says in her foreword, the literature of everything is now very unwieldy. A few years ago I discovered that some experiments I had just published were foreshadowed precisely by Z. Lorković in work published in the scientific yearbook of the University of Zagreb in 1928. Missing that reference was fairly easy, but even keeping up with current journals in the library is a nightmare, and those able to do so are increasingly subscribing to computerized literature-search services. Even that has its perils—if you try it with “Large White” as a search word, as I did, you will end up with dozens of papers on the culture of a breed of swine by that name, popular in Eastern Europe. Remarkably, Feltwell did this compilation without computerized assistance. Probably no one will ever do such a job that way again.

Anyone working on any aspect of pierid biology will have recourse to this book for many years to come. *Pieris brassicae* is the most-studied pierid on most fronts—*Colias eurytheme* is probably next in line. The extent to which it is legitimate to extrapolate to other pierids, or even to other species placed in the old genus *Pieris*, is problematical; *brassicae* and its very close relatives form an odd, isolated pocket in the group, distinguished by a very reduced chromosome number and other things. Still, it is all we've got to compare most things to.

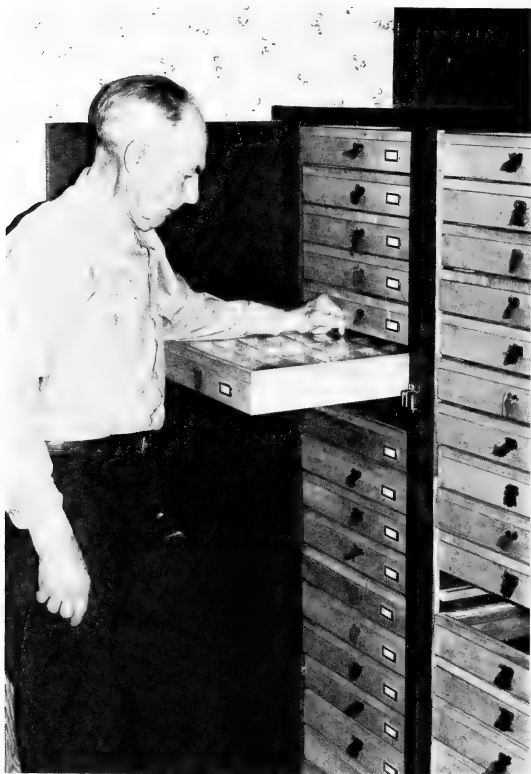
The book is obviously a compilation. The information conveyed is telegraphic, fragmentary, and often so out of context that no real picture of its significance emerges. Of course, much of the information conveyed is trivial, but unless one already knows the field one might be hard-pressed to tell what is important and what is not—in a way, Large White Butterfly is organized like an organic chemistry course, in which, to be safe, you learn everything. Information on aberrations and the like is dated and pretty meaningless when their etiology and developmental context are unexplored. They might be very interesting to developmental biologists, physiologists, or geneticists, but how is one to tell?

This is not a coffee-table book. Despite its price, which works out to 18.3¢ a page, there aren't even any color plates (But why should there be, in a book about a black-and-white “bug?”). The book belongs in all major institutional reference libraries, where it will save graduate students, especially, a great deal of travail. If it fails to convey much impression of what the Large White really *is*, how it lives, and how it fits into its environment, it at least points the way to the original sources. The moral is simple: If you want character development, don't read the phone book like a novel.

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OBITUARY

MURRAY OTTO GLENN (1893-1981)



Murray Glenn (1977)—photo by G. L. Godfrey

MicrolepidopteroLOGY lost one of its most dedicated and productive, but also unsung, workers when Murray Glenn died in a hospital in Spring Valley, Illinois on 26 July 1981. He was not well known to many Lepidopterists, yet Dr. J. F. Gates Clarke (in litt.) characterized him as having "contributed more to our knowledge of midwestern microlepidoptera with particular reference to Illinois than any other person except, perhaps, the late Dr. Annette Braun."

Murray Otto Glenn was born in Magnolia, Illinois on 3 October 1893, the son of Isaac and Helen (Otto) Glenn. He married Lena F. Bell on 21 May 1925 in Normal, Illinois. She survives him together with three sons, Alan, Richard and Donald; a daughter, Marjorie (Mrs. George Haws); a sister, Mrs. Gladys Steer; 12 grandchildren and four great-grandchildren. A brother and a sister preceded him in death.

Glenn studied agriculture at the University of Illinois for three years after graduating from high school in 1911 but withdrew before taking a degree to join the Army during WWI. He left the service as a lieutenant. As a young man he was hired by a railroad to play semi-professional baseball in Montana to entertain the settlers there. Returning to his native state, he farmed over 600 acres with his brother near Magnolia. After retiring from farming he moved to Henry, Illinois where he spent the rest of his life.

He began to collect insects, particularly Coleoptera, as a high school student, but his serious study of Lepidoptera began in 1931 when his interest was attracted to their immatures. In rearing these he discovered many life histories and foodplant associations. He collected the holotypes of 18 new species of microlepidoptera and paratypes of 10 more, all described by other workers, and three of which were named in his honor. Several of these new taxa were described by Clarke, who said in further tribute to Glenn's work (in litt.) that "his specimens were beautifully prepared thereby facilitating study. It was always a pleasure to work with his material." Glenn published nothing on Lepidoptera during his long career; his only publication was as junior author with Dr. M. W. Sanderson of a note on Coleoptera (1963, *Coleopterists' Bulletin* 7:52).

Glenn occasionally collected in other parts of the United States, but by far the greater portion of his field work was done in the immediate vicinity of his home. His efforts produced a virtually complete record of the microlepidoptera of that portion of Illinois, especially useful in monitoring environmental changes over a 46-year period. Although microlepidoptera were his specialty, he did not neglect the larger Lepidoptera, including butterflies. He professed a humorous disdain for the latter, but nevertheless turned up a number of Illinois rarities.

Glenn continued his activities well into later life. He once told me that he had considered giving up moth work when he reached 80, but when he did he "couldn't see that 80 was any different than 79, so I am still doing what I enjoy most, and am collecting again this year." In 1969 he donated his macrolepidoptera to the Illinois Natural History Survey ("Survey") except for some common butterflies which he kept for show and eventual donation to a local school. In 1977 he turned over his identified micros to the Survey and his undetermined material to the United States National Museum of Natural History. The Survey regards the Glenn collection as the most important of the several Lepidoptera collections in its care.

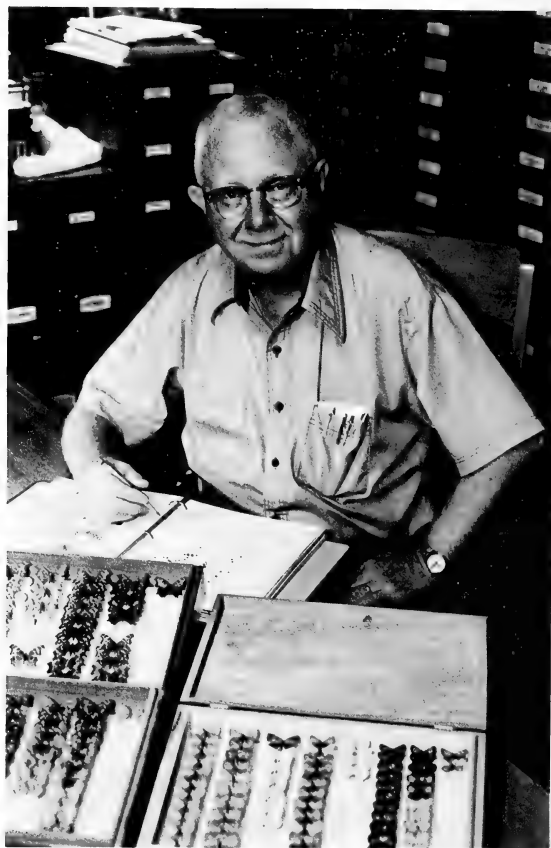
I became acquainted with Murray as a young man early in 1947, at about the same time that the Lepidopterists' Society, which we both joined as charter members, was being formed. Before meeting him my outside contacts had been few, and through him I made new ones and broadened my horizons. We remained lifelong friends. He was generous, modest, humorous and always kind and helpful; a true "handmaiden of science," who will be missed by all who had the honor and pleasure of knowing him.

I am very grateful to Dr. George L. Godfrey of the Survey for his help in the writing of this article. He published additional information on Glenn's collection and activities, including a list of 17 of the taxa based on Glenn holotypes (1978, *J. Lepid. Soc.* 32:235) (the 18th name remains in manuscript at this writing). An article on Glenn's life and work, some of which is excerpted herein by permission, was published by Godfrey and W. E. LaBerge (1977, *Illinois Natural History Survey Reports* No. 168). Family data were derived from Glenn's obituary (replete with errors concerning his scientific work) in the *Henry, Illinois News-Republican* of 29 July 1981. The photograph was taken by Godfrey in 1977 at the time of the transfer of Glenn's collection to the Survey.

RODERICK R. IRWIN, 24 East 99th Place, Chicago, Illinois 60628 (Research Affiliate, Illinois Natural History Survey and Illinois State Museum).

OBITUARY

ERNST J. DORNFELD (1911-1983)



Dr. Ernst J. Dornfeld (1911-1983), author of "The Butterflies of Oregon" (1980) (photo taken Nov. 1979 by John Neyhart).

Ernst J. Dornfeld died on 30 May 1983 in Corvallis, Oregon at the age of 72. A professional cell biologist, he had been chairman of the Department of Zoology at Oregon State University for 24 years prior to his retirement in 1976. He was interested in butterflies and skippers with a special interest in the fauna of Oregon, culminating in his book on the Butterflies of Oregon, published in 1980.

Ernst was born in Milwaukee, Wisconsin on 6 April 1911, the son of Ernst Phillip Dornfeld and Gertrude Dornfeld. His father, a Lutheran minister, encouraged him when he showed interest in butterflies at an early age. He attended Concordia College and then Marquette University, receiving his B.S. degree from Marquette in 1933. He began his graduate work at the same institution, then moved on to the University of Wisconsin, at Madison, where he received his M.A. degree in 1935 and his Ph.D. in 1937. He spent the summer of 1935 at the University of Michigan, Ann Arbor.

His graduate research work was in cell biology and occupied most of his time during that period. He did serve as Assistant in Lower Zoology at the Milwaukee Public Museum from 1930 to 1932, while an undergraduate student at Marquette. Ernst often acknowledged the strong influence his germanic heritage exerted on his scientific work and on his interest in the liberal arts. It was his feeling that his broad interests were encouraged by his family and by the many cultural activities in Milwaukee, including the Milwaukee Public Museum. This institution continues to occupy a prominent position in the cultural life of Milwaukee.

Ernst spent a year as an instructor in histology and embryology at the University of Oklahoma School of Medicine before coming to the then Oregon State College in 1938 as an instructor of Zoology. He moved up through the academic ranks to Assistant Professor in 1942, Associate Professor in 1946, Professor in 1950 and Chairman of the Department of Zoology in 1952, a position he held until his retirement from Oregon State University in 1976 as Professor Emeritus of Zoology. He married Lorena Sue Ferguson in 1945. They had five children, Ernst, Susan, Ruth, Margaret and Carl.

Ernst had a long and distinguished career as an academician and as a cell biologist. When he joined the department in 1938, there were six faculty members. When he retired in 1976, the department had grown to 17 faculty members. He was an unusually fine teacher, well organized, thorough, articulate and enthusiastic. During his years on the faculty, he taught eight different courses ranging from general zoology to the biology of the cell. He was well regarded by his students, receiving the Loyd Carter Award for "Inspirational Teaching" in 1947, the second such award to be given.

Ernst was an accomplished research scientist besides a teacher. His research centered on cell biology, particularly cell division and differentiation. He published 47 scientific papers, including 9 on the Lepidoptera. It is of interest to note that his first and last papers were on butterflies. Ernst received the Society of Sigma Xi Research Award in 1961, the Distinguished Professor Award from the Oregon State University Alumni Association in 1978 and the Citation for Outstanding Scientific Achievement from the Oregon Academy of Science in 1981. While his earlier awards were based largely upon his work in cell biology, gradually his expertise with the Lepidoptera became better known and added to his stature as a scientist, culminating in the appearance of his book on Oregon butterflies.

His interest in butterflies extended back to his childhood days and the encouragement he received from his family. He amassed a large collection of Wisconsin butterflies prior to coming to Oregon. Some of these specimens were contributed to the Milwaukee Public Museum at the time. His interest in Lepidoptera remained throughout his life but other research interests, particularly in cell biology, dominated his professional career for many years. His interest in butterflies was revived when one of his sons became interested in them in the early 1950's. Ernst began to study and collect the Oregon fauna with the same zeal and enthusiasm that he brought to his other work. He made numerous field trips into all parts of Oregon and gradually built up a magnificent collection of approximately 25,000 specimens, largely from Oregon. He compiled meticulous records of his own material and that of others against the day when he would have the time to complete his book on the fauna of Oregon. His retirement in 1976 provided him with that time he needed. He started to work on that book almost on the day he retired. It appeared in 1980, just the way he wanted it to be. He was able to incorporate the summed knowledge of each species found in the state, based on his own work and that of others. There were many others, for Ernst established and maintained contact with a number of lepidopterists, freely sharing his own knowledge and experience. His willingness to share and his enthusiasm was extended to a good many children in Corvallis, including the three sons of one of us (J.D.L.), who quickly learned that Ernst knew all there was to know about butterflies. Often, it was difficult to determine who was more excited over an interesting catch, Ernst or the youthful entomologist!

Ernst delivered the annual Sigma Xi lecture in 1978 entitled "About Butterflies." It was a beautifully prepared and illustrated lecture and was very well received. It was so well received, in fact, that shortly before he died, he told us that he had given that talk 26 times since 1978. He was a member of the Lepidopterists' Society for many years

and served as co-host for the 1967 meeting held at Oregon State University. He was an active participant in the various lepidopterists' workshops held around the northwest. His last active role was to host such a workshop in November of 1982 at Oregon State.

The Dornfeld collection, including his library and records, has been bequeathed to the Systematic Entomology Laboratory (SEL), Department of Entomology, Oregon State University. The SEL contains approximately 2.4 million specimens, including the largest collection of butterflies in the Pacific Northwest. Ernst donated thousands of hours to the SEL. He worked over the entire collection of butterflies in his meticulous fashion, even leaving room throughout the collection for his own specimens. He was very active in encouraging others to donate their collections as well, resulting in thousands of additional specimens for the collection. He took his scientific responsibilities very seriously.

While he was serious about his science, he was also infectiously enthusiastic and had a wonderful sense of humor. He was a perfectionist in everything he did but enjoyed nothing more than a joke upon himself. Both of us shared field and laboratory experiences with him for many years. We remember his warmth and friendship and especially his chuckle that often erupted into a loud laugh. Ernst had a love of life and learning and a real passion for butterflies. It was our privilege to have shared a part of his life.

Our thanks to John Neyhart, Roseburg, Oregon, for the fine photograph of Ernst.

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Cover illustration: Adult of the squash vine borer, *Melittia cucurbitae* (Harris) (Sesiidae), which occurs in the eastern half of the United States and along the Gulf Coast into Vera Cruz, Mexico. The larvae are destructive borers in the vines of various cultivars of *Cucurbita* spp. (squash, pumpkins and gourds). Original drawing by Dr. Charles S. Papp, Sierra Graphics & Typography, 1722 J Street #19, Sacramento, CA 95814, USA.

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CYPRIPEDIUM FLOWERS ENTRAP ADULT THYMELICUS
(LEPIDOPTERA: HESPERIIDAE) IN
NORTHERN MICHIGAN

EDWARD M. BARROWS

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ABSTRACT. Adults of the introduced skipper *Thymelicus lineola* were attracted to the nectarless flowers of the native orchids *Cypridium reginae* and *C. calceolus*. No doubt in search of food, they crawled into orchid labella. Up to 24 skippers and other insects became entrapped and died in a single labellum.

The European skipper, *Thymelicus lineola* (Ochsenheimer), was first discovered in North America in London, Ontario, Canada, in about 1910 (Saunders, 1916; Klots, 1958). Since this time it has spread to British Columbia, New Brunswick, Manitoba, Connecticut, New Jersey, New York, Pennsylvania, Ohio, Michigan, Maryland, and Virginia (Burns, 1966, pers. comm.; Preston & Westwood, 1981) and has become a pest of hay fields in Canada (McNeil & Duchsne, 1975; McNeil et al., 1976). Adults seek nectar from many species of flowers including the lady's-slipper orchids *Cypridium reginae* Walter and *C. calceolus* L. This report increases knowledge about the peculiar entrapment of adult *T. lineola* by the labella of these orchids in northern Michigan. Arthur (1962) previously reported this phenomenon regarding this butterfly and *C. reginae* in Ontario, and Catling (1974) reported it in both Ontario and southern Michigan.

Observations were made in summer, 1977, in a marshy and swampy area on the property of the University of Michigan Biological Station, Cheboygan County, Michigan, when the skipper was abundant. Orchid labella that were partially or wholly dried after anthesis were removed from pedicels for inspection of their contents. *Thymelicus lineola* was uncommon in the study area in the summer of 1978 when I attempted to continue this study.



FIG. 1. A *Thymelicus lineola* probing the labellar orifice of a nectarless flower of *Cyripedium calceolus*.

Thymelicus lineola frequently alighted on orchid flowers, extended their proboscides into labellar openings and crawled into the labella (Fig. 1). They apparently obtained no food from these nectarless flowers (Stoutamire, 1967; pers. obs.). *Cyripedium* labella are adaptations for bee, not butterfly, pollination; bees may become temporarily entrapped in them and effect pollination by depositing pollinia as they escape through one of two small orifices at the labella bases (Stoutamire, 1967; Catling, 1974).

On 26 June, 219 *T. lineola* were found in 42 *C. reginae* flowers. Each flower contained from 0 to 11 males ($\bar{x} = 5$) and from 0 to 4 females ($\bar{x} = 0.5$). On 4 July, 42 flowers contained 427 dead *T. lineola*,

with from 0 to 15 males ($\bar{x} = 7.4$) and from 0 to 12 females ($\bar{x} = 2.7$) per flower. The flowers contained significantly more males (90.41%) on 26 June than on 4 July (73.0%) ($P = 0.035$, test for equality of two percentages). Up to 24 *T. lineola* were found in a single labellum. Catling (1974) reported up to five of them per labellum. In late June, I discovered a female acridid grasshopper, *Melanoplus islandicus* Blatchley, eating dried *T. lineola* that she obtained through a hole in a dried labella. These flowers also contained salticid and thomisid spiders; entomobryid springtails; perlodid stoneflies; reduviid and mirid bugs; derodontid, elaterid, and lathridiid beetles; anisopodine, chloropid, phorid, and syrphid flies; geometrid moths; and andrenine bees. Most of these arthropods were dead.

On 26 June and 4 August, a total of eight of 11 inspected *C. calceolus* flowers contained insects. From one to three males of *T. lineola* were in four of the flowers and one female *T. lineola* was in one flower. These flowers also contained a thomisid spider, a culicid fly, geometrid moths, lathridiid beetles, and halictine, andrenine and megachilid bees.

