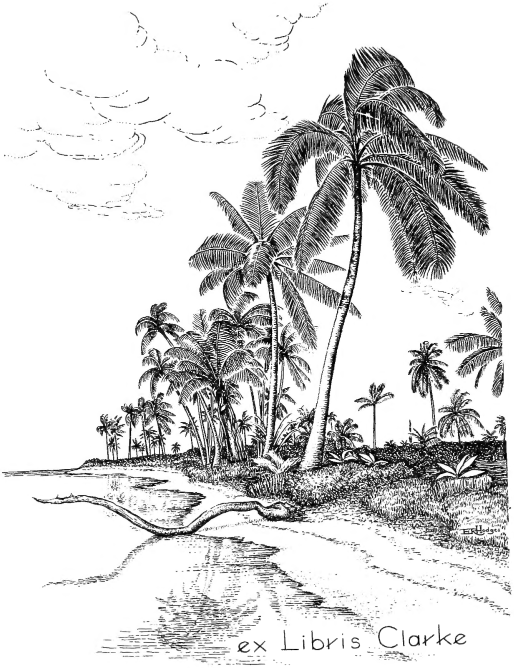

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Cover illustration: Head (antennae mostly missing) of *Paranthrene tabaniformis* (Rottemburg). This drawing was prepared by George Venable, Smithsonian artist, for inclusion in the Sesiidae fascicle for the Moths of America North of Mexico. The dusky clearwing, a Holarctic species, is a borer in the exposed roots, stems and branches of willows and poplars.

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THE LIFE HISTORY AND ECOLOGY OF *EUPHYDRYAS GILLETTII* BARNES (NYMPHALIDAE)

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ABSTRACT. Based on studies of several populations, the life stages of the montane butterfly *Euphydryas gillettii* and its natural history and ecology are described. *E. gillettii* shows unusual developmental flexibility in that it can diapause as second, third, or fourth instars, depending on climatic conditions; in addition, one population in a colder habitat is mostly biennial, while others are annual. In spite of this flexibility, the species has limited distribution in isolated populations over a narrow geographical range.

Euphydryas gillettii Barnes occurs in the middle Rocky Mountains, ranging from western Wyoming, through northern Idaho and western Montana, and into Alberta (Ferris and Brown, 1981). While much work has been published on other species of *Euphydryas* in the past 20 years (Ehrlich et al., 1975; Cullenward et al., 1979; Brown and Ehrlich, 1980; Stamp, 1982), little has been known about *E. gillettii.* Until very recently (Williams, 1981; Holdren and Ehrlich, 1981), the only report in the literature on the biology of this species was that of Comstock (1940), which describes the eggs and early instars.

We have studied *E. gillettii* in several locations recently and here report on its life history and ecology. Four populations have been observed extensively: natural populations in the Teton and Beartooth Mountains of Wyoming, and two populations introduced into Colorado from the Teton colony. In addition, several other populations have been visited.

TABLE 1. Width of the head capsule, spine length, and body size for the different instars of *Euphydryas gillettii*.

Instar	Width of head capsule (mm)	Length of spines		Body length moving (mm)
		Shaft (mm)	Setae (mm)	
First	0.44 ± 0.01 (30)	0.02	0.2–0.3	3–4
Second	0.61 ± 0.03 (81)	0.30 ± 0.04 (28)	0.2–0.4	4–6
Third	0.90 ± 0.04 (46)	0.46 ± 0.06 (43)	0.3–0.5	5–9
Fourth	1.17 ± 0.13 (84)	0.69 ± 0.10 (39)	0.5–0.7	9–13
Fifth	1.47 ± 0.18 (39)	0.74 ± 0.10 (42)	0.6–0.9	12–18
Sixth	2.40 ± 0.12 (5)	0.74 ± 0.16 (27)	0.7–1.2	15–30

Study Sites

The Beartooth population lives along a small stream in a montane meadow of 2620 m (8600 ft) elevation. The butterflies fly in an elongate area, roughly 60 m by 240 m, which is surrounded by coniferous forest of primarily *Picea engelmanii*. The highest density occurs in an area of secondary growth, where trees are scattered sparsely through a moist bottom area near the stream.

The Teton population is the largest known for this species. The butterflies are widely scattered over an eastern facing slope at 2100 m (6900 ft) elevation, occurring in an area roughly 400 m by 1500 m of mostly herbaceous vegetation. Streams run down through this slope, and trees, mostly *Picea* and *Populus tremuloides*, grow along the stream beds. Adults are found throughout the slope.

The two Colorado sites are in Gunnison County. One, adjacent to the Rocky Mountain Biological Laboratory at Gothic (2900 m, 9500 ft), is similar to the Teton site. It consists of a moist meadow containing thick stands of willows on an east-facing slope, bounded by spruce forests, the East River, and the cliffs of Gothic Mountain. The second, Pioneer Resort (2700 m, 8800 ft), is less open than either the Gothic or Teton sites, but the flora is similar.

Description of Life Stages

Measurements of the head, spines, and body for the different instars are given in Table 1.

Egg. Nearly spherical; rounded base with sides sloping in to flattened top. Approximately 22 longitudinal ridges which extend most of distance down from apex, with irregular pitting on base; horizontal striations between ridges (Comstock, 1940). Color yellow-green when first oviposited (see Egg Development for color changes). Diameter 0.78 ± 0.02 mm (n = 11) and height 0.86 ± 0.04 mm (n = 11) (eggmass shown in Fig. 1a).

First Instar Larva. Head blackish brown with few thin, colorless setae. Body pale greenish yellow with colorless setae arising from 12 longitudinal rows of brown papillae. Appearance is of a pale body spotted with brown. Spiracles brown. Anal prolegs darker than other prolegs, which are concolorous with body; true legs brown (Fig. 1b).

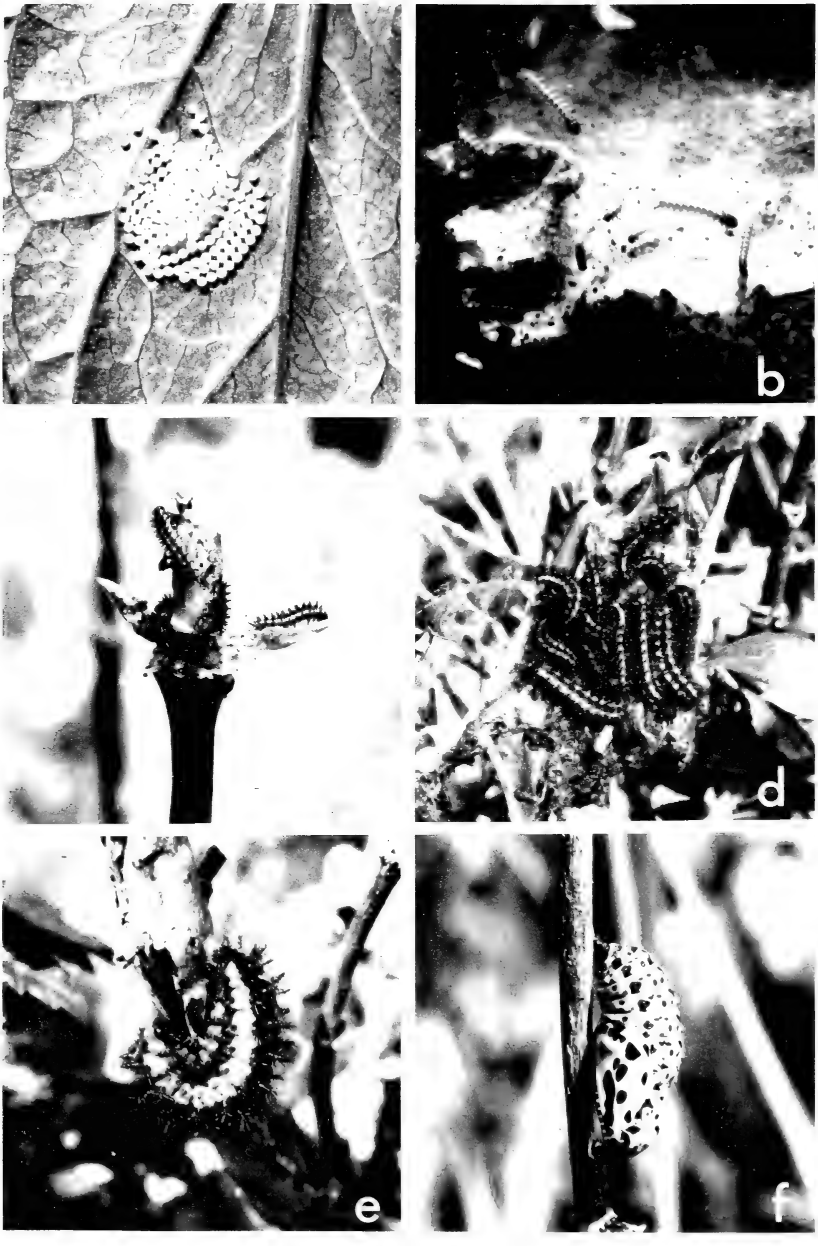

FIG. 1. Life stages of *Euphydryas gillettii*: **a**, egg mass; **b**, first and second instars (prediapause); **c**, third instars (postdiapause); **d**, fourth instars (postdiapause); **e**, sixth instar prepupa; **f**, pupa.