The native skippers, *Polites themistocles* Latreille and *P. coras* (Cramer), also enter *Cypripedium* labella; however, they were not found entrapped in them (Guignard, 1886; pers. obs.). In comparison to *T. lineola*, these native butterflies may be able to escape from the labella due to their greater strength, behavioral flexibility, or both. Catling (1974) suggested that *Euphyes* and *Ancyloxipha* skippers flying in a bog with *C. reginae* in Ontario may not be trapped due to their having feeding habits different from *T. lineola*. Further, he made the plausible hypothesis that fatal entrapment of *T. lineola* is an "accident" due to their encountering a North American orchid with characteristics of *C. reginae*. Finally, he surmised that pollination of this orchid may be reduced by entrapment of *T. lineola* because they could obstruct pollinator movements. These and other interesting hypotheses regarding this skipper and these orchids remain to be tested.

ACKNOWLEDGMENTS

Edward G. Voss (University of Michigan), John M. Burns (Smithsonian Institution), and an anonymous reviewer made helpful suggestions regarding this article. Ashley B. Gurney (USDA, Washington, D.C.) identified the *Melanoplus*.

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SIGNIFICANCE OF VISITS BY HACKBERRY BUTTERFLIES (NYMPHALIDAE: *ASTEROCAMPA*) TO FLOWERS

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ABSTRACT. Behavioral studies were conducted on hackberry butterflies (*Asterocampa* spp.) in central Texas as to their visitations to certain flowers. The butterflies were observed most abundantly on snakewood flowers (*Colubrina texensis*). A higher percentage of females were counted during sampling. It is speculated that *Asterocampa* spp., especially females, visit flowers which serve as a nitrogen source and do not require the carbohydrate-rich nectar sources of most other flowers.

Visits by rhopaloceran species to angiospermous flowers are well known even to laymen. However, as any knowledgeable lepidopterist is aware, some species are rarely or never observed at flowers. One group of butterflies generally believed not to visit flowers are the hackberry butterflies of the nymphalid genus *Asterocampa*. Howe (1975: 113) states that "they do not visit flowers but feed on decaying material—rotting fruit, fermenting tree sap, animal excrement and carcasses." No record of *Asterocampa* visiting flowers was known to Shields (1972) who reviewed butterfly flower visitation records. The most extensive published account of the life history account of any *Asterocampa* appears to be that of *A. celtis* (Langlois & Langlois, 1964). Adults were observed feeding at wet mud and fruit (mulberries and cherries). Kimball (1965) recounted observations of *Asterocampa* spp. feeding at rotten persimmons and oozing hackberry trees. *A. clyton* and *A. celtis* have been observed feeding at pig carrion in a state of "advanced decay" (Payne & King, 1969). Visits to waterholes in Arizona by *A. celtis* were observed by Bauer (1953). In Arizona, *A. leila* has been observed feeding at coyote feces which contained much *Opuntia* fruit; they were never observed at flowers or mud puddles (Austin, 1977). In the eastern United States, Shapiro (1966) reported that *A. celtis* was "never seen . . . on flowers" while *A. clyton* were "occasionally seen clustered on over-ripe fruit." The only reference to *Asterocampa* on flowers that I have found is Scott and Scott (1980), who report that *A. celtis* in Colorado "rarely feed on flowers (*Jamesia*, etc.) but often feed on sap especially of willows and occasionally feed on mud or on *Rubus* berries." Kimball (pers. comm.), however, says he has observed *Asterocampa* spp. visiting a variety of flowers on several occasions. The purpose of this communication is to document significant visitations by *Asterocampa* spp. to angiospermous flowers and to elucidate environmental factors which resulted in this activity.

OBSERVATIONS

All observations discussed below, unless otherwise so indicated, were made in McKinney Falls State Park, Travis Co., Texas, just southeast of Austin. The specific area was an upland flat above the left bank of Onion Creek. Shallow soil covers the underlying Pflugerville Limestone (Upper Cretaceous: Gulf Series) except for isolated areas and the scarp where bedrock is exposed. Three vegetational associations are present at the site. The woodland consists of cedar elm, *Ulmus crassifolia* Nutt., with an occasional plateau live oak, *Quercus fusiformis* Small. A meadowlike open area is dominated by small bur-clover, *Medicago minima* (L.) L. and yellow stonecrop, *Sedum nuttalianum* Rof. A thicket association occurs at certain woodland edges and the scarp of the upland flat. Dominant shrubs of this thicket are snakewood, *Colubrina texensis* (T. & G.) Gray; Texas persimmon, *Diospyros texana* Scheele; spring herald, *Forestiera pubescens* Nutt.; and pink cat-claw, *Mimosa borealis* Gray. The only hackberry occurring in this immediate area are seedling, sapling and small shrubby netleaf hackberry, *Celtis reticulata* Torr. Approximately 50 m from the study site, tree-size (to 8 m) individuals of both *C. reticulata* and Texas sugarberry, *Celtis laevigata* Willd. are present.

Observations on the study site were initiated on 7 March 1977 in connection with studies on other rhopalocera. An occasional *Asterocampa* was observed as early as 19 April when one fresh specimen of *A. antonia* (Edwards) was observed. Open flowers of snakewood were initially observed on 18 April. Moderate numbers of this species and *A. texana* (Skimmer) were observed feeding at flowers of *Colubrina* (Rhamnaceae) as early as 25 April (see Table 1). Flowers of snakewood are rather inconspicuous, being about 5 mm in diameter. The reduced petals form a yellowish five-pointed star surrounding a central green disc. Subsequently, for over two weeks adults of both species were observed at snakewood flowers. Last observed *Asterocampa* feeding at snakewood flowers was 10 May, although open flowers persisted through at least 19 May at this site. Apparent age of the butterflies was quite variable. All of the *A. texana* were fresh in appearance, although an age of one or two weeks is not unlikely. Adults of *A. antonia* varied from fresh to worn, very tattered adults. These tattered *A. antonia* were predominantly males.

Detailed behavioral observations of these butterflies were recorded. A butterfly at a snakewood flower was always observed to be moving its proboscis over the surface of the bowl of the flower. Nectar was not the object of this behavior. Unidentified substances, possibly including rich amounts of various amino acids, were obtained from the green

TABLE 1. *Asterocampa* observed at snakewood (*Colubrina texensis*) flowers in 1977.

	<i>A. antonia</i>		<i>A. texana</i>	
	♂	♀	♂	♀
25 April	—	3:0*	—	0:1
26 April	3:1	5:0	—	1:1
29 April	0:1	0:3	—	2:0
6 May	—	1:0	1:0	1:0
10 May	—	—	—	1:0
Total	3:2	9:3	1:0	5:1

♀ total—14:4; ♂ total—4:2; *A. a.*—12:5; *A. t.*—6:1.

* At flower : not at flower. Butterflies counted as "at flower" only if proboscis observed extended to disk of flower.

central disk. That significant amounts of amino acids may be available from snakewood flowers is indicated by the presence of carrion and dung flies at these flowers. Flowers attracting such flies must utilize high-level amino acid solutions in order to lure them away from their normal food sources which are naturally high in nitrogen (Baker & Baker, 1973a, b, 1975). All butterflies listed in Table 1 were observed to perform such behavior. During such activities neither feet nor antennae of *Asterocampa* touched the flower. Detection of the flower is apparently made visually with verification involving the highly flexible tip of the proboscis. Occasionally, the antennae are flexed up and down in unison, but no physical contact of the antennae was made with the flower. Possibly olfactory receptors in the antennae are receptive to chemicals emanating from the flowers. Movement from flower to flower was accomplished by walking along branches.

As only the proboscis of *Asterocampa* comes into contact with the flower, these butterflies are unlikely to be effective pollinators. From this standpoint, *Asterocampa* spp. can be considered to be "cheaters" or nutrient-thieving flower visitors (Heinrich & Raven, 1972), because they do not participate in pollen transport. Legitimate flower visitors (actual pollinators) included at least two paper wasps (*Polistes annularis* and *P. apacheanus*), 2 tachinid fly species, 1 ichneumon wasp, 1 muscid fly, 2 syrphid fly species, 1 conopid fly, honey bees (*Apis mellifera* L.) and 1 blow fly.

A number of other rhopaloceran species visited snakewood flowers, while several butterflies present in the area were never observed visiting these flowers (Table 2). Examination of Table 2 reveals a definite dichotomy between two classes of butterflies—those species which visit snakewood flowers and those that don't. That this is an ecologically significant dichotomy is remarkably demonstrated by the behavior of pollinating agents of snakewood and of balsam gourd, *Ibervillea lindheimeri* (Gray) Greene, a vine growing upon snakewood. Both plants

TABLE 2. Rhopalocera observed during survey.

Species observed at snakewood flowers	Species at other flowers
<i>Atlides halesus estesi</i> Clench	<i>Erynnis funeralis</i> (Scudder & Burgess)
<i>Panthiades m-album</i> (Bdv. & Lec.)	<i>Battus philenor philenor</i> (Linnaeus)
<i>Strymon melinus franki</i> Field	<i>Phoebis sennae marcellina</i> (Cramer)
<i>Libytheana bachmanii larvata</i> (Strecker)	<i>Abaeis nicippe</i> (Cramer)
<i>Asterocampa antonia</i> (W. H. Edwards)	<i>Nathalis iole</i> Boisduval
<i>Asterocampa texana</i> (Skinner)	<i>Chlosyne lacinia adjutrix</i> Scudder
<i>Vanessa atalanta rubria</i> (Fruhstorfer)	<i>Agraulis vanillae incarnata</i> (Riley)
	<i>Danaus plexippus plexippus</i> (Linnaeus)
	<i>Danaus gilippus strigosus</i> (Bates)

were blooming simultaneously, but pollinators of the two plants formed two mutually exclusive groups. *Asterocampa* and other visitors to snakewood flowers totally ignored balsam gourd flowers, while visitors to balsam gourd flowers (e.g., the butterfly, *Abaeis nicippe* Cramer, and a bumblebee, *Bombus* sp.) totally ignored snakewood flowers. Flowers of the two species were no more than five centimeters from each other.

Although *Asterocampa* were found abundantly on snakewood flowers, a limited number of other food sources were noted. On 29 April one female *A. antonia* was observed on pencil cactus, *Opuntia leptocaulis* DC.; the proboscis of this individual was actively probing at the internodal joints of this plant. On 10 May a female *A. texana* alit on my arm, extended its proboscis and probed along the skin surface. On this same day one male *A. texana* and one female *A. antonia* were observed visiting flowers of Canada garlic, *Allium canadense* L. var. *canadense*. On 13 May one male *A. antonia* was observed feeding at flowers of this same plant. On this same day one female *A. texana* was observed feeding at mud. On 20 May one male and one female were observed feeding at flowers of *Acacia angutissima* (Mill.) O. Ktze. var. *hirta* (Nutt.) B. L. Robinson.

One female *A. texana* was observed feeding on rotting fruit of purple leaf plum (*Prunus cerasifera* Ehrh. var. *pissardii* Koehne) in a residential yard in Austin. This butterfly appeared to be using its antennae to help locate fruit. The antennae were flexed up and down on the surface of the fruit in unison and were even whirled in complete circles in front of the body. However, widespread probing at the fruit with the proboscis was also observed.

Most blossoms present during those observations were ignored by *Asterocampa*, however. These included *Medicago minima* (L.) L., *Sedum nuttalianum* Rof., *Lesquerella recurvata* (Gray) Wats., *Gailardia pulchella* Foug., *Tradescantia ohioensis* Rof., *Phacelia congesta*

Hook., *Cooperia drummondii* Herb., *Torilus nodosa* (L.) Goert. and *Zexmenia hispida* (H.B.K.) Gray. Of particular interest were observations of two female *A. texana* which were observed landing on flowering inflorescences of *P. congesta* after they were "frightened" away from snakewood flowers (one individual disturbed by *Polistes apacheanus*, one by author). Each butterfly began investigating the *P. congesta* inflorescence with its proboscis; this behavior did not last more than two or three seconds as the butterflies appeared to be almost repelled by some characteristic of these flowers. The butterflies flew off to a branch of snakewood following this behavior.

DISCUSSION AND CONCLUSION

Of vital importance to the elucidation of the significance of flower visitation by *Asterocampa* is the preponderance of females in the samples observed. Of twenty-four butterflies actually verified to be feeding at snakewood flowers, eighteen or 75.0% were females. Normally, samples of butterflies from flowers yield a preponderance of males. However, these species are obtaining mostly carbohydrate from their nectar sources, although nectar of butterfly flowers are often fairly rich in amino acids (Baker & Baker, 1973b). Adult protein requirements are relatively low in these species, because nearly-sufficient amounts of nitrogen are obtained during its larval development.

Some butterfly larvae, however, are probably not able to store sufficient nitrogen for reproductive efforts because of difficulty in extracting nitrogen from foodplant material. The phytochemical defense of many tree species involves the production of "quantitative" poisonous substances, e.g., tannins, resins and silicates (Feeny, 1976). Owen (1959) observed that a British satyrid butterfly, *Pararge algeria* (L.) rarely visits flowers; whereas, a congeneric species, *P. megera* (L.), frequently visits flowers. This was explained by habitat selection, the former species confined to woodlands and the latter to open areas, presumably because of habitat restriction of larval foodplant. Such an explanation may well be valid in the above case but does not hold for *Asterocampa*. While the *Celtis* utilized as larval foodplants occur in woodlands, these woodlands are open associations and in no way form closed canopies except under certain conditions; carbohydrate-rich nectar sources are nearly always nearby. Lack of visits by *Asterocampa* to showy, "typical butterfly" flowers (see list in text above), are caused by a lack of certain nutrients required by adult *Asterocampa*, especially females.

Quite possibly, *Asterocampa*, because it feeds as a larva on an "apparent" foodplant (see Feeny, 1976), suffers from a nitrogen-deficient larval diet. As a result, the imago would have to acquire sufficient nitrogen in order to reproduce. As the female contributes more pro-

toplasm to the eggs which initiate the next generation, nitrogen requirements for adult female *Asterocampa* would be expected to be higher than requirements for male *Asterocampa*. As females would then spend more time obtaining nitrogen, one would expect to find more females than males in a given time period at a nitrogen source, e.g., flowers of *Colubrina texensis* or snakewood. However, certain differences in adult energy budgets of male and female butterflies are known (Adler, 1982).

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A TWELVE YEAR COUNT OF THREE CALIFORNIA BUTTERFLIES

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ABSTRACT. A weekly population count of three northern California butterflies, *Danaus plexippus*, *Nymphalis antiopa* and *Papilio rutulus*, over twelve years was conducted in a lowland California suburban yard. The data support Shapiro's theory that *N. antiopa* goes into hibernation locally about mid-June. They do not support the occasionally heard statement that the numbers of butterflies are declining; no systematic trend is evident, but year-to-year fluctuations are pronounced. A hypothesis that *P. rutulus* thrives on extremes of rainfall is proposed.

Most Lepidopterists cannot afford the time to do long-term butterfly counts. This is a twelve year count of the northern California butterflies, *Danaus plexippus* (Linnaeus, Danidae), *Nymphalis antiopa* (Linnaeus, Nymphalidae), and *Papilio rutulus* (Lucas, Papilionidae), made in a suburban Citrus Heights, Sacramento County, yard. The dominant vegetation was *Quercus wislizenii*, *Juglans hindsii*, *Fraxinus velutina*, *Catalpa speciosa*, and a variety of unknown grasses. Flowers that attract butterflies are *Vinca major*, *Verbena peruviana*, *Phlox* spp., and *Rhododendron* spp. There are many other flowers that were rarely if ever visited.

Citrus Heights lies in a Mediterranean climatic regime, with very high year-to-year variability in both seasonal precipitation and its timing (Figgins, 1979). The study period (1970-1982) embraces the most extreme and variable northern California weather in the 20th century, and to the extent that weather influences butterfly population levels, which is at least a debatable point (Shapiro, 1979), the counts reported should reflect the range of variation of which these species are capable.

The field of view was generally 100 m to the north, east, and south with obstructions of shrubs and trees 10 m to the northeast and southeast. Observations to the west were sporadic to 20 m. The sample was based on a two hour watch period starting between 1100 h and 1300 h every day except for cold or wet periods. Of course there were some days missed or observation periods of less than two hours. The elevation was 50 m, and the count was by unaided eye.

The numbers of butterflies actually seen in such a count could be affected by a very large number of factors, some of which relate to actual population levels, while others may not. Examples of the latter are mowing, pruning, and planting practices on adjacent properties, which could affect the spatial distribution of host plants and nectar sources, and thus individual dispersal as well. Since the individual butterflies were not marked, the counts can at best be regarded as an

TABLE 1. *Danaus plexippus* two hour daily per week count for twelve years at an observation point in Citrus Heights, California, U.S.A.

Date	1970	1971	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
II/26-III/4	—	—	—	0	0	0	—	0	0	0	0	0
III/5-11	—	0	0	0	0	0	—	0	1	0	0	0
III/12-18	—	0	0	1	0	1	—	0	0	0	0	0
III/19-25	4	0	0	0	0	0	3	1	3	0	0	0
III/26-IV/1	2	3	0	0	1	0	1	0	2	0	0	0
IV/2-8	5	2	0	3	0	1	2	0	3	0	5	0
IV/9-15	1	1	0	0	1	4	5	2	3	0	4	0
IV/16-22	0	0	0	0	0	2	7	0	0	0	1	2
IV/23-29	0	0	1	0	0	1	4	2	0	1	3	0
IV/30-V/6	1	0	1	1	1	1	1	2	0	1	0	1
V/7-13	1	0	0	0	2	2	1	0	2	0	0	0
V/14-20	0	1	0	0	0	2	1	0	0	0	0	0
V/21-27	1	0	0	0	0	0	0	1	1	0	1	0
V/28-VI/3	0	0	0	1	1	1	0	6	4	2	2	0
VI/4-10	0	2	1	1	2	0	3	2	2	3	3	0
VI/11-17	2	1	2	2	0	0	1	3	2	1	3	0
VI/18-24	3	1	0	2	0	1	1	2	1	0	3	0
VI/25-VII/1	1	0	1	1	0	0	0	3	0	0	2	1
VII/2-8	1	1	1	0	0	0	0	3	2	0	2	0
VII/9-15	2	1	0	4	0	0	1	10	2	3	5	1
VII/16-22	4	1	1	1	2	1	2	13	3	0	2	7
VII/23-29	4	10	5	3	5	1	7	14	2	1	6	4
VII/30-VIII/5	3	11	3	6	7	8	3	15	3	7	5	16
VIII/6-12	1	10	3	9	15	4	14	7	5	9	6	6
VIII/13-19	5	15	7	7	3	1	7	26	7	5	5	5
VIII/20-26	5	0	3	12	9	7	3	8	3	5	4	3
VIII/27-IX/2	16	—	1	7	2	6	2	3	4	8	4	2
IX/3-9	15	—	1	10	10	7	2	2	1	2	4	4
IX/10-16	14	—	1	3	5	2	1	5	1	9	2	3
IX/17-23	9	—	1	3	8	11	3	0	2	6	3	6
IX/24-30	4	—	0	3	16	5	1	4	4	2	4	1
X/1-7	4	—	0	1	13	11	3	3	3	3	1	1
X/8-14	1	0	0	0	4	3	0	0	0	0	1	3
X/15-21	1	0	0	0	1	0	2	4	0	0	0	3
X/22-28	0	0	0	0	0	1	0	3	0	0	0	1
X/29-XI/4	0	0	—	0	—	1	0	0	0	0	0	0
XI/5-11	0	0	—	—	0	0	0	2	0	0	0	0
XI/12-18	0	0	—	—	—	0	0	0	0	0	0	0
Total	100	60	33	81	98	79	70	147	70	71	83	68

index of local abundance and certainly not as literal population estimates. Nonetheless, they are definitely useful. Throughout the twelve years there were no major disturbances in the surrounding vegetation or land-use patterns, and the count methods, however idiosyncratic, were thoroughly consistent. The data are thus indicative of local abundance, and similar long runs of such data are rare in the butterfly literature. They are largely consistent with trends observed in the same geographic area, using more extensive sampling methods by A. M. Shapiro (pers. comm.) between 1972 and 1982.