Second Instar Larva. Head blackish brown with black setae. Body developing characteristic banding pattern of later instars: dorsal band pale yellow; dorsolateral band brown and irregular; lateral (stigmatal) band dull white; ventrolateral band light brown; and ventral band cream colored. Spiracles blackish brown. True legs brown. Crochets black; anal prolegs brown on outside. Branching spines develop from papillae and simple seta of first instar; shafts of spines light brown with black setae. Rows of spines as follows: one mid-dorsal in dorsal band; two in dorsolateral band, more dorsal row positioned caudal to second, and second on edge of next band; one row in lateral band; and two rows of small spines or tubercles adjacent to each other in ventrolateral band. Spines developed on all thoracic and abdominal segments, with exception of first and third rows, which are missing from thoracic segments (Fig. 1b).

Third Instar Larva. Head capsule black with black setae. Body has same banding pattern of previous instar, but with deeper colors. Ventral band with thin mid-ventral brown line. Prolegs yellow with black crochets; anal prolegs dark brown on outside. Spiracles black. Shafts of spines blackish brown on all rows except mid-dorsal row, in which shafts are yellow-brown (Fig. 1c).

Fourth Instar Larva. Banding pattern further developed with greater contrast: dorsal band lemon yellow; dorsolateral band blackish brown with brown bases to spines; lateral band white with black spiracles; ventrolateral band brown; ventral band pale yellow with brown mid-ventral stripe. True legs black; prolegs yellow with brown bases and black crochets, and anal prolegs mostly black on outside. Shafts of all spines black, though with ring of lighter color at base of each, with yellow on light colored bands and brown on darker ones (Fig. 1d).

Fifth Instar Larva. Colors and patterns as in previous instar, with following exceptions: dorsal stripe bright lemon yellow, dorsolateral band black, spines and setae jet black, and all prolegs yellow but dark on outside.

Sixth Instar Larva. Continued development of previous banding pattern, with sharper contrast between bands. Midventral line blackish brown.

Prepupa. Slight discoloration of last instar, with some shortening and thickening (Fig. 1e).

Pupa. Ground color cream with black markings. Orange markings also occur except on wing cases; they are concentrated on abdominal segments, where there are seven orange warts per segment. Pupae average 16 mm long (Fig. 1f).

Adult. Head and thorax black; abdomen black above and somewhat lighter underneath. Palpi and legs concolorous with distinctive brownish orange color of postmedian band (this color is closest to the reddish orange of color 7B7 in Kornerup and Wanscher, 1978; it is nearly identical to the orange-rufous, color II-11i, of Ridgway, 1912). Antennae black with thin white rings and with yellowish clubs. Dominant color of dorsal wing surface black; veins black; marginal band of orange and submarginal band of white much reduced, often disappearing in secondaries; postmedian band crossing both wings, 3–4 mm wide, and prominent; median spot band white and reduced, disappearing by anal margin; discal cell of primaries with four alternating spots of white and characteristic orange-rufous color, with another spot of each color in postcellular space; secondaries with three spots of each color in cell and postcellular space; basal area black. Underwings with same patterning as above, but black color reduced and spots expanded; this is especially true on secondaries in median to basal area, where there is great expansion of orange-rufous color and where black is limited to borders of spots. Males smaller than females, with forewing length 16.5 to 23 mm (mean = 20.9, n = 162); for females, forewing length 20.0 to 25.5 mm (mean = 23.7, n = 199) (Fig. 2b).

Ecology

Oviposition. As reported by Comstock (1940), the larval host is *Lonicera involucrata* (Rich.) Banks (Caprifoliaceae), a shrub 0.5 to 3 m tall that grows in moist soil in thickets and wooded areas throughout the geographical range of *E. gillettii* and far beyond (e.g., California, Mexico, Alaska, and Quebec). The leaves are glabrous, short-petiolate, elliptic-oblong to elliptic-obovate in shape, and 5–14 cm long and 2–8 cm wide (Hitchcock et al., 1959). Thus, the leaves are large enough to allow females to move completely to the underside of the leaves when ovipositing. Some authors (e.g., Tietz, 1972) have listed other larval foodplants, but eggs on or oviposition behavior near any plant other than *L. involucrata* is extremely rare. Of more than 600 egg masses seen in the Beartooth population, only four have been found on a plant other than *L. involucrata*; these occurred in 1982 on an unusually large and conspicuous specimen of *Valeriana occidentalis* Heller (Valerianaceae, a family related to the Caprifoliaceae). Post-diapause larvae may wander to other species of plants, however.

Female *E. gillettii* oviposit mostly in late morning. Prior to oviposition they fly slowly above the shrub and herbaceous layer, fluttering near or touching branches that are among the most apparent (highest or densest). They do not appear to follow vegetational edges. While searching for oviposition sites, they occasionally touch plants other than *Lonicera,* but then they usually fly on within 2 sec.

Once a female does find *L. involucrata,* she flutters near the shrub, lands on a leaf, walks on it for a few seconds, and then flutters in the air, landing on the same or a different leaf. This process continues for 1 to 30 minutes, and even when she is blown or chased from the shrub, she returns to the same leaf or to one quite near it. She gradually increases the time spent on one leaf, walking up and down the dorsal surface near the leaf midrib, repeatedly opening and closing her wings, and occasionally moving entirely to the underside of the leaf. After the female backs over or flips sideways to the underside of the leaf, there is an initial quiescent period of a minute or two which generally precedes oviposition. Sometimes she may return to the upper surface after remaining quiescent for a brief time, walk around the leaf again, and perhaps even move to another leaf. When she finally begins ovipositing, she remains motionless with the wings usually held open (Fig. 2b). Oviposition behavior of *E. gillettii* is quite similar to that described for *E. phaeton* (Stamp, 1982). Females appear to spend much time and effort assessing the potential oviposition site; individual females have been observed to spend more than two hours in the above behaviors before actually beginning to oviposit.

The leaves chosen for oviposition are always large and near the top of a growing stem. In the Beartooth population, 51% of the egg masses were on the highest leaf pair and 36% on the next highest leaf pair (2 years, n = 453). Only one of 456 egg masses was found on the upper surface of a leaf, and only 7 of the 62 eggs from that egg mass hatched, while 30 were dislodged. The chosen leaves may or may not have other

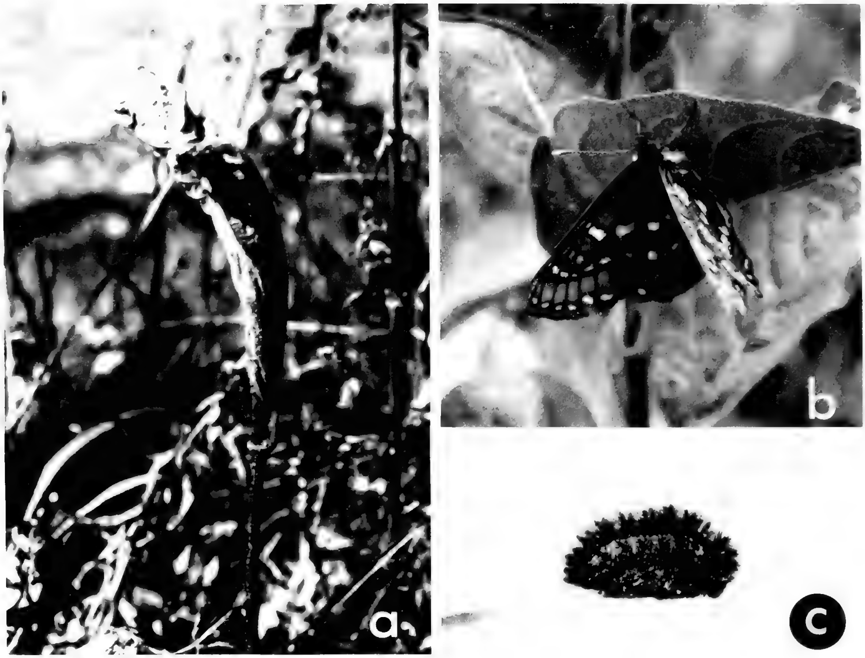

FIG. 2. *Euphydryas gillettii*: **a**, prediapause feeding web, which becomes the hibernaculum; **b**, ovipositing female; **c**, parasitized fifth instar prior to emergence of the parasitoid.

egg clusters already on them; in the Beartooth population, 44% (n = 456) of all egg masses were on leaves that had another egg mass on the same leaf (23% of all leaves with eggs, n = 332), resulting in a mean of 1.37 clusters per leaf. Egg masses are also clumped in *E. phaeton* (Stamp, 1982).

Approximately one-half of all egg clusters touch the leaf midrib. An ovipositing female faces the edge of the leaf and, while moving her abdomen back and forth, touches the lower leaf surface with the tip of the abdomen. If she then touches the midrib or another protruding leaf vein, she may use it as a guide in oviposition. Often she will use a previous egg mass as a guide. She lays the eggs row by row in both directions, and sometimes a second layer or more is oviposited upon the first. The far edge of the egg mass averages 2.0 cm from the edge of the leaf and the near edge 1.1 cm (n = 52), a distance which reflects the length of the body (roughly 1.6 cm).