TABLE 2. *Nymphalis antiopa* two hour daily count per week for twelve years at an observation point in Citrus Heights, California, U.S.A.

Date	1970	1971	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
I/16-21	—	—	—	—	—	—	—	1	0	1	0	0
I/22-28	—	—	—	—	—	0	—	0	0	0	0	0
I/29-II/4	—	0	—	—	—	1	—	0	0	0	1	0
II/5-11	—	0	—	—	—	0	1	0	1	3	0	0
II/12-18	—	0	—	0	—	0	0	0	0	1	0	1
II/19-25	—	0	0	1	—	0	0	0	0	0	1	0
II/26-III/4	—	0	0	0	0	4	0	0	0	0	1	1
III/5-11	—	1	0	0	0	0	2	0	5	0	6	1
III/12-18	—	1	0	0	0	0	0	0	0	0	1	0
III/19-25	0	3	0	0	1	0	0	0	2	0	0	0
III/26-IV/1	1	2	1	0	1	0	0	0	0	1	0	0
IV/2-8	1	2	1	0	1	0	3	1	4	0	1	0
IV/9-15	1	0	0	0	0	0	1	0	1	1	0	0
IV/16-22	0	0	0	0	0	0	0	1	0	0	0	0
IV/23-29	0	0	0	0	0	1	0	0	1	0	1	0
IV/30-V/6	0	0	0	0	0	0	0	0	0	0	0	0
V/7-13	0	0	0	0	0	0	0	0	1	0	1	0
V/14-20	8	0	0	0	0	4	2	2	1	3	3	0
V/21-27	39	0	4	3	0	8	1	1	11	5	19	0
V/28-VI/3	57	2	3	0	0	10	6	1	6	2	12	6
VI/4-10	24	18	4	2	4	11	5	2	8	10	3	2
VI/11-17	150	21	0	0	3	7	3	2	1	0	3	5
VI/18-24	58	5	0	1	2	4	0	1	4	0	0	0
VI/25-VII/1	15	1	0	0	4	0	0	0	1	1	1	1
VII/2-8	6	4	0	0	7	0	0	2	2	3	0	0
VII/9-15	2	5	0	0	2	1	0	5	2	1	0	0
VII/16-22	6	4	1	0	1	0	0	2	0	0	0	0
VII/23-29	6	7	1	0	4	1	0	2	0	0	2	3
VII/30-VIII/5	18	13	0	0	0	1	0	2	1	0	0	1
VIII/6-12	3	3	0	1	0	0	0	1	0	0	0	0
VIII/13-19	0	2	0	0	0	0	0	1	0	0	0	0
VIII/20-26	1	0	0	0	0	0	0	0	0	2	0	1
VIII/27-IX/2	0	0	0	0	0	0	0	0	1	0	0	1
IX/3-9	0	0	0	0	0	0	0	0	0	0	0	0
IX/10-16	0	0	0	0	0	0	0	0	0	0	0	0
IX/17-23	0	0	0	0	0	0	0	0	0	0	0	0
IX/24-30	2	0	0	0	1	0	0	0	0	0	0	0
X/1-7	0	0	0	0	0	0	0	0	0	0	0	0
X/8-14	2	0	0	0	1	0	0	0	0	3	0	1
X/15-21	0	0	0	0	2	0	2	0	3	1	0	0
X/22-28	0	0	0	0	0	0	0	1	2	0	1	0
X/29-XI/4	0	0	0	0	0	1	0	0	0	0	0	0
XI/5-11	0	0	—	0	0	0	0	0	0	0	0	0
XII/17	—	—	—	—	—	1	—	—	—	—	—	—
Total	400	94	14	8	35	56	26	28	48	38	57	24

Because of missed days and less than two hour watch, data for 1972 are not included. That is most unfortunate, because that season followed the coldest winter during the count years.

The year 1978 was unusual. Following the drought of 1976 and 1977,

TABLE 3. *Papilio rutulus* two hour daily count per week for twelve years at an observation point in Citrus Heights, California, U.S.A.

Date	1970	1971	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
III/12-18	0	0	0	0	0	0	0	0	0	0	0	0
III/19-25	4	1	0	0	0	1	0	2	0	0	0	2
III/26-IV/1	3	1	0	0	0	1	1	2	2	1	2	0
IV/2-8	16	0	1	0	0	1	3	1	2	0	9	0
IV/9-15	11	5	1	1	0	1	11	6	8	2	15	0
IV/16-22	27	0	1	1	1	10	20	3	9	8	12	13
IV/23-29	16	2	10	0	3	9	29	10	10	4	16	22
IV/30-V/6	21	0	6	11	5	13	6	14	7	17	21	35
V/7-13	10	0	6	14	10	25	4	12	6	2	16	39
V/14-20	11	5	3	8	8	20	4	7	10	8	7	17
V/21-27	33	7	2	15	5	12	0	4	10	2	10	11
V/28-VI/3	30	5	0	0	4	10	4	5	8	3	4	6
VI/4-10	4	14	0	2	2	5	4	1	5	0	1	3
VI/11-17	4	6	2	2	3	1	3	3	2	1	1	1
VI/18-24	4	2	0	0	0	0	0	9	3	1	6	1
VI/25-VII/1	15	3	5	1	0	3	4	11	8	3	22	3
VII/2-8	24	1	11	0	1	10	6	11	19	9	36	8
VII/9-15	40	2	14	12	5	22	10	47	23	25	21	21
VII/16-22	27	28	13	9	16	33	16	51	38	17	21	59
VII/23-29	50	25	30	38	30	53	27	76	48	18	35	90
VII/30-VIII/5	23	44	39	44	40	30	12	58	31	35	26	92
VIII/6-12	24	28	13	58	31	17	26	36	24	33	9	96
VIII/13-19	7	20	7	11	38	23	11	14	9	9	7	33
VIII/20-26	5	4	1	3	19	10	6	8	2	2	2	17
VIII/27-IX/2	15	3	2	0	9	5	2	6	8	3	4	3
IX/3-9	10	0	2	1	3	5	1	1	4	1	2	1
IX/10-16	1	0	0	0	2	0	0	3	1	2	0	0
IX/17-23	1	0	0	0	0	0	0	1	0	0	1	0
IX/24-30	1	0	0	1	0	1	0	0	0	0	0	0
X/24	0	0	0	0	0	0	0	0	0	0	0	1
Total	435	206	169	232	234	323	210	198	297	203	306	572

D. plexippus reached the highest count observed, and *P. rutulus* reached the fourth highest weekly count. Several other species not systematically counted were also present in the greatest numbers seen.

A scrutiny of Tables 1 through 3 will give an understanding of the variation of population of the species. It has been said that butterfly populations are declining (Moucha, 1974; Newsom-Brighton, 1982). These data do not support that statement, but perhaps twelve years' count is too short to say.

Citrus Heights is not a very good site for counting *D. plexippus* (Table 1), because there are no known *Asclepias* within miles. However, it is in the migratory path to the coastal hibernial colonies. The majority of those caught were females, many of which were fluttering over vegetation before late August. After that practically all flew straight through in a south or southwesterly direction.

The data do not show the great swings in *D. plexippus* population reported in the eastern U.S. and Canada (Urquhart, 1960), where in some years there are practically none. Locally they varied within more narrow limits, from a high count of 147 in 1978 to a low of 33 in 1973. There were few spring migrants seen here. The maximum number per week was seven in 1977 in the spring.

D. plexippus reaches a peak population in mid-August of most years. Do they start migrating at that time? It is known that they start arriving at the Richmond colony, the closest one at a distance at 130 km, in mid-September (pers. obs.).

The count of *N. antiopa* is the most fascinating of the three species. It has the greatest variation from a high of 150 in the week of 11 to 17 June 1970 to zero in 1974 and 1980. The total yearly count goes from a maximum of 400 in 1970 to a minimum of eight in 1974.

This count supports Shapiro's (Shapiro, 1974) theory that it goes into hibernation after the generation of late May and early June, because few sightings are made after that. This behavior is a great mystery because there is seemingly ample time and food for the production of another generation here in late August and September. It would seem to be a great opportunity to increase its numbers and thereby, increase survival potential.

Individual *N. antiopa* can be seen here in late fall and winter months on warm sunny days. The earliest was 19 January 1980 and the latest was 17 December 1976. It should be noted there were only four sightings from the week of 27 August to 2 September to 8 to 14 October. There were few sightings after that.

There is a problem with the count in May and June. There is a grove of *Salix babylonica* 80 m east of the observation point where most of the sightings were made. There were so many that the same individual was likely counted several times. I arbitrarily decided not to count a second appearance for two minutes after the first to reduce duplicate counts. If an individual was in view for several minutes nothing was counted for the two minutes after it disappeared.

Fortunately, I started counting *N. antiopa* in 1970 because of the unusually large population that year. From casual observation in 1968 and 1969 there were few in those years.

P. rutulus was the most numerous during the count period. However, the numbers cannot be compared interspecifically because of behavioral differences among the species (specifically, male patrolling behavior or territoriality in *P. rutulus* which would tend to increase repeat sightings and hence the count). Once again, only an intraspecific index of abundance can be inferred. *P. rutulus* reached a peak annual count in 1982 of 572, followed by another peak of 435 in 1970. The minimum annual count was 169 in 1973. It is the last to appear of the

three species and the first to disappear. It never appeared before 20 March, and several years it appeared on that date. In 1975 it didn't appear till 20 April. The latest it appeared was 22 October 1982.

In 1978 following the driest winters on record of 1976 and 1977, *P. rutulus* reached the fourth highest weekly count of 76 the week of 23-29 July. In 1982 following the wettest winter this century the three consecutive weekly counts starting 23 July reached the highest of 90, 92, and 96. These facts lead to the obvious but incongruous hypothesis that *P. rutulus* thrives on extremes of rainfall. A possible explanation is that these extremes reduce predators.

Only in 1970, 1973, and 1982 did the spring count accurately predict the summer count. The springs of 1970 and 1982 were the highest of the twelve (12) years and were followed by high summer counts. The spring 1973 count was the lowest followed by the lowest summer count. The spring 1978 count was the second lowest followed by the fourth highest summer count. Therefore, generally, spring counts are unreliable predictors of summer counts.

Finally, from these data the July 4th butterfly census of the Xerces Society is conducted when few individuals of the species studied are on the wing in lowland central California at least, and therefore, potentially misleading.

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SEASONAL PHENOLOGY OF *BATTUS PHILENOR* (L.) (PAPILIONIDAE) IN CALIFORNIA¹

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ABSTRACT. The pipevine swallowtail butterfly, *Battus philenor* (L.), has a flight season extending over more than nine months (February to November) in central California. The major flight occurs primarily in April and is derived from overwintering pupae in diapause. This flight is followed by a partial second generation, consisting of 9-39% non-diapause first generation offspring. A subsequent temporally scattered flight, representing a third generation, is partially derived from earlier season diapausers emerging in summer and fall. Under field conditions, pupal diapause intensity progressively declines through fall and early winter. Pupal photoperiod response and diapause end by mid-winter. There is no sex ratio distortion in either second brood or summer-fall emergers. Spring field emergence of males tends to precede females, suggesting differences in relative rates of post-diapause development.

A necessary step towards an understanding of the population dynamics and distribution of Lepidoptera is to examine their seasonal phenology or timing of recurring periods of activity and dormancy in relation to key environmental factors. For species with a diapause phase, the appropriate timing of the onset, maintenance, and termination of diapause, followed by postdiapause development and resumption of reproductive activity is vital to the successful adaptation to their environment.

The pipevine swallowtail, *Battus philenor* (L.), has an extended flight season in central California with adult activity recorded from February to November (Opler & Langston, 1968; Shapiro, 1974). Little, however, is known about how the flight season is related to the population dynamics and pupal diapause of this species. Shapiro (1975) suggested that the long flight season and apparent multivoltinism results from reproduction by a non-diapause fraction of each generation. Thus, each generation may be a mixture of both continuous developers and individuals that undergo an aestivo-hibernal pupal diapause (Masaki, 1980) and emerge the following spring.

In this paper we examine the phenological "strategy" or timing of the active and diapause states of *philenor* as they relate to the annual periodicity and variability of the central California habitats. Specifically, we estimate the number, timing, and derivation of annual broods and determine when diapause terminates under field conditions.

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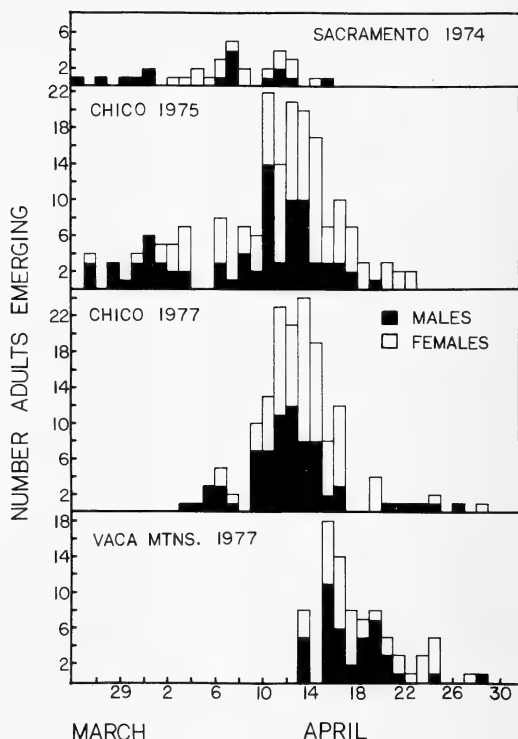


FIG. 1. Spring emergence of first brood adult *B. philenor* from overwintering pupae.

MATERIALS AND METHODS

We collected living material from the following populations: Chico, Butte Co., CA, 39°42'N (latitude), 60 m (altitude); Davis, Yolo Co., CA, 38°30'N, 16 m; Vaca Mountains (from Mix Canyon to Solano Lake, approx. 7 km SW Winters), Inner Coast Range, Solano Co., CA, 38°25'N, 50–300 m; Sacramento, Sacramento Co., CA, 38°30'N, 15 m.

To estimate diapause incidence and adult emergence under field conditions, we sampled first generation final instar larvae and prepupae from the Davis, Chico, Vaca Mtns., and Sacramento populations during mid-May to mid-June from 1974–1976. Samples were maintained outdoors, at Davis, on cuttings of the foodplant, *Aristolochia californica* Torr., in large (46 cm side) screened cages. Completion of feeding and pupation occurred within one week of collection. Both larvae and pupae were sheltered from rain but exposed to normal seasonal variations of temperature and photoperiod. Individuals were labelled with col-

TABLE 1. Percent non-diapause of first brood *Battus philenor* (A) and percent of adults emerging in July, August, or September from first brood diapause pupae >30 days old (B). Number in parentheses is sample size; NS = not sampled.

	1974		1975		1976	
	A	B	A	B	A	B
Davis	25.0 (4)	—	23.1 (26)	—	NS	—
Vaca Mtns.	39.0 (141)	3.2 (93)	27.4 (168)	—	15.8 (146)	5.7 (123)
Chico	NS	—	8.8 (616)	3.7 (135)	14.2 (558)	21.3 (230)

lection and pupation date and monitored daily for adult emergence and sex. We used the same collection, storage, and recording methods to study the timing of spring adult emergence the following year.

The termination of diapause, or completion of diapause "development" (Beck, 1980), can be studied in photosensitive species by determining the date at which photoperiod no longer influences the rate of morphogenesis; i.e., when morphogenesis is primarily a function of temperature and proceeds at a rate similar to that of non-diapause individuals (Tauber & Tauber, 1976). Since *philenor* pupae are photosensitive, with the rate of diapause development inhibited under short-day photoperiods and increased under long-day photoperiods (Sims & Shapiro, 1983), we were able to study field diapause development as follows: Pupae, derived from final instar Chico larvae collected on 11 June 1976, were maintained outdoors through summer and fall in Davis. At monthly intervals from 20 November 1976 to 20 February 1977, samples of pupae were transferred from their outdoor location to LD10:14, LD15:9, and a natural photoperiod (greenhouse) at approx. 23.5°C and monitored for emergence. Data were analyzed using ANOVA procedures and Duncan's Multiple Range Test (DMR) for significance of differences between means (Sokal & Rohlf, 1969).

RESULTS

Our 1974–1977 adult emergence data from overwintered pupae show a unimodal peak of spring emergence during the second and third weeks of April (Fig. 1). This peak coincides with a period of rapid *Aristolochia* growth.

Non-diapause pupae and resulting adults obtained from field-collected first generation larvae provided an estimate of the magnitude of the second generation. The second generation ranged from less than 10% to almost 40% of the surviving first generation pupae (Table 1). The Vaca Mtns. population (1974–1976) illustrates that considerable yearly variation may occur in second generation size. Mortality of first generation pupae was low, ranging from 5–10%.

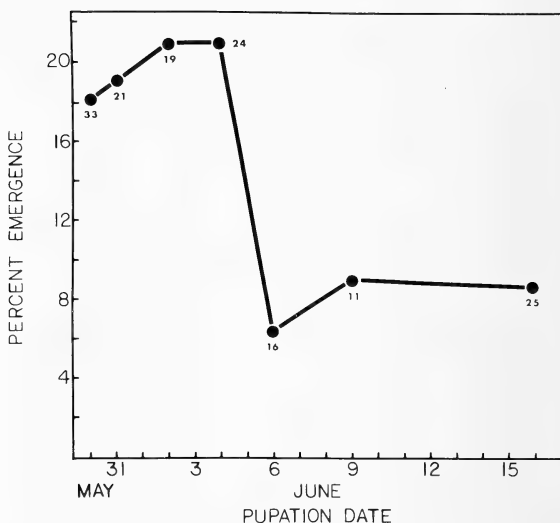


FIG. 2. Mean pupation date and percent adult emergence of *B. philenor*. Vaca Mtns. population; spring 1976. Numbers indicate sample size.

Pupae from the Vaca Mtns., over 18 days in late spring, 1976, showed a marked decrease in adult emergence with increasing pupation date (Fig. 2). Increasing diapause was not correlated with temperature (daily mean or minimum) but may have been related to host-plant quality which deteriorated visibly (increased leaf toughness and decreased succulence) during this period. A seasonal increase in pupal diapause is a possible bias in our estimation of second brood magnitude despite using larvae collected from mid-May to early June. Thus, samples taken relatively early in the season might overestimate, while late-season samples may underestimate non-diapause among first-brood individuals.

From first generation pupae in aestival diapause (>30 days post-pupation), a small number of adults continued to emerge in July, August, and September (Table 1). The extent to which this scattered flight is augmented by a third generation is unknown, but since relatively few larvae were observed on *Aristolochia* after June, the third and any subsequent broods are presumably quite small.

Diapause in the field was considered terminated when there was no significant difference in time (days) to adult emergence among the short-day, long-day, and natural photoperiods at 23.5°C to which pupae were transferred at monthly intervals from November to February (Tauber & Tauber, 1976). Using this criterion, pupal diapause ends

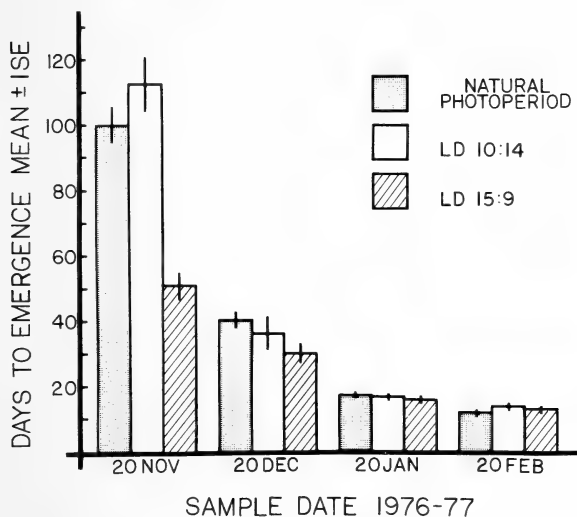


FIG. 3. Adult emergence from diapause *B. philenor* pupae maintained outdoors prior to 23.5°C exposure at the indicated photoperiod.

during the 30-day period following the winter solstice (Fig. 3). Under each photoperiod, adult emergence time was significantly less in January than in December samples, while emergence times for January and February were similar (DMR test, $P < 0.05$). Pupae from the November and December samples displayed a distinct photoresponse. November pupae at LD15:9 emerged significantly sooner than those at LD10:14 or natural photoperiod, while December pupae at LD15:9 emerged sooner than those under a natural photoperiod.

There was little departure from a 1:1 sex ratio among either second brood (51.5% ♂♂, $n = 264$) or summer-fall emerging individuals (51.6% ♂♂, $n = 64$). A comparison of cumulative numbers of males and females present after the onset of seasonal emergence shows that males tend to emerge somewhat before females (Fig. 4).

DISCUSSION

Central California populations of *philenor* have two major flights each year. The first and largest flight occurs in March and April and derives from the unimodal emergence of adults from overwintered pupae. Most first brood pupae undergo an aestivo-hibernal diapause (Masaki, 1980) and overwinter. Some individuals emerge to form a partial second generation, the magnitude of which shows both inter- and intrapopulation variation (Table 1). There is evidence suggesting

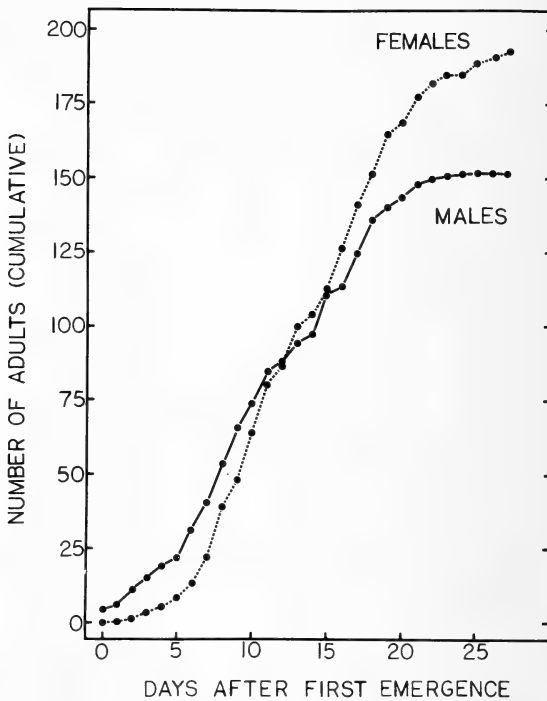


FIG. 4. Cumulative emergence of spring generation *B. philenor* adults from overwintering pupae, by sex. Chico, CA population; combined emergence of 1975 and 1977.

a positive relationship between the pupation date of first brood larvae in the field and diapausing frequency (Fig. 2). The increase in diapause parallels the visually-determined seasonal decrease in young succulent *Aristolochia* foliage available for larval consumption. Rausher (1981) documented a similar seasonal decrease in the quality of *Aristolochia* from Texas. In Texas, the increase in the sclerophyllization (=increased leaf toughness and decreased nitrogen) of *A. reticulata* (Nutt.) between March and May led to poorer larval growth and increased larval dispersal of *philenor*.

Emergence of adults from the diapausing first generation age-cohort is divided between summer-fall and the following spring. The summer-fall emergers contribute to the scattered flight of *philenor* from July to November in California. The emergence polymodality represented by the aestivo and aestivo-hibernal diapausers of the first generation *philenor* age-cohort does not conveniently fit into any of the phenological categories suggested by Waldbauer (1978). Despite this, it is not a

unique example. Among other papilionids, *Papilio maacki* Fenton (Ichinosé, 1974), *Eurytides marcellus* (Cramer) (Scudder, 1889), and some populations of *Papilio machaon* L. (Wiltshire, 1957) show similar discontinuity in pupal diapause duration as does the noctuid moth, *Barathra brassicae* L. (Masaki, 1956; Dolidze cited in Danilevskii, 1965). The reproductive success of *philenor* adults emerging in summer-fall is unknown. Since females oviposit exclusively on tender growing shoots and first instar larvae can only feed on these, opportunities for summer reproduction are usually limited. Following the onset of fall rains in September and October, a small amount of new *Aristolochia* growth may become available, and we have found both ova and final instar larvae on this growth in late October.

Diapause development in *philenor* is completed before midwinter (Fig. 3). No photoresponse was found in pupae sampled one month after the winter solstice; the development rate of pupae at this time was similar to non-diapause pupae at the same temperature. It is most likely that morphogenesis and adult emergence in the spring following diapause termination are functions of temperature accumulations above a minimum temperature developmental threshold.

Previous observations that individuals of later broods are primarily males (Fee, 1979) are not supported by our results which show no sex-ratio distortion among either second brood or summer-fall emergers. The only evidence for sex-related phenological differences was obtained from adult emergence from overwintering post-diapause pupae. Females lag slightly behind males in emergence times, suggesting a greater heat unit requirement among females for completion of development.

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DISTRIBUTION AND NOTES ON THE GREAT DISMAL
SWAMP POPULATION OF *MITOURA HESSELI* RAWSON
AND ZIEGLER (LYCAENIDAE)

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ABSTRACT. The microdistribution of *M. hesseli* within selected areas of the Dismal Swamp (VA and NC) is found to be coincident with the occurrence of its larval foodplant, *Chamaecyparis thyoides* (L.) B.S.P. (Cupressaceae). Observations on nectar feeding, apparent predation on adults by birds, perching behavior by adult males, and other behavioral phenomena are reported. Two new categories of beak-inflicted wing damage in Lepidoptera are described, and a possible selective advantage for the dorsal "false head" found in many lycaenid species is discussed. The white spot of the discal cell of the ventral forewing is found to be an unreliable character for separating *M. hesseli* from *M. gryneus* (Hübner) in Virginia, but the subterminal brown bars in cells M_1 and M_2 of the ventral hindwing are unique to *M. hesseli*.

Since its original description and the subsequent description of its early stages (Rawson et al., 1951), little has been published concerning the biology or behavior of Hessel's hairstreak, *Mitoura hesseli* Rawson and Ziegler (1950). Progressive range extensions have been reported (Pease, 1963; Anderson, 1974; Johnson, 1978; Baggett, 1982); and it appears that this insect will be found throughout the range of its larval foodplant, *Chamaecyparis thyoides* (L.) B.S.P. (Cupressaceae).

The geographic proximity and the morphological and biological similarities between *M. hesseli* and *M. gryneus* (Hübner) suggest recent speciation. Although the normal foodplant for *M. gryneus* is *Juniperus virginiana* L. (Cupressaceae), it has been successfully reared on *C. thyoides* (Remington & Pease, 1955); and Gifford and Opler (1983) have reared *M. hesseli* on *J. virginiana*. The wing patterns of the two species are nearly identical, and the genitalic similarities (and differences) were reported by Johnson (1976).

In view of this close biological relationship, the reported behavioral differences between the two species appear striking. The literature suggests that, except for at the type locality, *M. hesseli* is an infrequent find even in the vicinity of *C. thyoides* and is best collected at flowers near the foodplant rather than on the foodplant itself. The pugnacious territoriality of adult male *M. gryneus* is well known (Johnson & Borgo, 1976), and experience with this species in Virginia shows that it is

rather ubiquitous. A short hedgerow of several *J. virginiana* is adequate to support a double-brooded colony. It is intriguing that the microdistribution and adult behavior of *M. hesseli* should vary so greatly from its closest extant relative. The authors were able to study the *M. hesseli* population in the Great Dismal Swamp National Wildlife Refuge, located in southeastern Virginia and northeastern North Carolina, for the purpose of clarifying the nature of these differences and perhaps uncovering some explanation for them.

MATERIALS AND METHODS

The study site was the Great Dismal Swamp National Wildlife Refuge (the Refuge), located approximately between latitudes 36°26'N and 36°48'N and longitudes 76°22'W and 76°33'W. A thorough characterization of the Refuge and surrounding swamp was given by Kirk (1979). *Chamaecyparis thyooides* is found in the Refuge as an invader of ditch edges, as a member of variable dominance in a generally mixed hardwood forest, and in pure stands of many hectares extent (Fig. 1). Roads and ditches provide the only access to the Refuge interior, although it is possible to penetrate off-road areas on foot with great difficulty. All roads follow ditches, but many ditches are unaccompanied by roads and are often impassable due to rooted and fallen vegetation.

Several trips were made in 1981 to scout potential sites for locating *M. hesseli*. With the aid of a vegetation map provided by the Refuge administration, those areas of *C. thyooides* accessible by vehicle were identified. In 1982, a qualitative sampling program was begun. Selected 0.8 km (0.5 mi.) sections along passable roads were sampled for *M. hesseli*. Each section was sampled at least once, and there was no uniformity of sampling effort. With the one exception described below, the collection or positive sight identification of two specimens was sufficient to consider a section positive for *M. hesseli*. Flowering shrubs, vegetation perches, and damp patches in the road were examined thoroughly. Enough other spring species were in flight to ensure that sections not near *C. thyooides* would be examined as closely as those near the foodplant. This regimen was followed on 3, 13, 19, and 20 April and in the late afternoon only of 2 April. Approximately 24 km of road were examined in this manner, and sections were selected so that about one third were in areas where *C. thyooides* could be seen along the road or in the forest. The remaining sections were at various distances from the foodplant.

On 13 April, a 5- to 6-meter-wide trail through a dense stand of mature *C. thyooides* was discovered and followed for ca. 1 km (Fig. 1, point A). The edges of the trail were lined with immature *C. thyooides*,

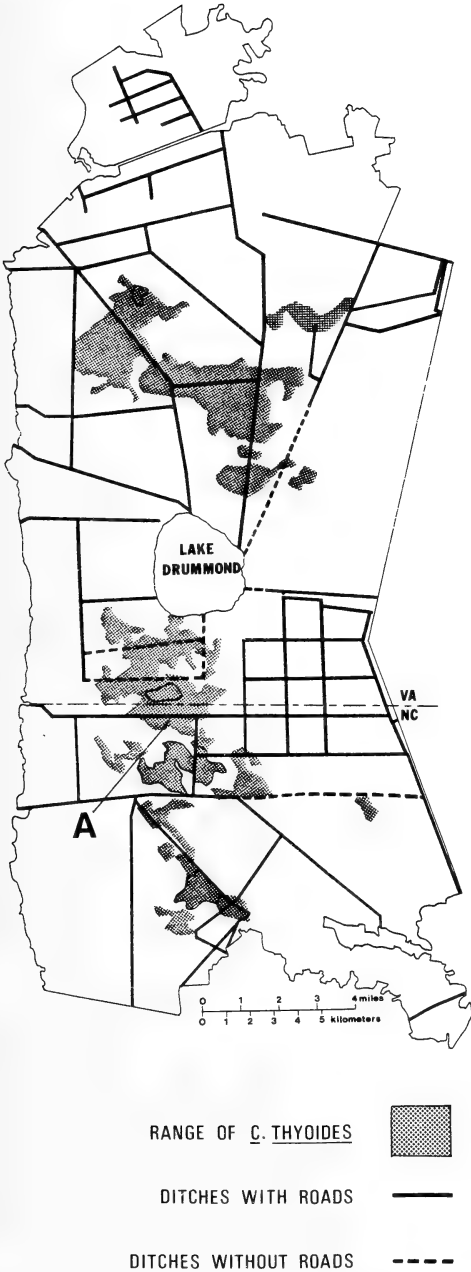


FIG. 1. Distribution of *Chamaecypris thyoides* within the Great Dismal Swamp National Wildlife Refuge in relation to roads and ditches. Point A is site of trail discussed in text. (Adapted from U.S. Geological Survey open-file map 76-615.)

4–6 m tall, behind which loomed the crowns of mature trees, 18–22 m tall. *Mitoura hesseli* was abundant along this trail, and a series was collected for later examination. The remaining field data consisted of general observations on the behavior and habits of this butterfly species.

Out of the field, 32 adults were sexed and examined for the presence of both the white spot in the discal cell of the ventral forewing and the brown bars distad of the postmedian line in cells M_1 and M_2 of the ventral hindwing, several characters used by authors to differentiate *M. hesseli* from *M. gryneus* (Rawson & Ziegler, 1950; Clench, 1961; Howe, 1975). A series of *M. gryneus* ($n = 74$) was similarly examined. The latter specimens were collected in Virginia, although none was collected in the vicinity of the Refuge. Rudimentary white spots of only several scales were considered as absent.

A single visit to the Refuge was made on 6 July 1982 expressly to photograph *M. hesseli* in its natural setting. Some supporting observations were made at this time.

RESULTS AND DISCUSSION

Distribution. Positive and negative collection sites are indicated in Fig. 2. Ditches and roads have been removed from this figure for clarity. The negative results in the vicinity of a mature stand of *C. thyoides* (Fig. 2, point A) are likely artifactual. This site was visited at ca. 0900 EST on an overcast day with winds to 77 kph (48 mph) and was the only site in the vicinity of the foodplant which did not yield *M. hesseli*. Summer-brood individuals were abundant here on 6 July, and it is assumed that the aforementioned weather conditions were responsible for the negative findings in April. Neighboring areas proved to be densely colonized when examined under more favorable weather conditions. Point B in Fig. 2, in combination with the positive samples to the east of it, suggests that *M. hesseli* is likely found throughout that northwestern stand of *C. thyoides*. Other such opportunities (in which a stand could be bracketed by samples) were unfortunately unavailable. Point C in Fig. 2 is the only section which was positive for *M. hesseli* based only on sight records. No *C. thyoides* grew along the road or in the forest along this section, but it had recently invaded the far bank of the adjacent ditch. *Mitoura hesseli* was seen nectaring on blossoms of *Vaccinium corymbosum* L. (Ericaceae) along that bank, just out of reach of our nets. Sights not in the vicinity of *C. thyoides* were consistently negative.

General observations. *Vaccinium corymbosum* was the dominant flowering plant in the Refuge on 2, 3, and 13 April; and it rarely grew far from *C. thyoides*. In contrast to the findings of Rawson and Ziegler (1950) in New Jersey, *M. hesseli* was found to utilize *V. corymbosum*

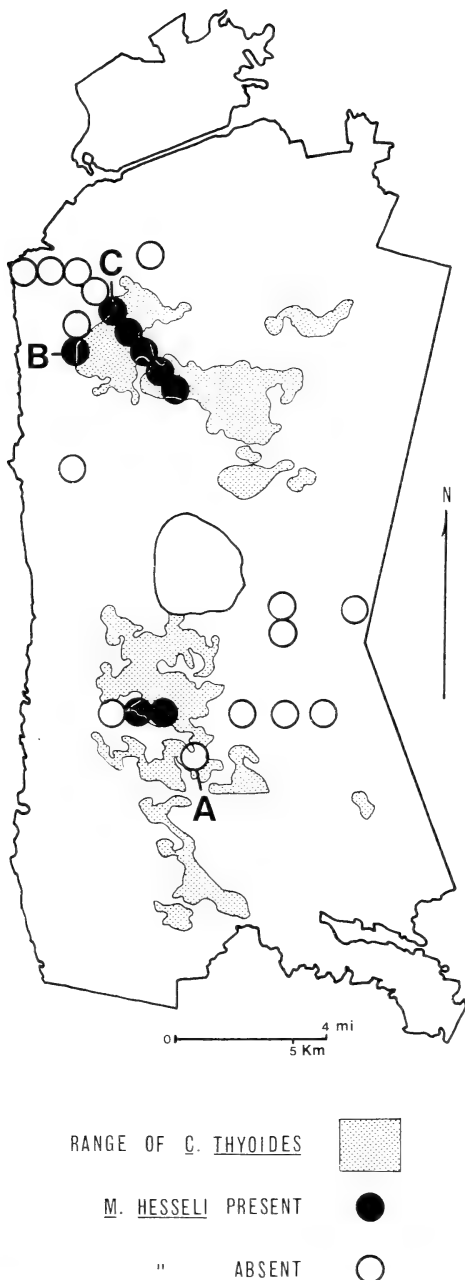


FIG. 2. Results of qualitative sampling program, illustrating the distribution of *Mitoura hesselei* in relation to its larval foodplant, *Chamaecyparis thyoides*, within the Great Dismal Swamp National Wildlife Refuge. Points A and B are discussed in text; Point C is based on sight records only.

readily as a nectar source. Most specimens thus collected were female, but the actual sex ratio was unrecorded. By 19 April, *V. corymbosum* was past flowering; and other plants with varied distributions were beginning to flower. *Amelanchier intermedia* Spach (Rosaceae) was the only additional bloom on which *M. hesseli* was seen to nectar in the spring. *Sassafras albidum* (Nutt.) Nees (Lauraceae) and an unidentified willow (*Salix* sp., Salicaceae) were flowering locally but not near any site at which *M. hesseli* was recorded. Summer-brood individuals were seen to utilize *Cephalanthus occidentalis* L. (Rubiaceae), *Phytolacca americana* L. (Phytolaccaceae), and *Apocynum* sp. undet. (Apocynaceae) as nectar sources. Despite many fresh flower heads of *Achillea millefolium* L. (Compositae) and *Daucus carota* L. (Umbelliferae) in the immediate vicinity of abundant *M. hesseli*, neither was ever visited by the butterfly during several hours of observation (late afternoon, 6 July).

The flight of *M. hesseli* when nectaring is very distinct from that of *M. gryneus*. While the latter retains its darting flight when approaching nectar sources, the former assumes a fluttering, casual flight, at least at *Vaccinium* blossoms. In one instance, while beating bushes to dislodge perching or nectaring individuals, a female *M. hesseli* was seen to remain undisturbed even though the flower cluster on which she was nectaring was roughly shaken. In July, a second female was perched out of camera range on a *C. occidentalis* blossom, and she could not be dislodged with repeated, direct taps of the net handle. The senior author broke off the branch on which she was perched and brought it into a clear area where he was able to photograph the specimen at close range for several minutes until the butterfly, apparently satiated, flew away.