In the Beartooth population, egg clusters have ranged in size from 23 to 310 eggs (n = 72), with a mean of 146 (Fig. 1a). In the Teton population, the average size over a three year period was 130 eggs per mass (n = 189), while in Colorado the average was 128 eggs per mass. In contrast, the egg masses of *E. editha* contain 45 eggs on average (Labine, 1968), while those of *E. phaeton* contain 274 (Stamp, 1982). Oviposition in *E. gillettii* proceeds at an average of 3.8 eggs per minute (n = 48 clusters), requiring 38 min to lay an average sized cluster; *E. editha* oviposits at a slower rate, needing 30 min to produce its smaller cluster (Labine, 1968). Based on observations of 150 marked female *E. gillettii* seen to display pre-oviposition behaviors or to oviposit at least once, none oviposited more frequently than every other day.

Egg Development. During the course of development in the Beartooth population, a mean of 13% of the eggs (n = 48 clusters) are lost from the egg mass due to dislodgement or detachment (19 eggs from a 146 egg average). Sometimes the edge of an egg mass peels away from a leaf, but most egg loss occurs where the eggs are more than one layer deep. The variance in egg loss per cluster is high, however, and most clusters lose few eggs. Presumably those eggs which detach from the leaves and fall to the moist, shady, predator-infested soil surface below do not hatch.

In Colorado, up to 30% of the egg masses are lost entirely during the developmental period due to heavy predation. Furthermore, few egg masses escape without some predation; losses of roughly 10 to 20% of the eggs in a mass are common. The predators are the same for the eggs as they are for the larvae: erythraid mites, myrid bugs, beetle larvae, and browsing mammals, the latter including moose and cattle.

The eggs change color during development from a pale straw-yellow when first oviposited, sometimes with a greenish tint, to a distinct gold, and then to darkening shades of red-brown. They become blue-gray about two days before hatching, a color which results from the formation of a dark head capsule beneath the white translucent egg shell.

The eggs hatch from July into September, while the snow begins falling in late August in these mountainous areas. Eggs hatch in 23 to 45 days in the Beartooth population, depending on the exposure of the oviposition site. In Colorado, the majority of the eggs hatch in 18–30 days, although those masses that are produced late in the season develop more slowly. Eggs at the center of the egg mass are the first to hatch, and most eggs hatch within a two day time span (Williams, 1981). A substantial fraction of the eggs, roughly 20% in the Beartooth population, hatch in early September after the leaves of *L. involucrata* have begun to wilt and turn yellow.

Prediapause Larvae. Newly emerged larvae feed partially on the egg shells, and within 24 hours they migrate to the upper surface of the leaf, where they begin forming a communal feeding web (Fig. 1b).

The oviposition leaf is the first feeding site and is the base of the web; it curls inwards and is bound ever more tightly as time passes. Prediapause larvae feed only on the epidermis and parenchyma of the leaves, leaving behind the patterned network of veins. Feeding occurs during the day; nocturnal feeding has not been observed. Gradually more leaves are added to the feeding web by binding lower leaf pairs to the first leaf. In this way the communal web grows larger, sometimes with the incidental binding of grasses and other leaves that are adjacent to the hostplant leaves. The "knots" (Scudder, 1889) thus formed are quite apparent in the field since they generally occur at the apices of the most conspicuous stems (Fig. 2a). Because different egg masses are often oviposited on the same or adjacent leaves, the larvae in a single feeding web may be the products of several different egg masses, even when these egg masses hatch on different dates.

Mortality is high during the prediapause period. Parasitic wasps identified as *Benjaminia* sp. (N. Stamp, pers. comm.) have been collected from the feeding webs, and the above-mentioned predators take a heavy toll. At least 80% of the larvae in the Beartooth population disappear before reaching winter diapause, while 50–60% of the Colorado larvae die or disappear.

Most, if not all, of the larvae that result from a single egg mass remain in the same feeding web overwinter. Though these hibernacula are well attached to the woody stems of the shrubs, most are dislodged by winter snow.

Unlike the larvae of other well-studied *Euphydryas*, which diapause in the fourth instar, *E. gillettii* are apparently able to overwinter in response to environmental conditions as second, third, or fourth instars. For instance, the Beartooth colony, constrained by the rapid onset of winter at the end of the flight period, diapauses (first winter) in the second instar. In Colorado, where the two sites differ markedly in the length of both the larval and the food-plant growing season, the populations diapause at different instars even though they originated from the same parent colony in the Tetons. Like the original population, the larvae at 2440 m in Colorado reach the fourth instar, while at 2920 m they appear to overwinter successfully after the first molt but develop to the fourth instar given a sufficiently long summer (Holdren and Ehrlich, 1981). Overwintering larvae may pass through an extra molt before emergence, as occurs in *E. editha* (M. Singer, pers. comm.).

Postdiapause Larvae. In Colorado and Wyoming the larvae terminate diapause soon after the snow melts, which in most years is late May at 2440 m (8000 ft) and mid-June at 2920 m (9600 ft). The larvae feed on newly formed buds of *L. involucrata*, boring holes into the larger apical buds and consuming entirely the smaller axillary buds

(Fig. 1c). By the time the larvae have molted into the fifth instar in the annual populations, the leaves are slightly expanded, measuring roughly 2 cm in length. In postdiapause fourth instars in the biennial population, the larvae may still feed in aggregations (Fig. 1d) on relatively large and well developed leaves. Although many postdiapause larvae feed on shrubs bearing the previous year's webs, like other *Euphydryas* species, some disperse. Extensive, characteristic feeding damage as well as postdiapause larvae have been observed on isolated *L. involucrata* shrubs on which there had been no prediapause larvae. In the Beartooth population, some postdiapause larvae have been found feeding on *Castilleja linariaefolia* Benth. (Scrophulariaceae), *Valeriana occidentalis* Heller (Valerianaceae) and *Pedicularis bracteosa* Benth. (Scrophulariaceae). All of these plants have iridoid glycosides, secondary compounds known from the host plants of other *Euphydryas* (Bowers, 1981).

Diapause-related and postdiapause mortality appear to be quite high in Colorado. The number of postdiapause larvae found is consistently much smaller, by as much as two orders of magnitude, than the number of large third instars observed shortly before diapause. Both postdiapause larvae and pupae may be parasitized, the latter in Colorado by the hymenopteran *Ptermalus vanessae* Howard, which oviposits into mature larvae or pupae. Parasitized larvae in the Beartooth population cease feeding and movement in the fifth instar (Fig. 2c), and the *Benjaminia* parasitoid then emerges three to four weeks later.

Most, if not all, larvae in the Beartooth population return to diapause for a second winter before pupating; they spend the first winter in the second instar and the second in the fifth instar. The second diapause apparently is not obligate, but the shortness of the growing season in this habitat has led at least part of the population into a two-year life span; Williams (1981) has demonstrated another adaptation in this population for the cold climate, that of ovipositing so that the eggs are warmed maximally by the sun. A biennial life cycle has also been reported for *Euphydryas maturna* (Forster and Wohlfahrt, 1955), a close, European relative of *E. gillettii*.

Larvae generally move away from the host shrubs for pupation (Figs. 1e & 1f), and the pupation sites are usually within 50 cm of the ground. While distinctive in color and pattern, the pupae are not easily found. Pupation requires about three weeks.

Adults. The adults fly during a four week period from June to mid-August. As is typical for butterflies (Wiklund and Fagerstrom, 1977), males are the earliest to emerge and show the greatest wing wear early in the season, and the male to female ratio declines gradually through the flight season (Williams, in prep.). Males also fly earlier in the morning than females and in relatively greater numbers on cloudy days. Males are much stronger fliers; though smaller (in accord with Singer, 1982), they fly at faster speeds, are more difficult to catch, and are more difficult to manipulate when netted.

These butterflies spend much of the day sunning near the ends of branches high in coniferous trees, typically with the wings open slightly more than 180 degrees. Males fly back and forth through the habitat more than females, while females fly down to nectar more frequently. Occasional individuals puddle in the afternoon when other activity is reduced. Nights are spent in trees at heights of at least 3 m.

Mating is rarely observed because of the predilection of this species for the tops of nearby conifers. Chases of individuals near tree tops are common during the middle of the day, with males chasing both females and other males. It remains curious, though, that males infrequently chase females while females nectar in the herbaceous layer.

The butterflies do not have to move far to nectar. There is a profusion of flowers in the *E. gillettii* habitat, largely because it is moist, and they feed readily at the available blossoms. The commonest nectar source for the Wyoming populations is a white geranium, *Geranium richardsonii* Fischer and Trautvetter (Geraniaceae), which is also used in Colorado where the most important source is probably *Erigeron peregrinus* (Pursh) Greene (Compositae). After senescence of the primary nectar source, *E. gillettii* in Wyoming turns readily to yellow composites, mostly several tall *Senecio* which begin blooming as the *Geranium* cease. Given the abundance of flowers and the relatively limited time spent nectaring, adult food resources would not seem to be a major limiting factor in the population dynamics of this species.