Two or three specimens of *M. hesseli* (sex unrecorded) were seen to flounder across the road as if in physical distress. When collected, these proved to be fresh, post-teneral specimens with no evident, external injuries. These may have been diseased or parasitized individuals, or they may have been struck by passing vehicles. The latter possibility is unlikely since there is almost no vehicular traffic within the Refuge, but it cannot be discounted. No attempt was made to culture disease agents or rear parasites from these specimens.

The walk along the trail revealed hitherto unreported behavior patterns in *M. hesseli*. Here this species behaved much the same as *M. gryneus*. Males were seen perching on immature *C. thyoides* and darting out after passing butterflies and other insects. Most were seen on the sunlit side of the trail, and most selected perching positions in the top third of the trees. Numerous "dogfights" were seen involving two or three individuals, and individuals were occasionally seen visiting

Vaccinium blossoms, at which their flight showed no sign of the lethargic pattern described earlier. No females were seen or collected along this trail except for a single specimen collected on blossoms near the far end of the trail. No activity was seen around the canopy of the surrounding stand of mature foodplant, but the distance precluded conclusive observations. Two specimens (sexes unrecorded) were seen to land upon the trail and walk about for several cm, eventually climbing down into crevices formed by fallen limbs in the mud. Here they would quietly sit with only the tips of their hindwings exposed. These individuals are presumed to have been tipping ground moisture, although the forward portion of their bodies could not be seen to confirm this. It is also not known why they crawled into crevices to get moisture, since most of the trail surface was mud. No matings were observed for this species.

Predation. Evidence of predation by birds was seen in specimens collected during this study. Although no attacks were observed, numerous insectivorous birds are found in the area (Anonymous, 1980). Since Sargent's (1976) classification of beak damage was designed for and applied to noctuid species, no category (Type I, Type II, or Type III) is descriptive of the damage inflicted on Lepidoptera which rest with wings folded upright over the back. The resulting damage from an attack on an insect in this position is manifested in either two or four wings and is always bilaterally symmetrical. In keeping with Sargent's (1976) nomenclature, the names Type IV and Type V damage are suggested. Type IV damage (Fig. 3) is caused by attacks in which the beak is oriented roughly parallel to the major veins in the insect's wings. The beak crosses the wing margin rather than the costa. Three subcategories are recognized: IVa, which involves only the forewings; IVb, which involves only the hindwings and is typical of thecline lycanids (Robbins, 1980); and IVc, which involves both fore- and hindwings. Type V damage (Fig. 4) is caused by bites which cross the forewing costa. Here two subcategories are possible: Va, which does not extend to the hindwing costa; and Vb, which does.

Type IV damage generally results in notches in the wings, but Type V damage rarely does. In the latter case, beak imprints instead of notches are left on the forewing (in the case of Type Va attack), and no example of Type Vb damage has been seen. It is likely that Type Vb attacks are almost always successful due to the unlikelihood of the forewing costa tearing to allow the insect to escape (Robbins, 1980). This leaves to be explained why individuals with Type Va damage are observed, since the predator grasps the prey by the costae in this type of attack, also. The authors suggest that the insect's reaction to a Type Va attack is to snap open the hindwings (as a natural attempt at flight),

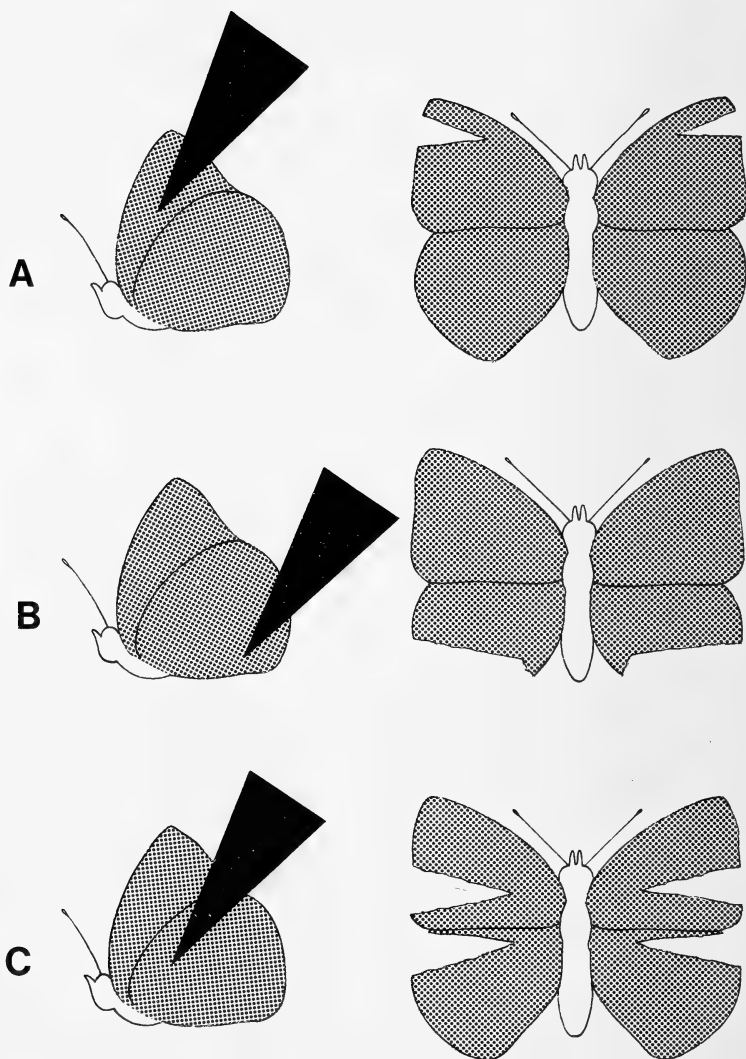


FIG. 3. Diagrammatic illustration of Type IV bird attack and resulting wing damage. **A)** Type IVa involves forewings only; **B)** Type IVb involving hindwings only (illustrated with remaining anal fragments removed, as is the case in many field-collected specimens); **C)** Type IVc involving all wings (after Sargent, 1976).

startling the bird and thus facilitating an escape. This may help to explain why so many thecline species exhibit a rudimentary "false head" on the dorsum of the hindwings as well as the more well developed one on the ventrum. Besides providing a deflection target for

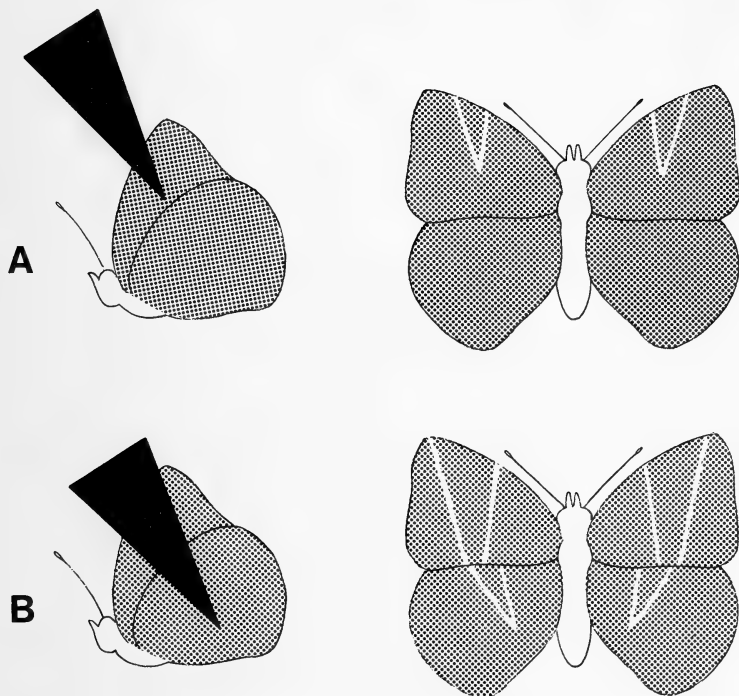


FIG. 4. Diagrammatic illustration of Type V bird attack and resulting wing damage. **A**) Type Va involving only the forewings; **B**) Type Vb involving all wings (after Sargent, 1976).

Type I attacks (attacks while in flight), an eyespot in this position would contribute to the startle effect in the event of a Type Va attack.

Fig. 5 illustrates damage types IVb, IVc, and Va, as found in the Refuge population of *M. hesseli*.

Wing maculation. The 15 male *M. hesseli* examined showed no white spot in the discal cell of the ventral forewing. Fifteen of 17 females (88.2%) had the white spot; the remaining two did not. Overall, 46.9% ($n = 32$) had the white spot. Of 74 *M. gryneus* examined, 6 of 58 males (10.3%) and 0 of 16 females had the spot. Overall, 8.1% had the spot.

This character does not appear to be reliable enough for field identification and should probably be omitted from future keys separating these two species. This trait appears sex dependent, reversed from one species to the other, but the significance of that (or even its validity) is uncertain based on these limited data.

All *M. hesseli* and no *M. gryneus* examined showed the brown bars

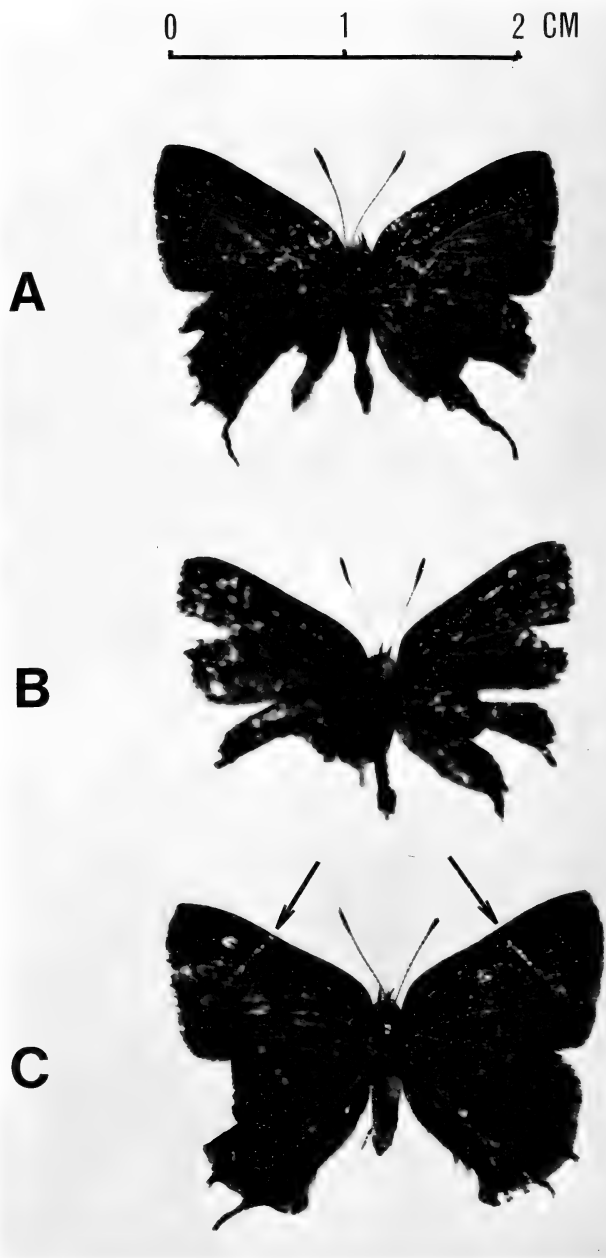


FIG. 5. *Mitoura hesseli* showing Types IV and V wing damage. **A)** Type IVb damage (δ , Great Dismal Swamp, Camden Co., NC, 13-iv-1982); **B)** Type IVc damage (δ , same data as A) with anal area of left hindwing missing, also; **C)** Type Va damage with beak imprints indicated by arrows (δ , Great Dismal Swamp, Suffolk, VA, 13-iv-1982).

distal to the postmedian line in cells M_1 and M_2 of the ventral hindwings. The number examined was slightly less for both species because of individuals with Type IVb damage which obliterated this character. We suggest that this character be used for field separation of these two species.

SUMMARY

The Great Dismal Swamp harbors a large population of *Mitoura hesseli* Rawson and Ziegler. With one exception which may be explained by poor weather conditions at the time of the spring visit, all sample areas containing *Chamaecyparis thyoides* (L.) B.S.P., produced Hessel's hairstreak. Summer-brood individuals were abundant at this one negative site. Areas narrowly removed from the foodplant were consistently nonproductive. *Vaccinium corymbosum* L., *Cephalanthus occidentalis* L., *Phytolacca americana* L., *Apocynum* sp., and *Ame-lanchier intermedia* Spach were observed as nectar sources for *M. hesseli*, and females were more common at flowers than were males. An area of immature *C. thyoides* at the margin of a mature, pure stand of that species revealed *M. hesseli* males perching and darting in a manner indistinguishable from *M. gryneus* (Hübner). No matings were observed, and it is suggested that the mature foodplant canopy be examined for its role in the ecology of *M. hesseli*. Evidence of predation by birds was seen in many collected specimens, and new categories of wing damage, Types IV (with three subcategories) and V (with two subcategories), are proposed to accommodate damage in species holding their wings folded upright at rest. It is suggested that the rudimentary, dorsal "false head" found in certain Lycaenidae may provide protection against certain kinds of predator attack. The white dot in the discal cell of the ventral forewing was found to be an unreliable field character for separating *M. hesseli* from *M. gryneus*. The character is possibly sex linked although linked to opposite sexes in these two species. It is found in 46.8% of *M. hesseli* (but never in males) and 8.1% of *M. gryneus* (but never in females). The subterminal brown bars in cells M_1 and M_2 of the ventral hindwing of *M. hesseli* were found to be reliable characters for separating this species from *M. gryneus*, in which they are absent.

ACKNOWLEDGMENTS

Collecting in the Refuge was made possible through the permission of the U.S. Department of the Interior and the cooperation of the Great Dismal Swamp National Wildlife Refuge management, Suffolk, VA. Dr. E. C. Turner, Jr. (Department of Entomology, VPI & SU, Blacksburg, VA) made transportation available; and the administration of the Tidewater Research Station, VPI & SU, Holland, VA, provided a much needed place to spend the nights. We are indebted to Dr. T. D. Sargent and Dr. R. K. Robbins for their helpful comments on an early draft of this manuscript.

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A NEW SPECIES OF *SPARTINIPHAGA* (NOCTUIDAE) FROM THE NEW JERSEY PINE BARRENS

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ABSTRACT. *Spartiniphaga carterae* Schweitzer is described as a new species from the New Jersey Pine Barrens. The type series consists of 5 ♂♂, 4 ♀♀ and 1 other specimen is known, all from Burlington County, New Jersey. The species is quite distinctive in maculation and male genitalia, but appears to be related to *Spartiniphaga inops* (Grote).

The following species is genitally close to *Spartiniphaga inops* (Grote). So far as known the ten specimens cited below are the only ones extant in collections. Nothing is known of its life history.

Spartiniphaga carterae Schweitzer, new species

Forewing. Male: Light ochreous, rather uniform. Lines often virtually invisible except for series of dark dots on the veins representing the postmedian, and a single such dot representing the antemedian. Two paratypes have dark postmedian and subterminal lines like *S. inops*. Reniform with faint dark outer and pale inner rings, broader costad, with black spot in anterior end. Orbicular a faint dark circle. **Female:** All markings tending to be lost, the allotype nearly immaculate, but entire pattern seen on males is traceable on the paratype. Ventrally powdered with fuscous, no pattern.

Forewing length: 13.8-15.2 mm ♂♂; 11.7-13.1 mm ♀♀.



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FIG. 1. *Spartiniphaga carterae*, holotype ♂.



FIG. 2. *Spartinihaga carterae*, allotype ♀.

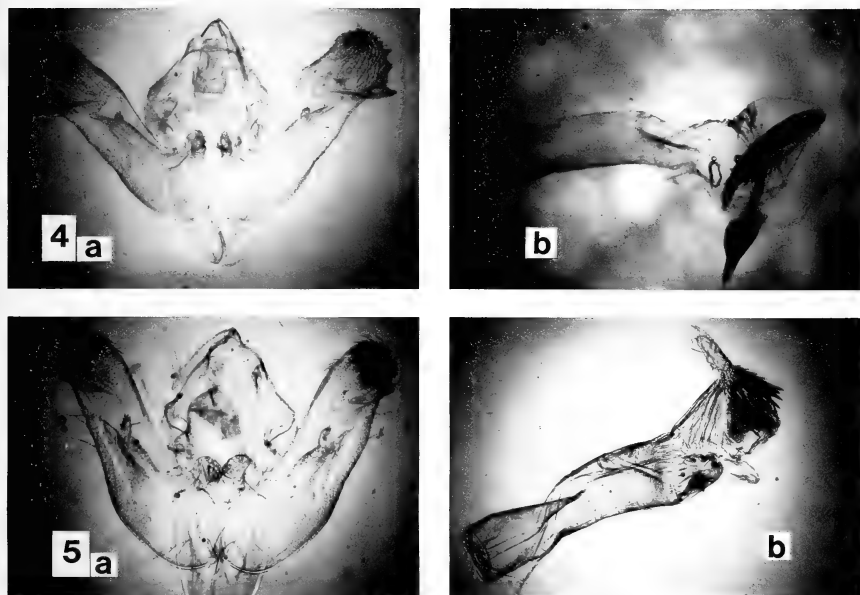
Hindwing. Very pale with slight ochreous tinge in the males, nearly pure white in the females. Unmarked above, except for brown postmedian line on one ♂. Ventrally with prominent discal spot and fuscous along margins.

Body. Head and thorax concolorous with forewing, abdomen paler. Thoracic tufts weak, abdominal basal tuft vestigial.

Male genitalia. Illustrated in Figs. 4a and 4b. Differences from *S. inops* (Figs. 5a, 5b) are listed in Table 1. The easiest characters for practical use are the size and shape of



FIG. 3. *Spartinihaga inops*, ♂, Mystic, New London Co., Conn., 1 Sept. 1925, leg. H. P. Wilhelm (YPM).



FIGS. 4a, b & 5a, b. **4a**, male genitalia of *Spartiniphaga carterae*, holotype (aedeagus removed)—**b**, aedeagus, vesica everted; **5a**, male genitalia of *S. inops* from same moth as in Fig. 3—**b**, aedeagus, vesica everted, specimen from Martha's Vineyard, Mass., 10 Sept. 1945, leg. F. M. Jones (YPM).

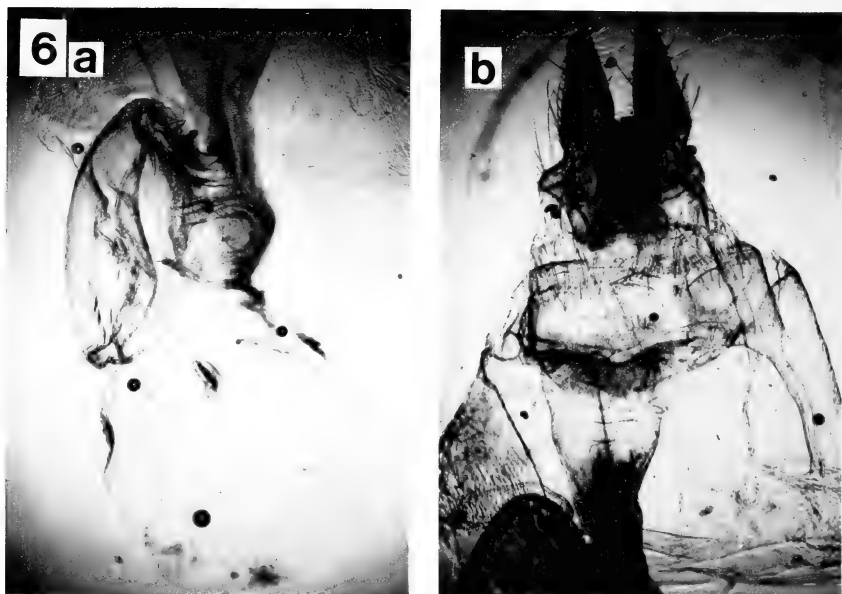
the basal tooth on the cucullus, which is spine-like on *S. carterae*, and the size and shape of the single large thorn-like spine in the vesica.

The presence of cucullar teeth on both species, the similarity in valve shape and in the vesica suggest that *S. carterae* and *S. inops* are fairly close relatives.

TABLE 1. Comparison of the male genitalia of *Spartiniphaga carterae* and *S. inops*. Two *inops* and three *carterae* were examined in temporary glycerin mounts.

Character	<i>S. carterae</i>	<i>S. inops</i>
Cucullar teeth	Basal one long, simple and pointed; 3 or more well separated smaller teeth	Four very small, largely fused, basal pair somewhat set off, larger
Ampulla	Short, slightly notched	Longer, simple
Saccular lobes	Somewhat pointed	Blunt
Juxta	Deeply cleft	Very shallowly cleft ¹
Aedeagus		
“Thorn”	Long, with well defined point	Much shorter, evenly tapered to a point
Cornuti	Longer, apparently more numerous	Shorter, apparently fewer

¹ The juxta cannot be clearly seen in the figure of *S. inops*.



FIGS. 6a, b. **a**, bursa copulatrix of *Spartiniphaga carterae*, paratype; **b**, ovipositor and associated structures.

Female genitalia. Illustrated in Figs. 6a and 6b, but not compared with other species.

Diagnosis, superficial. *Spartiniphaga carterae* can usually be distinguished from *S. inops* by the greatly reduced forewing pattern. *S. inops* (Fig. 3) apparently always has well defined antemedian, median, postmedian, and subterminal lines. Also the dots representing the postmedian line on the veins are larger on three male *S. carterae* than on most *S. inops* seen.

Types. HOLOTYPE: ♂, N.J.: Burlington Co., Batsto, 22 September 1973 at UV. leg. Dale F. Schweitzer. Illustrated in Fig. 1. Allotype: ♀, same data except 21 September 1975 at MV trap. Paratypes: ♂ same data as allotype; ♀ same locality, but 19 September 1970, UV trap, leg. Dale F. Schweitzer and Annie Carter; Whitesbog, N. J., E. P. Darlington, 17 Sep. 1936 (♂, 2♀♀), 20 Sep. 1940 (♂), 27 Sep. 1938 (♂).

The holotype and allotype are in the type collection of the Peabody Museum of Natural History, Yale University (YPM). Batsto paratypes are in my collection. The others are at the Carnegie Museum, Pittsburgh, PA and the Montshire Museum, Hanover, N.H. (1938 ♂). I have seen one other specimen of this species, collected by John W. Cadbury III and in his collection, from Whitesbog, N.J., 12 October 1940.

Dedication. This species is named for Annie Carter, the naturalist at Batsto Village (Wharton State Forest) who tended the trap in which the first Batsto specimen was taken and whose hospitality and assistance has contributed immensely to my research on Pine Barrens Lepidoptera since 1968.

Distribution. *Spartiniphaga carterae* is known only from Burlington County, New Jersey and is probably restricted to the New Jersey Pine Barrens.

The Batsto series was collected at the Batsto Nature Center near the east bank of the Batsto River, a few hundred meters upstream from

the dam at Batsto. The larva probably bores in one of the sedges growing in or along the Batsto or Mullica Rivers. No other species of *Spartiniphaga* has been collected in New Jersey.

ACKNOWLEDGMENTS

I thank Douglas C. Ferguson for examining and commenting upon one male paratype. The authorities at the following institutions permitted me to examine the collections under their care: American Museum of Natural History, New York; Carnegie Museum; Montshire Museum; Florida Department of Plant Industry; United States National Museum. The personal collections of H. D. Baggett, John W. Cadbury III, C. P. Kimball and Joseph Muller were also examined. I thank Joseph Gall for the use of his Zeiss Photomicroscope with which I took the genitalia photographs.

THE LARVA OF *HOMORTHODES FURFURATA* (GRT.) (NOCTUIDAE)

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ABSTRACT. The mature larva of *Homorthodes furfurata* (Grt.) is described and illustrated.

Homorthodes furfurata (Hadeninae) was described by A. R. Grote in 1874 based on material collected at Albany, New York. To date, nothing has been published on the immature stages of this species. Crumb (1956) described the larva of what he thought was *H. furfurata* based on an incorrect determination of the adults by Benjamin. As shown by Godfrey (1972), Crumb's determination actually applied to the closely related western species *H. uniformis* (Smith). Rockburne and Lafontaine (1976) gave maple (*Acer* sp.) as the host plant.

H. furfurata occurs from Nova Scotia (Ferguson, 1954), Maine, Quebec and Ontario, south to Massachusetts, and central New York state (Forbes, 1954). A female *H. furfurata* was collected at an ultraviolet light on 29 July 1978, 2.5 km south of Tomahawk Lake, Halifax County, Nova Scotia, and over the next week laid 10 eggs in a holding container.

The first instar larvae were confined with both living and dead leaves of maple, oak (*Quercus* sp.), cherry (*Prunus* sp.), *Osmaronia* sp., and *Taraxacum officinale* Weber as well as an artificial diet based on that of Hinks and Byers (1976). The larvae accepted only living *Taraxacum officinale* leaves but grew slowly with only two reaching maturity. Both larvae pupated by 10 October due to the constant conditions of laboratory rearing. Neither pupa survived the winter. *H. furfurata* overwinters as a larva with adults emerging the following July and August.

This paper describes the mature larva of *H. furfurata*. All illustrations were drawn to scale using a camera lucida and stereomicroscope. The terminology and abbreviations used follow Godfrey (1972).

Homorthodes furfurata (Grote)

General. Head: integument with minute granules; width 8.0 mm. Total length 25.8 mm. Body: integument with minute granules; Ab7-8 distinctly swollen; tapering cephalad. Prolegs present on Ab3-6, size increasing posteriorly; those on Ab3 slightly more than ½ the size of those on Ab6. Crochets uniorbital, 23-25 per third abdominal proleg, 25-29 per fourth, 28-34 per fifth, 33-37 per sixth. All setae simple.

Coloration (living material). Head (Fig. 3): blackish brown with a few black coronal freckles. Body (Figs. 1, 2): blackish, paler on ventral surface. Middorsal and subdorsal lines, whitish, narrow and broken, reduced to a series of dashes. Dorsal and subdorsal setal bases whitish. Spiracles dark orange-brown with black peritremes. Lateral shield of



FIGS. 1 & 2. *Homorthodes furfurata*, larva: 1, lateral view; 2, dorsal view ($\times 5.5$).

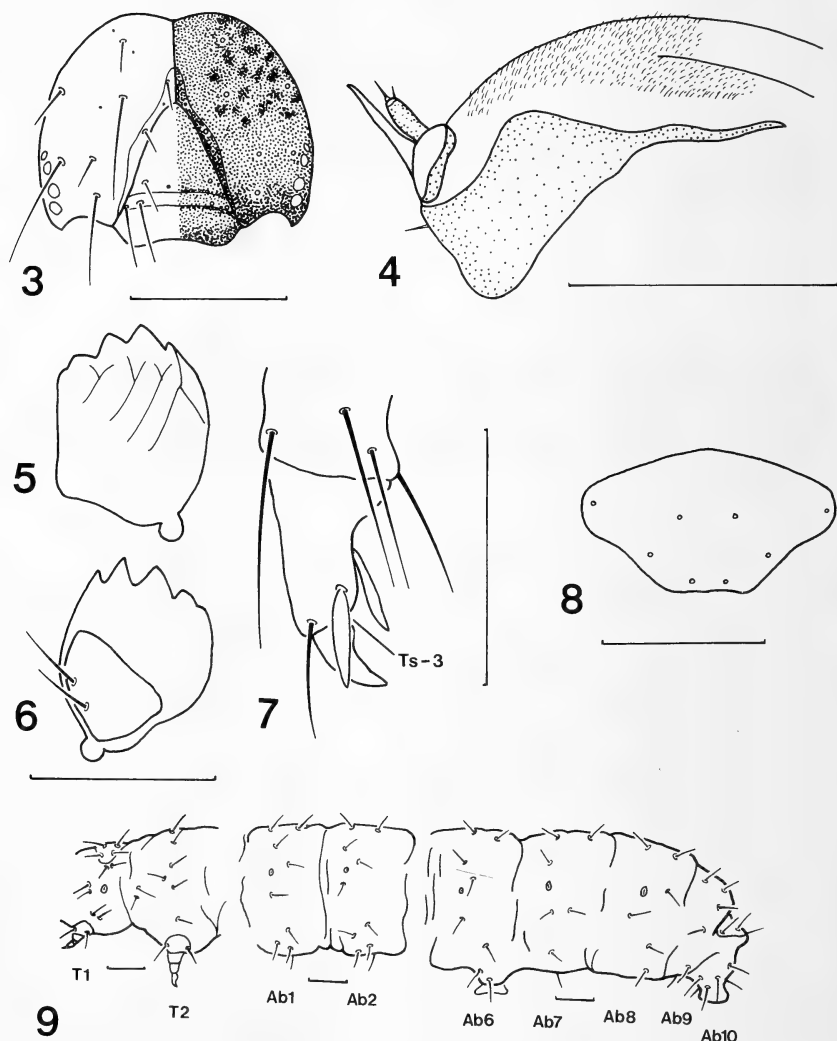
prolegs brownish black. Prothoracic shield orange-brown with lateral and posterior margins black.

Head (Fig. 3). Epicranial suture 0.45 mm long; height of frons (apex to Fa's) 0.49 mm; distance from F1 to anterior edge of clypeus 0.37 mm; interspace between F1-F1 0.23-0.25 mm; AFa anterior and AF2 posterior to apex of frons; A1-A3 forming an obtuse angle at A2; P1-P1 0.62-0.63 mm; P2-P2 0.64-0.65 mm. Distance from P1 to epicranial suture about $\frac{2}{3}$ that from P1-L; L cephalad of juncture of adfrontal ecdysial lines. Ocellar spacing: Oc1-Oc2 0.053-0.058 mm; Oc2-Oc3 0.034-0.039 mm; Oc3-Oc4 0.029-0.034 mm.

Mouthparts. Identical to those of *H. uniformis*. Hypopharyngeal complex (Fig. 4): spinneret very thin, transparent, tapering distally, about 1.5 times the length of Lps1; Lp2 and about $\frac{1}{2}$ the length of Lps1; stipular setae slightly more than $\frac{1}{2}$ the length of Lps1, slightly less than twice the length of Lp1, about equal to Lp2; Lps2 about $\frac{1}{2}$ the length of Lp1; distal and proximal regions of hypopharynx continuous, no medial transverse cleft present; distal and proximolateral regions of hypopharynx covered with small fine spines, spines becoming slightly longer proximally. Mandible (Figs. 5, 6): two well-separated outer setae present; inner surface with distinct ridges; lacking inner tooth; with six outer teeth, the sixth rounded and indistinct, the first five angular and well developed; outer margins of all teeth lacking serrations.

Thorax. Segment T1 (Fig. 9): prothoracic shield heavily sclerotized; SD1 and SD2 setal insertions separated from the edge of the prothoracic shield; interspace D1-D1 about 0.82 XD1-SD1; D2-SD2 about 1.57 SD2-XD2; seta L2 present, much finer than L1; spiracle elliptical, 0.19-0.20 mm high, 0.112-0.117 mm wide; peritreme wider laterally. T2 (Fig. 5): D1-D2 about 0.82 D2-SD2; all setae thin and hairlike, tapering and sharply pointed distally; coxal bases widely separated. T3: Ts3 spatulate (Fig. 9), not tapering distally as in *H. uniformis*.

Abdomen. Dorsal and lateral chaetotaxy of Ab1-10 as in Fig. 9. Ab1 with 2 SV setae, Ab2-6 with 3 SV setae, Ab7-8 with 1. Ab9: SD1 much finer and hairlike than D1 and D2. Ab10: anal shield as in Fig. 8. Dorsal margin convex, posterior margin entire. Length of D1 on Ab6-7 0.240-0.245 mm; D2 0.26-0.27 mm. Asp 7 0.12-0.13 mm high, 0.09 mm wide; Asp8 0.325-0.328 mm high, 0.15 mm wide.



FIGS. 3-9. *Homorthodes furfurata*, larval structures: 3, head capsule, frontal view; 4, hypopharyngeal complex, left lateral view; 5, left mandible, oral surface; 6, left mandible, outer surface; 7, left mesothoracic tibia and tarsus; 8, anal shield, dorsal view; 9, dorsolateral chaetotaxy of prothoracic (T1), mesothoracic (T2), and abdominal segments (Ab1-2, Ab6-10). Scale lines equal 1.0 mm.

Material examined. 2 specimens: 2.5 km south of Tomahawk Lake; Halifax Co., Nova Scotia. Reared on *Taraxacum officinale* Weber from ova obtained from a female on 29 July 1978. Larvae pupated 8-10 October 1978. Moth collected, determined, and larvae reared by K. A. Neil.

Remarks. The larvae of *H. furfurata* and *H. uniformis* are very similar and based

on the figures of *H. uniformis* given by Godfrey (1972), cannot be separated using head capsule and mouthpart structures. The spatulate Ts3 (Fig. 9) can be used to differentiate *H. furfurata* from *H. uniformis*, the latter having simple hairlike tarsal setae. *Homorhodes lindseyi* (Benjamin) has Ts3 spatulate, but can easily be separated from *H. furfurata* by the shorter tarsal setae, mandibular, and hypopharyngeal complex differences.

ACKNOWLEDGMENTS

I would like to thank Dr. G. L. Godfrey of the Illinois Natural History Survey for reviewing this manuscript, and Ronald Long of Simon Fraser University for photography.

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GENERAL NOTES

OBSERVATIONS OF HILLTOPPING *MITOURA SPINETORUM* AND *M. JOHNSONI* (LYCAENIDAE) IN CALIFORNIA

Mitoura spinetorum (Hewitson) and *Mitoura johnsoni* (Skinner) are medium-sized hairstreak butterflies having broad distributions but low-density and sometimes localized populations. These closely related species have similar reproductive biologies, and both use hilltopping behavior as a mate-locating strategy. Past observations of hilltopping behavior by these species are summarized, and new observations of some California populations are presented.

Previous reports of *M. spinetorum* behavior include hilltopping by males in the Providence Mountains, San Bernardino County, California, and Black Ridge, Mesa County, Colorado (Shields, 1965, J. Res. Lepid. 4:233-250); hilltopping by both sexes in the eastern Mojave ranges (Emmel & Emmel, 1973, Butterflies of Southern California, Nat. Hist. Museum Los Angeles Co., Science Series 26:1-148); perching on small pines near hilltops in Grand Canyon, Arizona (Scott, 1973, J. Lepid. Soc. 27:283-287); and perching by males on ridgetop pinyons and junipers in Nevada (Austin & Austin, 1981, J. Res. Lepid. 19:1-63). Shields (*in* Scott, 1973) observed *M. johnsoni* males perching on the tops of tall trees on a hilltop next to Thompson Canyon, Yolo County, California.

Our observations of hilltopping adults were made at two locations in the Inner Coast ranges of California: North Peak (1080 m) of Mt. Diablo in Contra Costa County and a ridge (310 m) at Butts Canyon in Napa County. Digger pine (*Pinus sabiniana* Douglas) and California juniper (*Juniperus californica* Carriere) occur in a semi-open area on the summit of North Peak. Only one conifer, digger pine, grows on the ridgetop at Butts Canyon in serpentine chaparral. Digger pine is commonly parasitized by pine dwarf mistletoe (*Arceuthobium campylopodum* Engelm.), the larval host plant of *M. spinetorum* and *M. johnsoni* in the study areas. *Mitoura spinetorum* occurs at both North Peak and Butts Canyon; however, *M. johnsoni* has been found only at the latter location.

Mitoura spinetorum appears to have three broods on North Peak. Adults have been found at this location from late March to early May, June to early July, and mid-August to late September (Opler & Langston, 1968, J. Lepid. Soc. 22:89-107; our observations 1975-1981). At Butts Canyon, adult *M. spinetorum* and *M. johnsoni* have been found in March, April, and June (Langston, pers. comm.; our observations, 1981). Although no late-season individuals of either species have been encountered at this site, it seems likely that at least *M. spinetorum* has a third emergence at Butts Canyon.

On North Peak, *M. spinetorum* males perch on the needles and occasionally on staminate cones of digger pine and foliage of junipers growing about the summit and nearby ridgetops. Some of these trees appear to be more often used for perching than others, as adults have consistently been found on the same conifers over several seasons. Trees used for perching are not necessarily the tallest present, may or may not have mistletoe, and are always located on a ridge crest but not necessarily at the highest point. At Butts Canyon, male *M. johnsoni* perch mostly about the tops of digger pines approximately six meters in height. Many of these trees are infested with pine dwarf mistletoe, some heavily.

Mitoura spinetorum males perch by alighting for periods of up to 35 minutes during which they may wave the antennae, rub the hindwings together, shift body orientation, or remain motionless. Males fly from perching sites to investigate conspecific males and other insects (lycaenids, hesperiids, and dipterans), to circle erratically about the perching site, or to transfer to other perching sites. One *M. spinetorum* was continuously engaged in these activities from 0920 to 1105 hours PST (Sept.) on North Peak. *Mitoura johnsoni* males exhibit similar perching behavior.

¹ Records of Clark County, Nevada *M. spinetorum* supplied by an anonymous reviewer also show a disproportionate sex ratio at hilltops (24 males, 0 females) and at canyon bottoms (4 males, 11 females).

Females were seen at our study sites only a few times. On 4 April 1981 two mating pairs of *M. spinetorum* were found on North Peak. Both were on trees frequently used by perching males. One pair was resting on juniper foliage, the other on a staminate cone of digger pine. Occasional North Peak females were seen flying about pine dwarf mistletoe on a ridgetop near the summit. Although no mating *M. johnsoni* were found at Butts Canyon, several ovipositing females were observed on the ridgetop in April. The disproportionate sex ratio at the ridgetops and summit may indicate female dispersal after mating.¹

These observations are consistent with Shields' (1967, J. Res. Lepid. 6:69-178) and Scott's (1970, J. Res. Lepid. 7:191-204) conclusions that butterflies with low population densities hilltop in order to facilitate the rendezvous of mates.

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LEPIDOPTERA REARED ON A SIMPLE WHEAT GERM DIET

Artificial diets have been used as food in rearing many species of Lepidoptera (Singh, 1972, Bull. N.Z. Dept. Scient. Ind. Res. 209 pp.; Vanderzant, 1974, A. Rev. Entomol. 19: 139-160; Hinks & Byers, 1976, Can. Entomol. 108:1345-1357). They may be synthetic (meridic), or composed of one or more natural products (oligidic) such as wheat germ and homogenized beans. The latter type is especially useful in rearing the larvae of polyphagous species of Lepidoptera, since no specific phagostimulants are required.