DISCUSSION

Euphydryas gillettii was originally described and placed in the genus *Melitaea* by Barnes (1897) from material collected in Yellowstone National Park, Wyoming; *M. glacialis* (Skinner, 1921) is a synonym. Gunder (1929), in his reorganization of North American *Euphydryas*, recognized the relationship of *E. gillettii* to the other *Euphydryas* species and pointed out that it is likely the most primitive of the North American species. L. G. Higgins (1978) then revised the genus *Euphydryas* and placed *E. gillettii* in a new genus, *Hypodryas*, along with the Palearctic species *E. maturna*, *E. intermedia*, *E. eduna*, and *E. cynthia*. Phenetically, *E. gillettii* seems most closely related with those species, although comparison of early stages and allozyme frequencies would clearly be desirable.

Following good taxonomic practice we have not accepted *Hypodryas* as a genus; obligatory categories—genera, families, etc.—should be kept conservative to facilitate communication (Ehrlich and Murphy, 1982). *Hypodryas* could be considered as synonymous with "the *maturna* species group" or, at most, a subgenus. *Euphydryas* is a phenetically quite uniform group. Because the genus is now so widely discussed in the non-lepidopterological literature, we would not suggest any change in the widely accepted generic name.

Of current interest in the study of butterflies is whether or not the prior presence of eggs influences where a female lays her eggs. In several species—*Battus philenor* (Rausher, 1979), *Pieris brassicae* (Rothschild and Schoonhoven, 1977), and *Anthocharis sara* (Shapiro, 1980)—active egg load assessment is indicated, and in all of these cases females avoid ovipositing where eggs currently are or recently have been. Female *E. gillettii* rarely avoid leaves that already have eggs; moreover, the egg clusters are grouped together more than one would expect if they were distributed in the environment at random (Williams, 1981). The same is apparently true of *E. phaeton* (Stamp, 1982). Though there has been no previous support for positive egg load assessment, the grouping of eggs or egg clusters together may further enhance survivorship of larvae if there is a selective reason, such as predator avoidance or thermoregulation, for grouping the eggs together initially. Stamp (1981, 1982) has considered reasons for such a grouping, though in her experiments, *E. phaeton* suffered increased parasitism when the groupings were too large. Because the larvae from different clusters of *E. gillettii* eggs do mix freely in communal feeding webs, the contagious distribution of clusters may be adaptive.

E. gillettii displays sedentary behavior and occurs in localized colonies with few populations known; these characteristics, along with the ease with which individuals may be caught, indicate that it could easily suffer from excessive human impact. How threatened the species may be is unknown, largely because it occurs in undisturbed mountain habitat, but much reduction in numbers in any one place could lead to the extinction of local colonies. Those who find a population in the field should exercise discretion when collecting, especially with females.

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CORRECT NAME FOR THE NEOTROPICAL SQUASH-VINE BORER (SESIIDAE: *MELITTIA*)

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AND

THOMAS D. EICHLIN[2]

ABSTRACT. The identity of the species of squash-vine borer occurring in Central and South America on cultivated Cucurbitaceae is established as *Melittia pulchripes*, not *M. satyriniformis*, which is a junior synonym of the Eastern squash-vine borer, *M. cucurbitae*. A lectotype is designated for *M. riograndensis*, a name which is then synonymized under *M. pulchripes*.

For more than a century the *Melittia* species whose larvae are commonly found boring in stems of many cultivated species of Cucurbitaceae in Central and South America has been referred to in the literature as *M. satyriniformis* Hübner. In a study by Duckworth and Eichlin (1973) it was found that in the Western Hemisphere these borers belong to a complex of three closely related species: *cucurbitae* (Harris), *satyriniformis* Hübner, and a third which they described and named *calabaza*. According to these authors (1973:154), the three species of the complex are easily distinguished by their external features and genitalia. A fourth species, *pauper* LeCerf, apparently occurs only in the vicinity of Lima, Peru. Both *cucurbitae* and *calabaza* are restricted to the United States and Mexico and are sympatric in the southern part of their range. The species distributed from Guatemala through Central and South America was regarded by them as *satyriniformis*, following the use of earlier authors.

Heppner and Duckworth (1981:26) established that *satyriniformis* is a junior synonym of *cucurbitae*. This was based mainly on the fact that Hübner stated that the type locality of *satyriniformis* was "Georgia" and therefore, must be conspecific with *cucurbitae*, the only squash-vine borer from the region.

We have examined the syntypes of *riograndensis* Brèthes (1920:284) and found that they are the same species as the Central and South American species previously and currently misnamed as *satyriniformis*. Two male syntypes of *riograndensis* were located in the Museo Argentino de Ciencias Naturalis (MACN), Buenos Aires, both bearing identical labels in Brèthes' hand-writing: "17"; "E. Ronna, vi. 1919, Pelotas"; "Type"; "Melittia riograndensis Breth."; (red rectangle). The

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male specimen which had been dissected is here designated as the lectotype; the second male becomes a paralectotype. These two specimens are covered by mold, and their external features are somewhat obscured; however, the genitalia are identical to those of *satyriniformis* (*sensu* authors, including Duckworth and Eichlin, 1973:fig. 3c), bearing the peculiar quadrate expanded process at the center of the valva. They also agree with the genitalia of a specimen reared by the senior author from stems of *Cucurbita* sp. at Turrialba, Costa Rica.

However, the oldest available name for this species is *Melittia pulchripes* Walker (1856:67). Syntypes in the British Museum (Natural History) were examined and a lectotype designated (Duckworth and Eichlin, 1978:21). At this time it was determined to be conspecific with the Central and South American squash-vine borer. The previous references to *satyriniformis* for the Neotropical squash-vine borer should in fact be applied to *pulchripes*. Also, *riograndensis* now becomes a synonym of *pulchripes* (NEW SYNONYMY).

The following is a summary of the species comprising the squash-vine borer complex:

Melittia cucurbitae (Harris)—eastern half of United States, Gulf Coastal areas of Texas and Mexico to near Guatemala.
Melittia calabaza Duckworth and Eichlin—Arizona, central and western Texas, interior areas of Mexico to west coast.
Melittia pulchripes Walker—Guatemala south throughout Central and South America to southern Brazil.
Melittia pauper LeCerf—currently recorded only from Peru.

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LIFE HISTORIES OF FOUR SPECIES OF *PHILIRIS* RÖBER (LEPIDOPTERA: LYCAENIDAE) FROM PAPUA NEW GUINEA

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ABSTRACT. The life histories of four species of *Philiris*, *P. helena* Snellen, *P. agatha* Grose-Smith, *P. intensa* Butler and *P. ziska* Grose-Smith, together with notes on their biologies, are described and illustrated.

Life histories of species of the genus *Philiris* Röber (Lycaenidae) from the Melanesian region have been little studied, but Forbes (1977) has recently detailed the life history of *P. moira* Grose-Smith from Papua New Guinea. Common and Waterhouse (1981) have briefly outlined the life history of *P. innotata* Miskin from Australia.

In the past, difficulty has been experienced with the placing of the correct females with the males of certain species of *Philiris*, but Sands (1979, 1980, 1981) has done much towards clarifying the taxonomy of the genus. The phyletic arrangement of all species, however, will remain unclear until the biologies of further species are known. It is hoped that the addition to the literature of four new *Philiris* life histories, and information about the morphology of their early stages, will assist in such a study. I am also preparing to describe the life histories of *Philiris harterti* Grose-Smith, *P. diana* Waterhouse & Lyell, *P. violetta* Röber, and *P. praeclara* Tite from Papua New Guinea, all of which feed on *Litsea* (Lauraceae).

Figs. 4 and 5 of the mature larva and pupa of *P. moira* are included here for ease of comparison. All life histories were studied from the Bulolo valley in the Morobe Province from approximately the center of the 10 km grid square reference DN50. The early stages of all species show remarkable camouflage against their foodplants. The duration of the life cycle of each species was about one month from egg to adult.

Philiris helena Snellen

Egg. Diameter 0.75 mm; white, spherical when viewed from above, oval from the side, ventrally flattened; micropylar pit surrounded by six smaller pits; egg honeycombed with larger, regular, ovoid pits, the walls of which are produced into long, outward curving spicules which shorten gradually towards median line.

Larva. First instar. 1.55 mm in length, 0.5 mm in width; oval and elongate in dorsal profile; head pale brown; body pale green, edged with pale yellow; hirsute, fringed with fine white setae.

Second instar. 3.5 mm by 1 mm; anterior end slightly wider; head pale brown; body pale green with white middorsal line, broken at each segment.

Third instar. 5 mm by 2 mm; similar to second but white middorsal line bordered with tan brown.

Fourth instar. 10 mm by 4.5 mm; similar to third but middorsal line pinkish brown pattern encircled by cream; body color pink where larva has been feeding on small, young, pink leaves of foodplant, otherwise pale green; setal fringe 1.5 mm in length.