Fifty-seven species of Lepidoptera, mainly Noctuidae but also Lymantridae and Geometridae (Table 1), were reared from egg to adult on a simple wheat germ diet from 1977-1980. Adult females were collected at either a 15 watt ultraviolet light or sugar bait. Females thus collected were placed in 10 × 6 × 2 cm clear polystyrene boxes and fed a 10-15% sucrose solution until eggs were laid.

Larvae of all species were fed an artificial diet based on that of Hinks and Byers (1976), except that kidney beans were used instead of pea beans. An additional 100 g of wheat germ and 12 ml of formaldehyde were also used. The formaldehyde had no effect on the growth of any species of Lepidoptera bred, although it is known to have an inhibitory effect on the growth of other kinds of insects (Singh & House, 1970, J. Insect Physiol. 16:1969-1982).

Rearing techniques followed those developed by Hinks and Byers (1976) for the genus *Euxoa*, except that larvae were reared in 10 × 6 × 2 cm clear polystyrene boxes, with 15-20 larvae/box. At the fourth instar the larvae were separated and reared to maturity individually in 15 × 100 mm disposable polystyrene Petri dishes. All larvae were reared at 25-30°C under a photoperiod of 15-9 h light-dark cycle.

Feeding was discontinued at the first visible signs of the prepupal period, and 5-10 larvae were placed in 946 ml polystyrene containers partially filled with moist, sterilized top soil. A strip of paper towel provided a vertical surface for the moths to crawl up upon emergence. The containers were sealed with clear polyethylene and were kept at the same temperature and photoperiod conditions as the larvae.

Newly eclosed larvae of two noctuid species, *Feralia comstocki* Grt., a general feeder on coniferous trees, and *Homorthodes furfurata* (Grt.) which has been recorded from *Acer* spp. (Rockburne & Lafontaine, 1976, The Cutworm Moths of Ontario and Quebec.

TABLE 1. Lepidoptera reared on artificial wheat germ diet.

Family	Species	Larval foodplant
Geometridae	<i>Melanolophia canadaria</i> (Wlk.)	General feeder
	<i>Pero morrisonaria</i> (Hy. Edw.)	General feeder
Lymantriidae	<i>Orgyia leucostigma plagiata</i> (Wlk.)	General feeder
	<i>Orgyia leucostigma sablensis</i> Neil	General feeder
Noctuidae	<i>Zale minerea</i> (Gn.)	General feeder on deciduous trees
	<i>Autographa flagellum</i> (Wlk.)	<i>Helianthis, Liatris</i> ¹
	<i>Plusia putnami</i> Grt.	Grasses
	<i>Acronicta innotata</i> Gn.	General feeder on deciduous trees
	<i>Acronicta noctivaga</i> Gn.	General feeder on deciduous trees
	<i>Crymodes devastator</i> (Brace)	Grasses
	<i>Phlagophora iris</i> Gn.	General feeder
	<i>Elaphria festivooides</i> (Gn.)	General feeder on deciduous trees
	<i>Xylena curvimacula</i> (Morr.)	General feeder
	<i>Lithophane innominata</i> (Sm.)	General feeder on deciduous trees
	<i>Eupsilia vinulenta</i> (Grt.)	General feeder
	<i>Eupsilia tristigmata</i> (Grt.)	General feeder
	<i>Eupsilia morrisoni</i> (Grt.)	General feeder
	<i>Siderides maryx</i> (Gn.)	_____
	<i>Polia imbrifera</i> (Gn.)	General feeder on deciduous trees
	<i>Polia latex</i> (Gn.)	General feeder on deciduous trees
	<i>Melanchra adjuncta</i> (Gn.)	General feeder
	<i>Melanchra assimilis</i> (Morr.)	General feeder
	<i>Lacanobia atlantica</i> (Grt.)	General feeder on low plants
	<i>Lacanobia grandis</i> (Gn.)	General feeder
	<i>Lacanobia lutra</i> (Gn.)	General feeder
	<i>Lacanobia legitima</i> (Grt.)	Grasses, general feeder on low plants
	<i>Lacanobia lilacina</i> (Harv.)	Grasses, general feeder on low plants
	<i>Lacinipolia renigera</i> (Steph.)	General feeder
	<i>Lacinipolia lorea</i> (Gn.)	General feeder
	<i>Lacinipolia olivacea</i> (Morr.)	General feeder on low plants
	<i>Pseudaletia unipuncta</i> (Haw.)	Grasses, general feeder
	<i>Leucania inermis</i> (Fbs.)	Grasses
	<i>Crocigrapha normani</i> (Grt.)	General feeder on deciduous trees
	<i>Orthosia revicta</i> (Morr.)	General feeder on deciduous trees
	<i>Orthosia hibisci</i> (Grt.)	General feeder on deciduous trees
	<i>Homorthodes furfurata</i> (Grt.)	<i>Acer</i> spp. ²
<i>Pseudorthodes vecors</i> (Gn.)	General feeder on low plants	
<i>Tricholita signata</i> (Wlk.)	Feeds in stems and flowers of various Compositae	
<i>Agrotis volubilis</i> Harv.	<i>Achillea millefolium</i> L., <i>Vaccinium vacillans</i> Torr. <i>Oenothera biennis</i> L. ⁴	
<i>Agrotis ipsilon</i> (Hufn.)	General feeder	
<i>Feltia heralis</i> (Grt.)	General feeder	
<i>Euxoa divergens</i> (Wlk.)	_____	
<i>Euxoa scandens</i> (Riley)	General feeder	
<i>Euxoa tristicula</i> (Morr.)	_____	
<i>Euxoa perpolita</i> (Morr.)	_____	
<i>Ochropleura plecta</i> (L.)	General feeder on low plants	

TABLE 1. Continued.

Family	Species	Larval foodplant
	<i>Peridroma saucia</i> (Hbn.)	General feeder
	<i>Diarsia jucunda</i> (Wlk.)	Grasses
	<i>Eurois astricta</i> Morr.	General feeder on woody plants
	<i>Xestia dolosa</i> Franc.	General feeder
	<i>Xestia normaniana</i> (Grt.)	General feeder
	<i>Xestia smithii</i> (Snell.)	General feeder
	<i>Xestia oblata</i> (Grt.)	General feeder on low plants
	<i>Metalepsis fishii</i> (Grt.)	<i>Vaccinium</i> ^{2,3}
	<i>Anaplectoides prasina</i> (D. & S.)	General feeder on low plants
	<i>Eueretagrotis perattenta</i> (Grt.)	General feeder

¹Tietz, 1972, An Index to the Described Life Histories, Early Stages and Hosts of the Macrolepidoptera of the Continental United States & Canada. 11, A. C. Allyn, Sarasota, 1041 pp.

²Rockburne & Lafontaine (1976).

³Ferguson, 1975, U.S. Dept. Agric. Tech. Bull. 1521, 49 pp.

⁴McCabe, 1981, J.N.Y. Entomol. Soc. 89(2): 59-64.

Can. Dept. Agric. Publ. 1593. 164 pp., 613 figs.) refused to eat the artificial diet. Both species were subsequently reared on previously recorded host plants.

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EGG PLACEMENT BY *PHOEBIS* (PIERIDAE) ON *CASSIA* (LEGUMINOSAE) "ANTICIPATES" THE TROPICAL RAINY SEASON

As the tropical dry season advances, one common response by green plants is a progressive loss of leaves, which is sometimes accompanied by a gradual development of new leaf buds near the end of this period (Janzen, 1967, *Evolution* 21:620-637). By the time the rainy season is underway, such a plant species exhibits considerable leafing-out, providing herbivorous insects with an expanded food base. At any given Central American locality, not all plant species respond to the same degree to the dry season.

At "Finca La Tigra" on the Atlantic slope (220 m elev.) of Costa Rica's Cordillera Central (near La Virgen, Heredia Province, 10°23'N, 84°07'W) the plant family Leguminosae exhibits a broad range of dry season response patterns during the longer of two dry periods characteristic of this Premontane Tropical Wet Forest locality (Fig. 1). Many legume genera remain fully leaved throughout the major dry season, although the production of new leaf buds is often low. Others remain evergreen and exhibit considerable leaf replacement at this time. Still others, such as the roadside shrub or small tree (canopy height 2-5 m), *Cassia fruticosa* Mill., exhibit considerable loss of mature leaves, followed by a gradual development of new leaf buds in the latter part of the major dry period, which usually extends from late December through March. This is also a period of greatly reduced flowering and complete absence of fruits on *C. fruticosa* (Allen M. Young, unpubl. data, 1973-1982). The guild or assemblage of herbivorous insects associated with this tree species must cope physiologically and behaviorally with this annual cycle of seasonal changes in the availability of various edible plant parts.

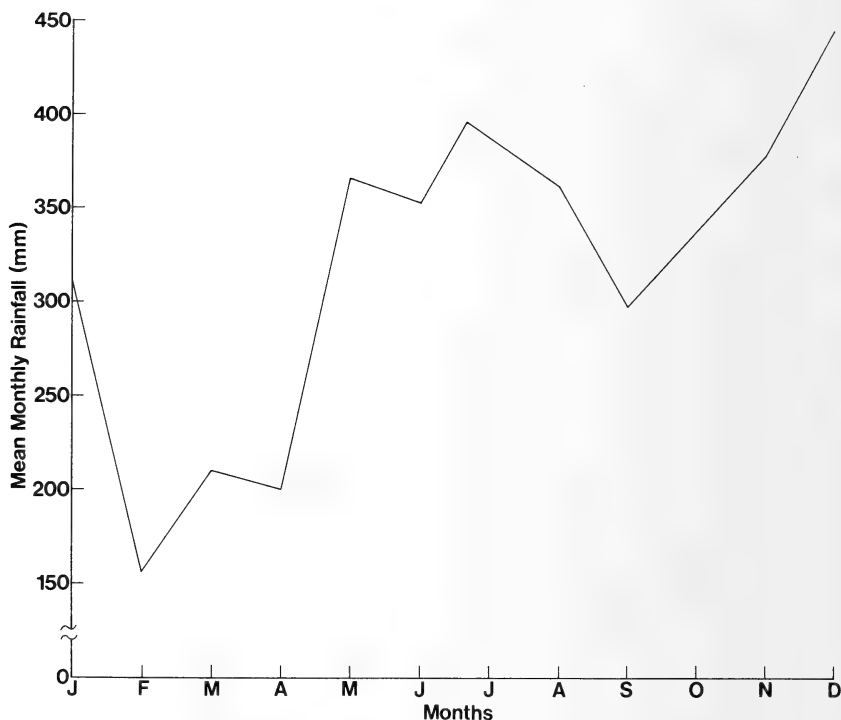


FIG. 1. Pattern of monthly rainfall at "Finca La Tirimbina," near La Virgen, Heredia Province, Costa Rica. Note the short dry season occurring in February and March.

In this note, I report that the pierid butterfly *Phoebis argante* (Fabricius), which is very abundant at this locality as it is throughout much of Costa Rica and Central America overall, behaviorally circumvents the deciduous habit of *C. fructicosa* by preferentially placing its eggs singly on the developing leaf buds while avoiding the severely thinned-out canopy of mature leaves. On one roadside stretch at La Tigra, I observed frequent egg placement on *C. fructicosa* by *P. argante* on roughly 30 trees between 1978 and 1982, providing a sample of 68 observed oviposition acts in the major dry season (December–March). In addition, 35 oviposition acts were observed during the lengthy rainy season characteristic of this region (Fig. 1).

During the rainy season, *P. argante* frequently places eggs singly on the fresh, fully-expanded leaves of *C. fructicosa*, as it does for other larval food plants at this locality during both rainy and dry seasons (A.M.Y., unpubl. data). A good example of the latter is *Pentaclethra maculosa*, a legume tree that remains evergreen throughout the dry seasons at this locality. But in the case of *C. fructicosa* as a larval food plant, during the latter part of the major dry season eggs are placed singly only on the small (length 4–10 mm, $n = 30$ measured on 7 March 1982) leaf buds that are scattered below the canopy of old leaves. A female butterfly weaves through the branches of the tree until it finds a new leaf bud and carefully places an egg on it (Fig. 2). A butterfly may thus deposit anywhere from 1 to 6 eggs on a single tree during one visit. Leaf buds having eggs are sometimes avoided, although a single female may place multiple eggs on a given bud. Butterflies do not even "inspect" the older leaves of a tree's canopy (Fig. 2).

The stage at which *P. argante* places eggs on leaf buds is followed by a period of



FIG. 2. **Above:** Position of eggs of *Phoebis argante* on unfolding new leaf buds of a larval host plant, *Cassia fruticosa* (Leguminosae) at "Finca La Tigra" in March. **Below:** The thinned-out canopy of mature leaves of *Cassia fruticosa* as it appears during February and March at "Finca La Tigra."

rapid growth and expansion of the buds, a condition that precludes the necessity of a potential egg diapause at this locality. The degree to which Neotropical pierids have diapausing eggs is unknown. The condition of rapid leafing-out is analogous to the availability of new leaf buds precluding the need for a reproductive diapause mechanism in the adults of butterfly species at such a locality. Eggs deposited on leaf buds in late February generally hatch in less than 10 days, and by this time the new leaves are considerably larger (expanded). Fresh adults of *P. argante* are found at this locality throughout the year, indicating a continuous breeding population structure made possible by (1) the behavioral flexibility that allows *P. argante* to place eggs on several alternate leguminous food plants at any one time, and (2) behavioral flexibility permitting different types of egg placement on a food plant that exhibits a markedly deciduous habit in at least the major dry season. Placing eggs on new leaf buds juxtaposes newly hatched larvae with a fresh food supply, and perhaps does so before other members of the herbivore guild associated with the leaves of *C. fruticosa* discover this resource at the beginning of the rainy season.

Such observations suggest that flexibility in egg placement behavior in a butterfly species that exploits a food plant with a deciduous habit is an effective mechanism by which the insect "anticipates" the expanded food supply of fresh, and perhaps, more edible, leaves, that will be available at the beginning of the tropical rainy season. Such a behavioral response permits the butterfly to breed throughout the year at such a locality. As with many Neotropical butterflies, *P. argante* possesses an egg-to-adult developmental period of about 40 days, including a larval period of 22 days, a period sufficiently long enough to "pace" development with the growth of new, highly edible, leaves of the larval food plant. Because this butterfly is geographically widespread throughout the Neotropical Region (Seitz, 1924, *Macrolepidoptera of the World*, Vol. 5: American Rhopalocera, Stuttgart: A. Kernan, 615 pp.; Howe, 1975, *The Butterflies of North America*, New York: Doubleday, 633 pp.), and because it exploits a range of *Cassia* species (d'Almeida, 1940, *Arq. de Zool. Estado de Sao Paulo, Revista do Museu Paulista* 1:67-152; Biezanko, 1959, *Arq. de Entomol. Minist. Agric. Brasil. Ser. B*; Teitz, 1972, *An Index to the Described Life Histories, Early Stages and Hosts of the Macrolepidoptera of the Continental United States and Canada*, Allyn Museum, 1041 pp.; Howe, op. cit.), regional or local larval food plant differences and the degree of seasonality are major determinants of whether or not the insect will exhibit the form of egg placement behavior described in this note. It is well known that many Lepidoptera species preferentially place eggs on fresh leaves of the food plant, regardless of a seasonal cycle in the availability of new leaves and other vegetative parts used as food. Presumably such plant parts are more edible for small caterpillars in the sense of having fewer defensive compounds (concentration, or range in types) and other barriers to successful feeding. What this present paper suggests is that in tropical regions with one or more dry seasons, we must view such preferences through the evolutionary lens of effects of the dry period on the supply of fresh leaves.

Not all legume-feeding Lepidoptera at this locality preferentially oviposit on young or fresh leaves. Even though the common woody legume vine *Machaerium seemannii* also flushes out new leaves in the dry season here, *Morpho peleides limpida* Butler and *Morpho granadensis polybaptus* Butler (Morphidae) place their eggs singly on the mature leaves of the vines (Young & Muyschondt, 1973, *Carib. J. Sci.* 13:1-49; Young, 1974, *J. Lepid. Soc.* 28:90-99; Young, 1982, *J. New York Entomol. Soc.* 90:35-54), even in the presence of young leaves. Newly flushed leaves in a leguminous food plant, therefore, may not always be more biologically suitable as larval food than the mature leaves of the same plant. But in the case of the *P. argante* × *C. fruticosa* association in Central America, newly flushed leaves may be more suitable as larval food than older leaves on the same trees. When 10 newly hatched first-instar larvae of *P. argante* were offered the old leaves of *C. fruticosa* that were present on trees in late February, some larvae nibbled at the edges of leaves, but all died within two days. A simultaneously studied set of another 10 first-instar larvae reared on the leaf buds where eggs were placed by ovipositing butterflies all developed normally during the same period, and none died. Clearly in this case, if we eliminate the bias of small sample size, older leaves of *C. fruticosa* available late in the dry season in Costa Rica are markedly unsuitable for

proper larval development in *P. argante* than newly unfolding leaves available at the same time. I suspect that full-sized mature leaves of *C. fruticosa* available in the rainy season are also highly unsuitable to *P. argante* larvae, before these leaves assume the brittle and blotched appearance that characterizes them in the dry season.

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CHERMOCK, HOVANITZ AND WEBER COLLECTIONS DONATED TO ALLYN MUSEUM

Among other accessions during 1980 and 1981 received by the Allyn Museum of Entomology of the Florida State Museum were three large and very significant collections of Rhopalocera donated by the heirs of Franklin H. Chermock, William Hovanitz and Bernard H. Weber. All of these collections have filled great gaps in the coverage of the Museum's holdings, especially in Arctic species and in the specialty groups of each of the donors.

Franklin H. Chermock collected and studied Lepidoptera assiduously and enthusiastically for over forty years until his death in 1967. Much of his early taxonomic work was done in collaboration with his brother, the late Ralph L. Chermock, and their investigations into the fauna of the Riding Mountains, Manitoba, were enormously valuable scientifically, resulting in the descriptions of many endemic butterflies from that region. Dr. Chermock's interest in Canadian butterflies continued up to the time of his death, and in company with his son, the late Paul W. Chermock, Frank collected and studied the butterflies throughout northern Manitoba and much of the Northwest Territories. The Chermocks, father and son, intended to describe many new taxa from these expeditions and distributed innumerable manuscript "paratypes" of these butterflies, many of which have been named subsequent to Frank's death by other authors. The Chermock collection contained 56,154 specimens (nearly all from the Nearctic), including 20 holotypes, eight allotypes, five syntypes and nearly 2000 paratypes, many from other authors. The "type series" of 56 proposed taxa were included and labelled. About 1300 microscopic genitalia slides and a useful library augmented the collection itself, along with a sizable body of correspondence relating to it. The Chermock material has provided the Allyn Museum collection with its first significant holdings in Arctic and Subarctic butterflies, and we are grateful to Frank's daughter, Mrs. Linda C. Hassinger, for the opportunity to preserve it and make it available for study.