Fifth instar. 16 mm by 6.5 mm; similar to fourth but middorsal line broader (3 mm), forming a diffuse pattern of four lines of white dashes; laterally this pattern is continued but is fainter (Figs. 2 and 6).

Pupa. 11 mm in length, 5 mm in width; oval from above, ventrally flattened; hirsute, covered by fine pubescence of soft, white setae; dimorphic depending on substrate color being either pale green or pale brown; abdomen greenish yellow dorsally with two pale green dorsolateral lines either side of wider green middorsal line which continues onto thoracic segments. Supported by cremaster and fine silk girdle (Fig. 7). Duration, 12 days.

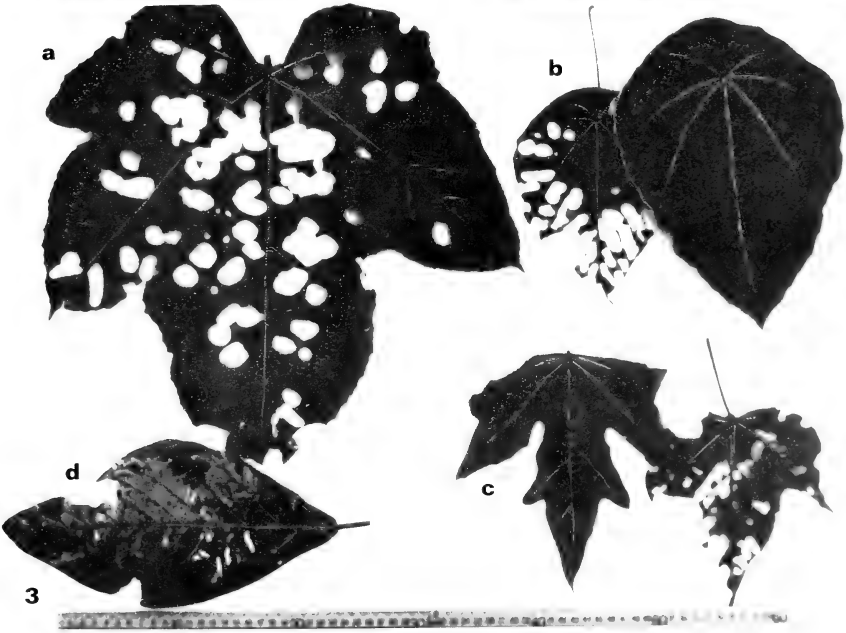
BIOLOGY. The foodplants are *Macaranga aleuritoides* F. Muell. and *M. quadriglandulosa* Warb. (Euphorbiaceae). Both species can grow up to 8 m in height. The leaves (Fig. 3) of both are broad and dark green. Those of *M. quadriglandulosa* are peltate, at the base (up to 35 mm in diameter) with a pointed tip and a serrated edge. Those of *M. aleuritoides* have five lobes are semipalmate and often grow to 70 mm in diameter. Both possess four to eight shiny, red, ovate glands on the upperside of the leaf bases which appear to be attractive to various species of ants. Gressitt and Nadkarni (1978, p. 114) mention that these extrafloral nectaries are also attractive to several families of flies. *M. quadriglandulosa* has a coarse felt-like covering of hairs on its leaves. The sap of both is sticky, clear and gelatinous. The foodplants are common throughout the Lae-Wau region in regrowth areas from sea level to 1200 m.

Adults of *P. helena* can often be seen in abundance where the foodplant grows. They rest on the upper surface of the leaves and may be frequently seen drinking on damp sand.

Eggs are usually laid single on the leaf petiole and adhere to the long, felty hairs (Fig. 1). The larvae when young eat only the lower epidermis, creating windows in the leaf. Later they eat many full holes (Fig. 3), skeletonizing the leaf with no more than the veins to hold its former shape. Ants are almost always present on the *Macaranga* foodplants, but their association with the *P. helena* larvae is minimal, and they seem more preoccupied with the plant glands.

Pupae are always attached to the old leaf bracts at the base of the main stem. If the bracts are dry and brown, then the pupae tend to be brown also. If the bracts are still pale green, then the papae are of the same color.

From a final instar larva of *P. helena* which was collected wild, a small tachinid fly emerged. The species appears to be prone to attack by these parasitoids because numerous mummified skins of final instar



FIGS. 1–3. *Philiris* early stages and feeding damage: **1**, egg of *P. helena* on petiole of *Macaranga aleuritoides*; **2**, eggs (above bract) and mature larva and empty pupal case of *P. helena* on bract of *M. aleuritoides*; **3**, damage to leaves of a) *M. aleuritoides*, b) *M. quadriglandulosa*, c) *M. involucrata*, d) *Ficus calopilina* (by *P. moira*).

larvae have been observed on the foodplants, each of which bore the ventral exit hole of a fly larva.

Philiris agatha Grose-Smith

Egg. Like that of *P. helena.*

Larva. The first three instars of *P. agatha* closely resemble those of *P. helena* but fourth instar pattern discernibly different. Larva of *P. agatha* slightly slimmer and more elongate than *P. helena.*

Fourth instar. 11 mm by 4 mm; head tan brown; body pale olive green; middorsal pattern bright white commencing from behind prothorax and composed of three parallel dashes on each segment which converge to form single broad line at anal end of larva; laterally, larva patterned with narrower parallel white lines; setal fringe 1.5 mm in length.

Fifth instar. 18 mm by 6 mm; similar to fourth (Fig. 8).

Pupa. 12 mm in length, 5 mm in width; hirsute, pale olive green, boldly patterned with white; prothorax with white, triangular markings above eyes; mesothorax with two broad white lines which curve around middorsal line; middorsal abdominal pattern composed of broad white dashes either side of midline; laterally abdomen bears single, broad, white, wavy line. Supported by cremaster and fine silk girdle (Fig. 9). Duration, 12 days.

BIOLOGY. The foodplant is *Macaranga involucrata* (Roxb.) Bail. (Euphorbiaceae), a tree which grows to 7 m in height. The leaves (Fig. 3) are variable in shape. They are either rounded or have three or five lobes, the central lobe being the longest. The leaves are covered with a fine white pubescence which makes them extremely soft and felt-like to the touch. They bear four small, often vestigial, glands on the leaf upperside near the petiole. The sap is clear, slightly sticky, and can have a strong camphor-like smell. It is a common plant of regrowth areas around the Bulolo valley.

Adults of *P. agatha* are less frequently seen than those of *P. helena* and may be classed as occasional in their habitat. They sometimes drink on damp sand and mud at creek margins and are very fast flying.

Eggs are usually laid on the underside of a small new leaf, or its petiole, at the apex of the foodplant. The larvae commence feeding on the young leaves. Then, as they grow, they move to feed on lower, older leaves. Leaf damage is shown in Fig. 3. No actual attendance of the larvae by ants was noted, although there were often brown tree ants on the foodplant.

The monomorphic pupae are invariably attached to the underside of a very young leaf (hardly larger than the pupa) at the apex of the foodplant. They match well the felty appearance and color of these leaves.

Philiris intensa Butler

Egg. Diameter 0.5 mm; white; hemispherical, with a regular covering of spicules.

Larva. First instar. 0.75 mm in length, 0.25 mm in width; oval in shape; head tan brown, lying well beneath prothorax; uniform greenish yellow; fringed with fine white setae.

Second instar. 3 mm by 1.5 mm; similar to first but with middorsal line patterned with reddish brown spots with dark green centers.

Third instar. 6 mm by 2.5 mm; similar to second but brown middorsal line broken centrally by two white spots.

Fourth instar. 8.5 mm by 3.5 mm; similar to third but spiracles white.

Fifth instar. 10 mm by 6.5 mm; similar to fourth but ground color darker green and matches that of leaf on which larva feeds; middorsal line of brown spots with white centers; setae fringe 1 mm in length, armed with prominent, outwardly directed barbs arranged in alternating rows along each hair (Fig. 10).

Pupa. 9 mm in length, 5 mm in width; smooth, not hirsute; apex of mesothorax with diffuse pattern of brown and white, ringed by olive green to edge of pale yellow wings; abdomen pale lime-green with brown and white middorsal pattern on segments 1–5; spiracles white, those on first abdominal segment encircled by brown spots. Supported by cremaster and fine silk girdle (Fig. 11). Duration 10 days.

BIOLOGY. The foodplant is *Pipturus argenteus* Willd. (Urticaceae), a common plant of creekside and regrowth areas, which grows to about 5 m tall. The leaves are pale to dark green and ovate with pointed tips and serrated edges. They average about 15–20 cm long and are felty to the touch. They are covered with minute white hairs. The small clusters of rounded, dimpled, opaque white fruit are gelatinous and are borne in alternating rows along fruit stalks.

Adults of *P. intensa* are commonly seen near the foodplant, and males are especially fond of drinking on damp sand.

Eggs are laid singly on the leaf underside, usually near the base. At all stages larvae eat the upper epidermis of the leaf and leave a characteristic long, narrow feeding trail of a meshwork of small veins. On occasion they were attended by small brown ants.

Pupation is always on the upperside of a large or small leaf of the foodplant and along the main vein just before it joins the petiole.

A small (8 mm long) orange ichneumonid wasp parasitoid was reared from a wild collected pupa.

Philiris ziska Grose-Smith

Egg. Diameter 0.55 mm; pale bluish-white, hemispherical with regular covering of spicules.

Larva. First instar. 0.75 mm in length, 0.25 mm in width; oval in shape; head tan brown, lying well beneath prothorax; uniform pale yellow; fringed with fine white setae.

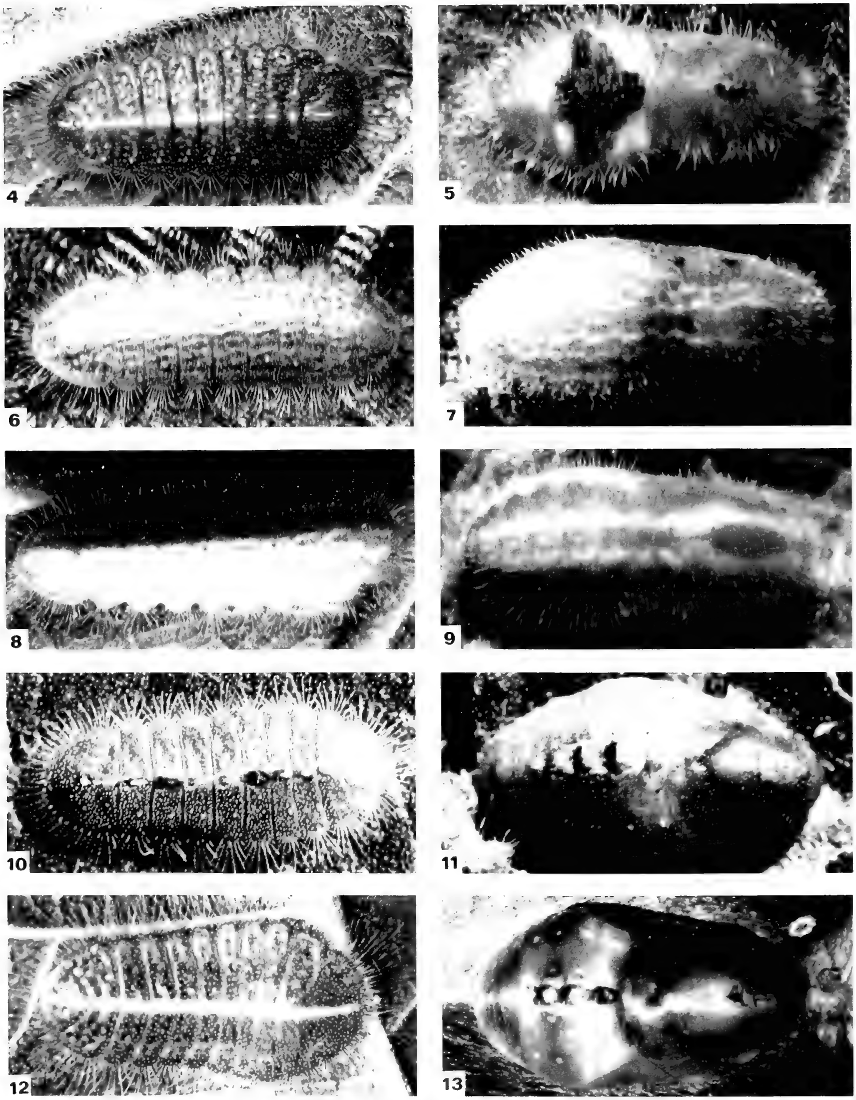
Second instar. 3 mm by 1.5 mm; similar to first but color straw-yellow; dorsal vessel shows as dark green middorsal line; middorsal line white, not extending onto thoracic or anal segments; four orange-red spots laterally, two at center of body and two on penultimate abdominal segment.

Third instar. 5 mm by 2.5 mm; similar to second but color greenish yellow with lateral spots brown; middorsal line extends along entire abdomen; setal fringe 0.55 mm in length.

Fourth instar. 8 mm by 4 mm, greatest width being at metathorax; dark green, paling to edges; middorsal line wholly white, or with pattern of brownish purple spots, three centrally and one on penultimate abdominal segment.

Fifth instar. 12 mm by 6 mm; dark green; middorsal line creamy white, along entire body length; setal fringe 2 mm in length (Fig. 12).

Pupa. 9 mm in length, 5 mm in width; similar to *P. intensa*; smooth, not hirsute; dark



FIGS. 4–13. *Philiris* spp., larvae and pupae: **4 & 5,** *P. moira*; **6 & 7,** *P. helena*; **8 & 9,** *P. agatha*; **10 & 11,** *P. intensa*; **12 & 13,** *P. ziska*.

green with middorsal pattern of chocolate-brown flecks on white on abdominal segments 1–4; same pattern repeated at apex of mesothorax and both areas surrounded by pale yellow; spiracles white. Supported by cremaster and fine silk girdle (Fig. 13). Duration, 12 days.

BIOLOGY. The foodplant is *Malaisia scandens* (Lour.) Bl. (Moraceae) which grows to about 5 m tall and is common along creeksides or road verges around Bulolo (altitude 700 m). Young leaves are soft and pale green. Old leaves are dark green and extremely brittle to the touch. They are ovate and may reach a length of 150 mm. The tree is a sprawling species which sends out long adventitious shoots. The small fruits are soft and red and are borne in many clusters along the branches.

Adults of *P. ziska* are often fairly common where the foodplant grows, especially alongside creeks.

Eggs are laid anywhere on the underside of new or old leaves, sometimes five on a leaf. The newly emerged larva eats the top of the egg and leaves a white ring of shell which remains attached to the leaf. At all stages the larvae feed on the lower epidermis of the leaf and leave the upper epidermis as windows of tissue. They will not accept any other related plant species. The larval ground color is a perfect mimic of a vein. They were seen to be attended by small brown ants.

Pupation is always on the upperside of the leaf along the mid-vein just before it joins the petiole. Up to 12 pupae have been found dispersed throughout one branch. The ground color is a perfect match of that of the leaf, and the brown markings edged with yellow resemble blemishes that are typically found on the leaves of various moraceous tree species.

P. ziska appears to be prone to attack by small, black chalcid wasp parasitoids. For example, one larva collected in its fourth instar ceased feeding and two 2 mm-long wasp larvae emerged to spin their cocoons beneath it before the larva died. Some pupae found had also died from what appeared to be a fungal disease.

DISCUSSION

A number of adults of each species have been reared and compared with material in the British Museum (Natural History) collection. In all cases males and females compared favorably with the pairings presented in the collection (as figured by D'Abrera, 1977). Representatives of each species have been placed in the collection of the Insect Farming and Trading Agency in Bulolo.

Comparison of the early stages, especially the morphology of the pupae, shows that *P. helena* and *P. agatha* are closely related as are *P. ziska* and *P. intensa*. The pupa of *P. moira* resembles more the latter pair than those of *P. helena* or *P. agatha* but is very distinct in that it is prominently hirsute, not smooth as in *P. ziska* and *P. intensa*, and its maculation is different. It is very similar to that of *P. innotata* and also that of *P. kapaura* Tite. Pupae of the latter species I have found attached to saplings of a species of fig with large (500 mm diameter), hirsute leaves. Therefore, *P. moira, P. innotata* and *P. kapaura* form a closely related group of species. The similarities between the larval morphologies and foodplant relations of *P. ziska, P. intensa* and *P. moira* (together with *P. innotata* and *P. kapaura*), however, suggest that these butterflies may also belong to the same species group. Females of *P. moira* are virtually indistinguishable from those of *P. ziska*.

It is noteworthy that I have found *P. moira* larvae feeding on *Ficus semivestita* Corner (Moraceae), near Bulolo, as well as *Ficus calopilina* Diels. The latter is the foodplant recorded for the species by Forbes (1977).

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COURTSHIP BEHAVIOR OF THE GULF FRITILLARY, *AGRAULIS VANILLAE* (NYMPHALIDAE)

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ABSTRACT. The courtship behavior of the Gulf Fritillary, *Agraulis vanillae* L., is described from motion picture records of successful and unsuccessful courtships between free-flying males and tethered virgin females. During most but not all courtships the male performs a previously undescribed wing clap display in which he alights next to the female and repeatedly claps his wings together, often catching the female's antenna between his wings during each clap. In the discussion it is suggested that this display presents chemicals signals to the female and has evolved in response to female choice for males that clearly announce their species identity to the female.

In recent years substantial literature has developed concerning the behavior and ecology of the heliconiine butterflies (for review: Brown, 1981). Surprisingly, only two papers (Crane, 1955; Gilbert, 1976) have dealt specifically with the mating behavior of heliconiines in spite of a growing amount of information on the nutritious materials passed by males to females during copulation and the female's use of these materials in oogenesis (Boggs and Gilbert, 1979; Boggs, 1981). The only courtship description per se for a heliconiine is to be found in Crane's paper on *Heliconius erato* Hewitson. Information on courtship behavior is essential in any attempt to evaluate the selective consequences of inter- and intra-specific variation in male's abilities to produce accessory gland secretions during copulation (Rutowski et al., 1983).