William Hovanitz collected and studied Rhopalocera for about forty years before his untimely death in 1977. He was best known for his genetic and variational studies; the personally collected material for these studies is preserved in his collection. He had no parochial bias, and those groups that were of special interest to him are represented in the collection from throughout their ranges, especially *Colias*, Argynninae and *Oeneis*. The Hovanitz material included 23,859 specimens, including more than 4400 *Colias*, significant numbers of which were from the Arctic of Canada and Alaska and from outside the Nearctic (especially the Andes of Peru, Bolivia, Chile and Argentina). One of the most valuable parts of the collection is material taken along a transect of the Alaska Highway from about Grande Prairie, Alberta (before the beginning of the Highway) to Tok Junction, Alaska. While this collection is particularly strong in *Colias*, other groups are well represented, such as *Clossiana*, *Oeneis* and the "blues." The only type material in the collection were two paratypes of *Colias thula* Hovanitz and two Bang-Haas *Colias*

cotypes. Our gratitude to Dr. Hovanitz' widow, Barbara, for this generous gift is here acknowledged.

Bernard H. (Bernie) Weber was an avid collector who also carried on an ambitious exchange program with other lepidopterists, chiefly throughout the United States and Canada. His collection is composed of 43,988 specimens, more than 90% of which are Nearctic and represent the majority of the presently recognized taxa of the region. Many so-called "rare" butterflies (such as *Speyeria egleis tehachapina* J. A. Comstock) are included in the collection in sizable series. California and West Coast butterflies are especially well represented, but there are good series from elsewhere as well; no type specimens are included. This collection came to the Museum through the kindness and foresight of Mr. Weber's widow, Virginia.

All of these collections have been or are being incorporated into the main collection of the Allyn Museum of Entomology where they will be available to researchers in the coming years. Suffice it to say that the staff of the Museum is grateful for the generosity (that human attribute that makes growth of museum collections possible) and far-sightedness of the donors in making these collections again available to Science.

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AN OLD FIRST UNITED STATES RECORD FINALLY PUBLISHED:
PAPILIO VICTORINUS (PAPILIONIDAE) IN LAREDO, TEXAS

On 17 August 1974 I collected a male *Papilio victorinus* Dbldy. in Laredo, Webb County, Texas. The relatively fresh specimen was collected in a large planted flower bed, which included a number of marigolds on the eastern edge of the city.

I first mentioned this capture in the May/June 1978 issue of the "News of the Lepidopterists' Society." At that time I was inquiring as to whether anyone else had collected this particular species in the U.S. I did not receive any correspondence as to such captures; subsequently, the publication of the 1981, *Catalogue/Checklist of the Butterflies of America North of Mexico* by Miller & Brown, with the omission of *P. victorinus*, reconfirmed my belief that this was indeed a first U.S. record.

Tyler (1975, *The Swallowtail Butterflies of North America*, Nature Graph Publishers, Inc., Healdsburg, California, p. 128) gives the range of this species as "Temperate and tropical regions of E. Mexico as far north as Nuevo Leon and Tamaulipas." Five additional specimens were collected during a short period in August 1974 on the Plaza Zaragoza in Monterrey, Nuevo Leon, Mexico. I had expressed the belief that *P. victorinus* was perhaps extending its range northward; however, more recent trips to northern Mexico have failed to turn up the species in any significant numbers. It appears that 1974 was just a good year for it. The fact that it can be found occasionally in good numbers in Monterrey, which is just south of the latitude of Brownsville, Texas, is an indication that collectors in southern Texas should watch for it.

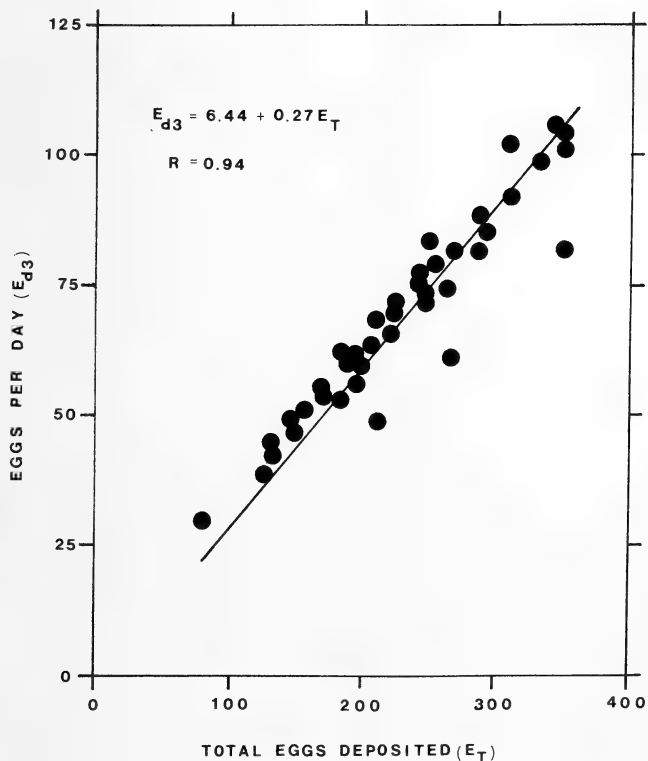
The specimen is presently in my collection at 135 N. Missouri St., Liberty, Missouri 64068.

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ESTIMATION OF DAILY OVIPOSITION RATES
IN REARED FEMALE *ANTHRAEA POLYPHEMUS* (SATURNIIDAE)

In rearing giant silkworm moths for research purposes, it is frequently important to use specimens having the same approximate age and physiological condition. Fundamental to obtaining such specimens is an understanding of oviposition patterns and the factors that may affect such patterns. We have studied oviposition in *Antheraea polyphemus* (Cramer) (Miller & Cooper, 1980, *J. Lepid. Soc.*, 34:256-259) and determined that reared females live an average of six days after mating and deposit an average of 216 eggs. Peak oviposition is during the first three nights after mating. We have also determined (Miller, et al., 1982, *Ann. Entomol. Soc. Amer.*, 75:107-108) that the number of mature eggs (NME) in reared females can be estimated from pupal weight (WT) by the linear regression equation: $NME = 2.22 + 45.9 WT$ ($r = 0.78$). The number of mature eggs at emergence is 74.0 percent of the total eggs (TE) and is related by the linear regression equation: $TE = 35.3 + 1.10 NME$ ($r = 0.96$). Studies have now been completed on two additional aspects of egg production in *A. polyphemus*: (1) the relationship between total eggs deposited and adult longevity and (2) the relationship between total eggs deposited and daily oviposition rates. These studies were undertaken because it was important to know whether females that lived longer, or contained larger numbers of eggs at emergence, deposited their eggs over a longer period of time and,



thus, for any particular group of eggs, resulted in wider variation in physiologic ages of the embryos and subsequent stages. Eggs were collected from 40 reared female *A. polyphemus* in paper bags as described by Miller & Cooper (1980). Daily oviposition rates represent the average eggs per night for the first three nights after mating. Total eggs represent the total eggs deposited during the lifespan.

Antheraea polyphemus females live from five to 10 days after mating (mean = 7.1; S.D. = 1.3). No significant correlation ($r = 0.14$) was found between the total number of eggs deposited and female longevity. However, daily oviposition rates were highly correlated ($r = 0.94$) with the total number of eggs deposited (Fig. 1). The total number of eggs deposited averaged 231.6 ± 67.7 . The number of eggs deposited per night during the first three nights after mating averaged 68.5 ± 19.4 . Thus, females that deposited greater total numbers of eggs during their lifespan did not live longer and deposit them over a longer period of time. They deposited their eggs at a greater rate during the first three nights after mating. The relationship between the three-day average oviposition (E_{d3}) and the total number of eggs deposited (E_t) is described by the linear regression equation: $E_{d3} = 6.44 + 0.27 E_t$. Using the relationship we previously demonstrated (Miller, et al., 1982) between NME and WT, and between NME and TE, it is possible to estimate daily oviposition (E_{d3}) on the basis of pupal weight (WT) as follows:

$$E_{d3} = 6.44 + (0.27 (22.4 + 45.9 \text{ WT}))$$

Aside from the value of this information in rearing giant silkworm moths for research purposes, the adaptive significance of these findings must also be noted. It appears that *A. polyphemus*, that does not feed as an adult, is able to efficiently use stored energy reserves obtained in the larval stage to deposit the majority of its eggs (74 percent) in a relatively short period of time (three days) independent of the total number of eggs deposited or the life-span of the moth.

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ADDITIONAL COMMENTS ON THE BUTTERFLIES OF THE AUSTIN, TEXAS, REGION

Recently, Durden (1982, *J. Lepid. Soc.* 36:1-17) presented and analyzed a list of 173 species of butterflies and skippers from a ten county region centered around Austin, Texas. Special attention was given to the 128 species found in Barton Creek canyon in the Balcones Fault Zone area of Austin. Below are comments on two species attributed to this author's collecting activities plus the report of an additional species to the Austin region.

In his list, Durden (op. cit.) credited an Austin specimen of *Siproeta* (*Victorina*) *stelenes biplagiata* (Fruhstorfer, 1907) to "R. Neck." Although stray individuals of this species undoubtedly occur in the Austin area on rare occasions, I have never collected *biplagiata* in Austin. The closest personal record of *biplagiata* to Austin is a female collected in Garner State Park, Uvalde County, Texas, on 14 October 1976. Collection was made in the canyon of the Frio River, approximately 210 kilometers from Austin. The specimen was extremely worn and exhibited very weak flight behavior. Both these

observations indicate that the specimen was a long distance dispersant organism, one of many individuals of several species of tropical affinity which move northward in late summer and autumn of years in which moisture is sufficient (Neck, 1978, J. Lepid. Soc. 32:111-115). Any Austin specimens would be of similar origin. Note should be made of the report of this species by Parks (Engelhardt, 1934, Brooklyn Entomol. Soc. 29:16) at San Antonio (125 km to the south) following a major hurricane in south Texas (see Neck, 1977, J. Lepid. Soc. 31:67-68).

The report of *Eueides isabellae zorcaon* (Reakirt, 1866) credited to "R. Neck" refers to a specimen sighted (but not collected) on 19 August 1971 on the floodplain of the Colorado River next to presentday Town Lake. This tract of land was highly disturbed by human activities in 1971 (now occupied by Austin High School). Weedy plants with significant nectar resources inhabited the area and attracted numerous species of butterflies. The most important nectar source was *Verbesina encelioides*, a plant which is a major nectar source for butterflies in central Texas (see Neck, 1977, J. Res. Lepid. 16:147-154). Fall 1971 was a time of prodigious northward movement by countless butterflies of numerous species as a result of heavy rains in August following a period of extreme drought (Helfert, 1972, Entomol. News 82:49-52; Neck, ms. submitted to J. Lepid. Soc.). Kendall (1972, J. Lepid. Soc. 26:49-56) reported a number of records of *zorcaon* from southern Texas in 1968; northernmost specimen was from San Antonio (125 km south of Barton Creek area). Occurrence of these 1968 specimens was attributed to introduction and establishment of breeding populations due to environmental effects associated with Hurricane Beulah of September 1967. Impact of this hurricane on the butterfly fauna of the Austin area has been discussed (Neck, 1978, J. Lepid. Soc. 32:111-155).

I do, however, have one species to add to Durden's list of Austin area butterflies. I collected a moderately worn female *Anteos chlorinde nivifera* (Fruhstorfer, 1907) on 10 November 1970 within the confines of the Brackenridge Field Laboratory (BFL) of the University of Texas at Austin within the city limits of Austin. The BFL specimen was collected near the mouth of an unnamed creek whose lower reaches are flooded by Town Lake (Colorado River), only 3.5 km from the mouth of Barton Creek. *A. c. nivifera* is well-documented to be a long distance traveler and is known as far north as Colorado and Kansas (Brown, 1960; J. Lepid. Soc. 14:156; Field, 1938, Bull. Univ. Kansas Biol. Series 39(10):1-328). Parks (see Engelhardt, op. cit.) also reported this species from Austin following a major hurricane in southern Texas (Neck, 1977, J. Lepid. Soc. 31:67-68). *A. c. nivifera* was also found in Austin in 1968 (*leg.* W. P. Hard, specimen in R. O. Kendall coll.); this year followed a major hurricane (Beulah) in 1967 which caused alterations in the butterfly fauna of the Austin area (Neck, 1978, J. Lepid. Soc. 32:111-115; 1981, *Ibid.* 35:22-26).

Another comment is appropriate concerning the listing under *Zerene cesonia* (Stoll, 1790) of form "stainkeae" Field. Durden was referring to the form with reduced marginal melanic markings. This form is correctly referred to as form "immaculsecunda" Gunder and is periodically common especially in late summer and autumn when substantial movement from Mexico occurs (see Neck, 1981, J. Lepid. Soc. 35:22-26). Form "stainkeae" is a "rather rare white female form . . . with change of color yellow to white" (Field, 1936, J. Entomol. & Zoology (Pomona College) 28(2):17-26), which has been illustrated by Kimball (1965, Lepidoptera of Florida, Fla. Dept. Agric. 363 pp. pl. 1, fig. 22). Durden (*pers. comm.*) has collected these whitish forms in the Austin area.

I thank R. O. Kendall for comments on this manuscript.

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OBITUARY

LUCIEN HARRIS, JR. (1899-1983), A Tribute

One of the country's most dedicated naturalists in recent times, Lucien Harris, Jr., spent a lifetime in the study and conservation of the natural history of his native state, Georgia, and the Southeastern region, and inspired all who knew him by his wealth of knowledge and experiences, and his quiet manner coupled with a unique intensity of spirit that radiated from the man.

Lucien Harris, Jr. was born on 9 September 1899 in Atlanta, Georgia to a long line of Georgians, his grandfather, Joel Chandler Harris (1848-1908), the southern folklore writer and author of the endearing Uncle Remus stories, being the most famous. Lucien grew up in Atlanta, graduated from Boys' High School and subsequently attended the University of Georgia, in Athens. After brief military service during World War I, he married Louise Nichols in 1919 and settled permanently in Atlanta. Over the next three decades the Harrises traveled extensively throughout the United States. Although an outdoors person by nature, Lucien established his career in the publishing field and served as the Southeastern Manager for Macmillan Publishers for many years. In that capacity he was directly involved with the logistics of the publication of *Gone With the Wind* and became a lifelong friend of its author, Margaret Mitchell. However, throughout his adult life, very often accompanied by Louise and their two sons, Lucien Harris III and James Robin Harris, Lucien spent virtually every moment he could find on field trips, to collect and study the butterflies and moths of the state and region.

Lucien's fascination with nature and wildlife no doubt was sparked by the picturesque stories of the animal characters in his grandfather's books, with which he was familiar from his early childhood. However, in his childhood and adolescence he became keenly interested in the observation of birds. During his teens, Lucien regularly went on bird walks with a family friend and a source of great inspiration, Wallace Rogers, who was a Methodist minister and also a nature photographer of considerable talent, with whom Lucien would later collaborate in co-authoring (along with Woolford B. Baker) a series of three volumes, *Southern Nature Stories*, directed at introducing children in the primary grades to the world of nature.

While observing the birds during those forays, Lucien also became interested in butterflies, which were abundant throughout Georgia in those years when most of the state was still undeveloped. Before he was out of his teens he found himself building a serious collection and dedicating increasing amounts of his time to collecting specimens over a continuously widening area of the state. In his twenties he established friendships with lepidopterists and other naturalists in the state and in the region, notably Dr. P. William Fattig, an entomologist, and Woolford B. Baker, a botanist, both at Emory University, Dr. F. Strohecker, an entomologist at the University of Miami, and Fred Naumann of Forsyth, Georgia, an enthusiastic lepidopterist. In 1929 Lucien called an informal meeting at Emory University of his friends in various branches of science who shared an interest in natural history and conservation and founded what came to be the Georgia Society of Naturalists, and he served as its president for a number of years. The group met regularly, published bulletins and organized field trips to explore diverse areas of Georgia, the largest state east of the Mississippi. One of those areas was the Okefenokee Swamp, and it was through the untiring efforts of Lucien and the Georgia Society of Naturalists that the swamp was designated a National Wildlife Refuge. It was also through the efforts and negotiations of the Society and of Herbert Lee Stoddard, Sr., one of its members, that the Tall Timbers Research Station, near Tallahassee, Florida, was founded. Today, its main building houses the Herbert Lee Stoddard, Sr. bird collection, and the Lucien Harris, Jr. butterfly and moth collections, containing virtually all the specimens he collected between 1930 and 1970.

As Lucien's interest in Lepidoptera grew to a full-time preoccupation in his teens and twenties, he became keenly aware of the dearth of publications on the butterflies and moths of the region. Indeed, there had been only one major book on Georgia's butterflies, the two volume study, *The Rarer Lepidopterous Insects of Georgia*, published in London



LUCIEN HARRIS, JR., 1899-1983

in 1797 by Dr. James Edward Smith, and illustrated by Georgia's pioneer naturalist, John Abbot (1751-1840). In a real sense Abbot, who collected and reared many of the butterfly species of Georgia and depicted them in their natural size and colors, with their caterpillars, chrysalids and foodplants, became Lucien's mentor, and for years his goal was to collect and document all the Georgia species painted by Abbot, even into the 1950's and 1960's, when collecting with fellow lepidopterists John C. Symmes, Stanley S. Nicolay and Fred Naumann. In the process, as many new records were added to those of Abbot, and new information was amassed on life histories, foodplants, distribution, etc., Lucien undertook to update Abbot's publication. In 1931, *A List of the Butterflies of Georgia* was published, being essentially an annotated checklist of the species taken in the state up to that time. A revised edition, edited by Austin H. Clark, was published in 1950 as *The Butterflies of Georgia, Revised*, containing substantial new material and a comprehensive bibliography prepared by Mr. Clark. These two publications, along with extensive new records by Lucien and many other collectors in the 1950's and 1960's, laid the groundwork for his culminating work, *The Butterflies of Georgia*, published in 1972 by University of Oklahoma Press. This volume, in the format of a field guide, covers and illustrates every species of butterfly known to occur in Georgia (NOTE: Four new species, *Erora laeta*, *Mitoura hesseli*, *Euphyes dukesi* and *Urbanus dorantes*, have been added to the state's fauna since the book's publication.). As many collectors have long since realized, however, the book has validity for virtually the entire Southeastern region, and it includes information on distribution, life history, foodplants, habitats and capture records for each species listed.

In *The Butterflies of Georgia* is a detailed account of the discovery by Lucien, Lucien

III and J. P. Knudsen of what turned out to be a new species of giant skipper (Megathymidae), which was described and named *Megathymus harrisi* by H. A. Freeman in 1955, in recognition of Lucien's achievement.

In addition to these accomplishments, Lucien was a charter member of the Lepidopterists' Society, a founding member of the Georgia Ornithological Society, an associate member of the American Association for the Advancement of Science, as well as a member of the Florida Audubon Society, the Tennessee Ornithological Society and the Georgia Academy of Science.

Lucien Harris, Jr. died on February 22, 1983, in a Decatur, Georgia nursing home after a long illness. He is survived by his wife, Louise, his sons Lucien III and James Robin, and their respective children. In addition to the greater part of his collection of butterflies and moths contained in the Tall Timbers Research Station, his material collected up to 1930 is housed at the Emory University Museum, Atlanta and the balance at the Fernbank Science Center, Decatur, Georgia.

It has been truly rewarding and inspiring to have known Lucien Harris, Jr. personally, to have experienced his contagious enthusiasm for the butterflies and other wildlife he knew so intimately, and to have received his friendship and comraderie. I am also deeply indebted to both Lucien Harris III and James Robin Harris for the information and photograph they provided me for the preparation of this tribute.

IRVING L. FINKELSTEIN, 425 Springdale Drive N.E., Atlanta, Georgia 30305.

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