The following study expands our knowledge of the behavior of heliconiines by describing the courtship of a member of this subfamily that is common in the southern United States, the Gulf Fritillary (*Agraulis vanillae* Linnaeus). Particular attention during this study was directed at describing a previously unreported display performed by *A. vanillae* males and its role in successful courtship. The discussion will focus on the potential functions of this unique display.

METHODS

Observations were made on a population of *A. vanillae* in suburban Tempe, Arizona. Preliminary studies in the spring of 1980 led to intensive study from March to June in 1981. From about 0800 h to 1600 h, adults of *A. vanillae* frequently visit *Lantana* spp. (adult nectar source) and *Passiflora* spp. (larval foodplant). Virgin females were obtained from larvae and eggs collected on *Passiflora* spp. either in the field or in cages in the laboratory. Larvae were reared to adulthood in translucent plastic shoeboxes (9 × 16 × 30 cm) on cuttings of *Passiflora*. The shoeboxes were kept near a window which exposed the larvae to a normal light-dark regime. Temperature and humidity were not controlled.

To observe courtship, newly emerged, virgin females no more than four to five days old (most were one day old) were tethered (for technique: Rutowski, 1978) and placed on a conspicuous perch on a *Passiflora* plant. Usuaully within a few minutes, passing males approached and courted the female. Courtships, both successful and unsuccessful, were filmed at 24 and 70 frames per sec with a Beaulieu 4008 ZM 2 super-8 movie camera.

RESULTS

Successful Courtship

By separating males and females immediately after coupling, twenty-five successful courtships (leading to copulation) were filmed using ten females. No single female was used to film more than three courtships. Of these 25 courtships, one involved two males and so, was disregarded, leaving 24 for the detailed analysis that gave rise to the description that follows.

Courtship began when either the male alit next to the female or the female began a flutter response as the male approached. Both were often preceded by a brief period during which the male hovered about 15 cm over the female before descending and initiating physical contact. Once the male alit he positioned himself with his wings open, his head close to that of the female, and the long axis of his body forming about a 45 degree angle with that of the female (Fig. 1). Once in this position the male began what will hereafter be referred to as the **wing clap display**. During this display the male's body remained in position but he repeatedly clapped his wings shut and then quickly reopened them. Between claps the wings were opened to about 90 degrees relative to one another. It was typical that in the position assumed by the male, the female's antenna on the side next to the male was laid back between the male's wings and was caught between them during each clap. During wing clapping and in some instances even before the male alit, the male's claspers were visibly spread. Just as, or before, the male ceased clapping his wings he began probing by curling his abdomen toward the female's hindwings and attempting to insert its tip up between her closed wings. Coupling occurred between the female's hindwings where its occurrence could not be closely monitored. However, it is assumed that either when it occurred or shortly thereafter the male became still briefly before he began slowly waving his wings and moving to a position facing away from the female while still

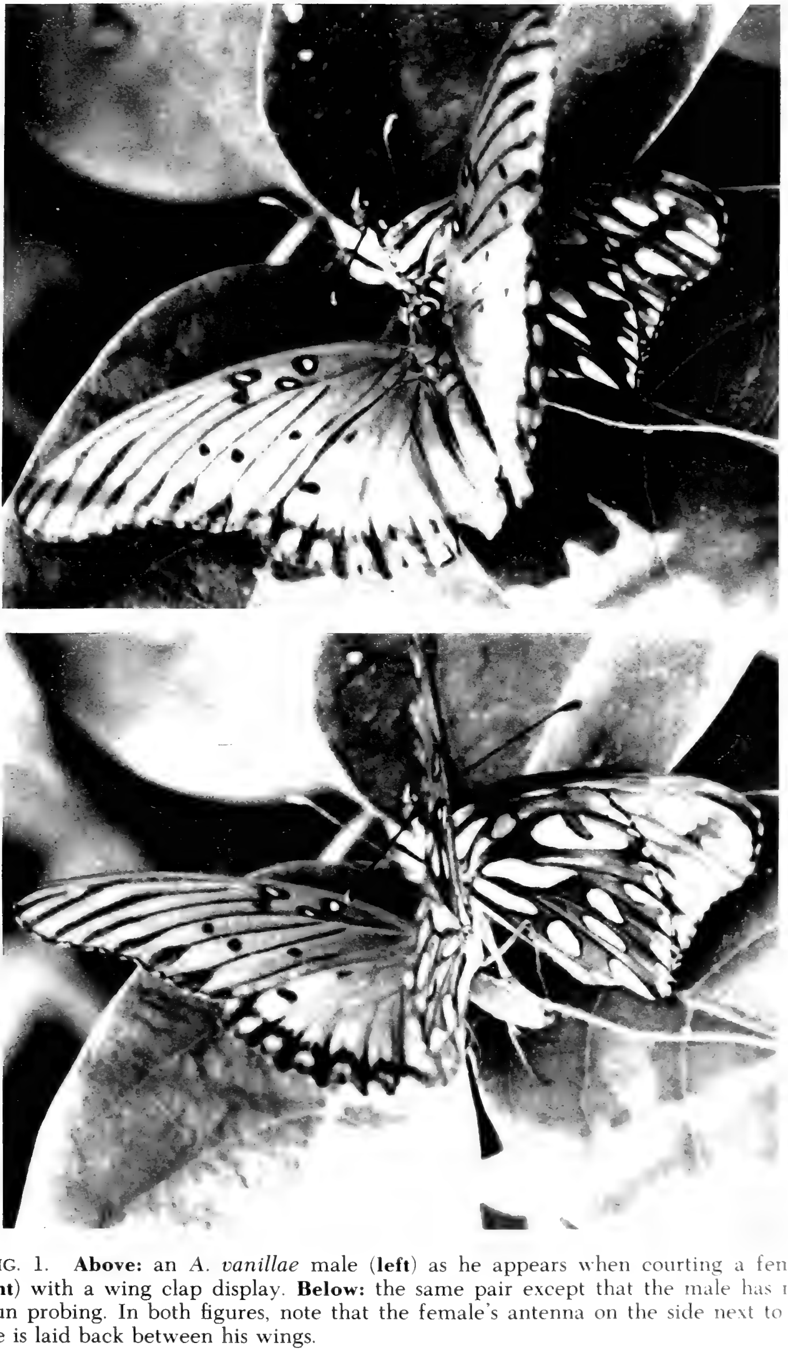

FIG. 1. **Above:** an *A. vanillae* male (**left**) as he appears when courting a female (**right**) with a wing clap display. **Below:** the same pair except that the male has now begun probing. In both figures, note that the female's antenna on the side next to the male is laid back between his wings.

TABLE 1. Temporal structure of successful courtship in *Agraulis vanillae.*

	Time event occurs before end of courtship					
	Courtships with wing clap display			Courtships without wing clap display		
Event	$\bar{x}$ ± SD (s)	range (sec)	n	$\bar{x}$ ± SD (s)	range (sec)	n
First contact by ♂	10.9 ± 5.1	2.7–23.6	17	8.04 ± 3.67	5.43–15.3	6
Last contact by ♂	8.1 ± 3.92	2.29–15.8	17	5.18 ± 2.17	1.8–7.46	6
♂ begins wing clap display	7.53 ± 4.1	1.92–15.8	17	—	—	—
♂ begins probing	3.53 ± 3.13	0.5–13.0	14	2.97 ± 1.46	1.46–5.53	5
♂ ends wing clap display	2.8 ± 2.86	0.37–12.8	17	—	—	—
♂ stops moving	0			0		

coupled. Wing waving often evolved directly into strong wing flapping by the male in an effort to initiate a post-nuptial flight.

This sequence of events was observed in 14 of the 24 courtships filmed. In another three records the male broke contact with the perch and alit again at least once but no more than twice. In one case the male performed a bout of probing while perched the first time. After alighting a final time, all of these males performed wing claps before probing.

A more striking variant of the courtships described above was observed in seven courtships in which the wing clap display was completely omitted. In these cases the male simply began probing immediately after alighting for the last time as they did in some of the courtships with wing claps but in these cases the males were successful. Hence, the wing clap display is not a requisite part of successful courtship.

Females opened and closed or fluttered their wings in only eight of the 24 courtships. In six of these the female performed a single flutter before or at the time of first contact by the male. If the male made repeated contact each contact often elicited a single flutter. Twice flutters were observed during the wing clap display and twice after the male had become still. Fluttering in immediate response to male contact was observed in three of the seven courtships in which males did not wing clap.

The temporal structure of courtships in which the male performed a wing clap display is shown in Table 1. In these summaries, there are some courtships in which the first contact was also the last; hence, some data points were used in the summaries for both events. Also, for convenience and summary purposes, we regarded the last time the male initiated probing as the time when the male began probing. This was not true of three courtships. The sample size of the summary of

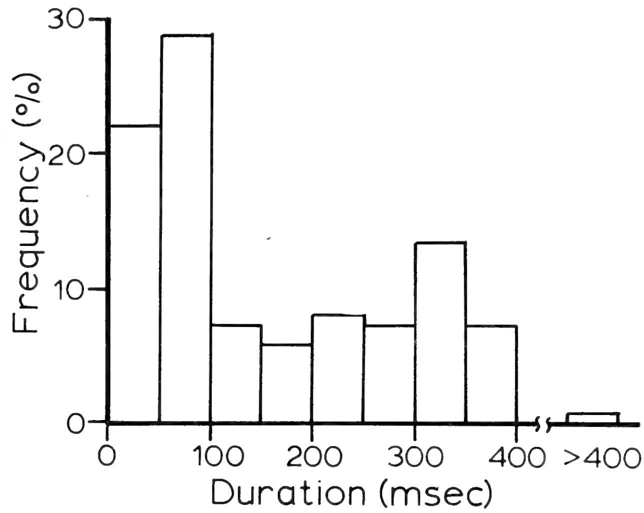

FIG. 2. The frequency distribution of duration for 132 wing claps. See text for details.

this event is less than that for the other events because in three cases the angle of filming did not permit viewing of the beginning of probing.

Courtships with the wing clap display have an average duration of about 11 sec and wing clapping begins within a second after the male alights for the last time. Probing usually began in the second before the display ended and slow wing waving followed coupling within 2 sec.

Table 1 also summarizes the temporal structure of courtships in which the male did not perform a wing clap display. The sample size for some events is less than seven, either because the film record began after the event occurred or because the filming angle prohibited viewing the event. Statistical comparisons of the time of occurrence of events held in common between the courtships with and without the wing clap display revealed that none of the differences were significant. In particular, neither the time of first contact nor the time of last contact differed from one type of courtship to the next. Factors contributing to this lack of differences were the high variances associated with the times of occurrence and the small sample sizes for courtships without the wing clap display.

The average duration of the wing clap display was 4.73 ± 3.34 sec ($n = 17$). Fig. 2 shows the average duration of each clap from the time the wings start to close from their spread position until they start to close for the next clap. The data are taken from 132 wing claps performed in five displays of 6, 12, 16, 41, and 57 claps, respectively, and filmed at 70 frames per sec. The histogram shows a mild but distinct bimodality. This reflects the fact that during the display the temporal patterning of the claps may take one of three forms: (1) a series of long claps, (2) a series of short claps, and (3) a series of alternating long and short claps. From the films we also measured that, regardless of overall clap duration, the wings were closed an average of 26.4 ± 9.37 msec ($n = 127$). Hence, the difference in duration between long and short claps is due primarily to a difference between them in the time the wings are open.

Most courtships were filmed at 24 frames per sec which made counting of individual wing claps difficult; thus, we were unable to obtain a good average for the number of wing claps per courtship. However, using a mean wing clap display duration of 4.73 sec and an average of 165 msec per clap, it may be estimated that in the typical courtship the male performs about 30 wing claps.

Unsuccessful Courtships

Courtships that did not lead to copulation were studied in less detail than those that lead to copulation. This was because unsuccessful courtships were more variable and difficult to characterize. In addition many of the film records of unsuccessful courtship were incomplete. However, 20 complete records were obtained and are summarized here. In five of these courtships the male contacted the female and hovered over her briefly before departing. In the other 15 the male alit next to the female at least once during the courtship. Of the males that alit, four departed without performing a wing clap display while the other 11 performed the display at some point in the courtship. Two males actually probed before wing clapping while three did not begin probing until they had wing clapped for some time. The other six males left the female after wing clapping without probing. During these courtships the females either did nothing (10 cases), fluttered the wings (8 cases), or assumed a posture like the pierid mate refusal posture (Obara, 1964) with the wings spread and the abdomen held perpendicular to the plane of the wings (2 cases). When females fluttered or spread their wings it could be seen that the pair of glands associated with the tergites at the end of the abdomen were periodically everted. Whether or not this occurs when the wings are closed was not determined.

In summary, courtship terminated before coupling either because the male left before an attempt (males did not probe in 16 cases) or because the female did not behave in a way that permitted coupling (4 cases).

DISCUSSION

The wing clap display performed by males of *Agraulis vanillae* is clearly an important part of successful courtship. Its form is reminiscent of displays performed by males of some other nymphalids. The male of the grayling (*Hipparchia* (=*Eumenis*) *semele* Linnaeus) after alighting next to a perched female moves so that he is face to face with the female and, by rocking forward with the wings open, catches the female's antennae between his forewings. The male then closes his wings and rocks gently back, drawing the female's antennae across patches of scent scales on the male's forewings (Tinbergen et al., 1942). During the courtship of the great spangled fritillary (*Speyeria cybele* Fabricius), the male assumes a position perched next to the female like that seen in *A. vanillae*, and "at intervals he would suddenly open and close his wings" (Clark, 1932:110). The interval between these openings and closings becomes less as the courtship progresses. Magnus (1950) reports that males of the fritillary (*Argynnis paphia* Linnaeus) when perched alongside and facing a female, clap their wings in such a way that the female's head and antennae are caught between them. In *Heliconius erato*, the closest relative of *A. vanillae* that has been carefully studied, the male persists in flapping his wings after alighting and while moving into position for coupling (Crane, 1955). Perhaps this behavior was the one from which the wing clapping display of *A. vanillae* was evolutionarily derived.

Indications are that the wing clapping display is involved in presenting chemical signals to the female. Obviously, the male's position behind and to the side of the female is poor for presentation of visual stimuli, and the fact that the female's antenna is between the male's forewings during the display suggests that the display is designed to deliver a chemical signal. This conclusion is reinforced by the observation that androconia that are likely to be scent-producing are found on the dorsal surface of the male's forewings along several of the veins (M_1, M_2, M_3, Cu_1, Cu_2, 2A; Muller, 1877). In addition there are large apparently glandular structures associated with the internal faces of the claspers that might produce a chemical signal. The claspers are often spread or opened during most of the courtship. Experiments are planned to determine the roles of these structures in the courtship behavior of *A. vanillae*.

Rutowski (1983) has recently discussed the selection pressures that have led to the evolution of species-specific male courtship displays in butterflies. A similar analysis of the courtship of *A. vanillae* suggests that selection for signals that announce the species identity of the male to the female has been of particular importance. The nutrient investment of *A. vanillae* males and the general ecology and behavior of this species is not so different from that of the other species of butterflies as to suggest that they led to the evolution of the wing clapping display (Rutowski et al., 1983). In addition, although *A. vanillae* females may occasionally approach and chase males as observed in other species (Crane, 1955; Rutowski, 1980; Rutowski et al., 1981; Wiklund, 1982), it does not seem that problems of sexual discrimination for females are any more severe than they are in *Heliconius erato,* which like *A. vanillae,* is essentially sexually monomorphic with respect to visual characters but whose courtship lacks the wing clap display (Crane, 1955).

Species discrimination would seem, however, to pose a potential problem for *A. vanillae* females. A field guide to the butterflies of North America (Pyle, 1981) reveals that there are at least eight butterflies sympatric with *A. vanillae* that are very similar in color and markings. These species include *Danaus gilippus* Cramer, *D. plexippus* Linnaeus, *Dryas julia* Fabricius, *Marpesia petreus* Cramer, *Limenitis archippus* Cramer, *Dione moneta* Hübner, *Anaea floridalis* Johnson and Comstock, and *A. andria* Scudder. Given that an *A. vanillae* female is likely to be approached and courted by males of any of these species, selection might favor those females that prefer conspecific males that perform a display or offer a signal clearly indicative of their species identity. While it is known that the danaids have their own unique male courtship behavior (hairpencilling: Brower et al., 1965; Pliske, 1975) the other species are not behaviorally well-known enough to assess the extent to which their courtships are different from that of *A. vanillae.*

A final question about the wing clap display concerns the fact that it is not performed in all successful courtships like the wing spread display sometimes performed by males of the pierid, *Nathalis iole* Boisduval (Rutowski, 1981(83)). Why do some females accept a male without the performance of the display? Obviously, females vary in receptivity, and some will accept males without the display. These may be males with such potent chemical signals that they are able to satisfactorily stimulate the female without the display. In any event it seems from both successful and unsuccessful courtships that males will attempt copulation without wing clapping, which in turn suggests that the display has certain costs for males. Just what these costs are or might be is currently not clear (although, see: Burk, 1982).

ACKNOWLEDGMENTS

Thanks to Michael Boppré for showing us the location of androconia in *A. vanillae,* to Mark Newton for assistance in filming courtship, and to the National Science Foundation for financial support (Grant No. BNS 80-14120).

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CHECKLIST OF MANITOBA BUTTERFLIES (RHOPALOCERA)

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ABSTRACT. A list of butterflies (*Rhopalocera*) occurring in Manitoba is compiled from records of resident and non-resident collectors, published literature, museums, university collections and the author's collection.

It has been forty years since the last published checklist of Manitoba butterflies (*Rhopalocera*) by G. Shirley Brooks in "A Revised Check List of the Butterflies of Manitoba" (1942). Since that list is out-dated and not readily available, the present list has been prepared, including a number of species not previously recorded.

Many parts of Manitoba have been collected very sparingly, and I am afraid the habitat will be destroyed before these areas have been studied. There is very little virgin prairie left in this province, and some of that is not accessible to collectors. Some species in this habitat are threatened. Most of the province, however, is largely undeveloped, and there are large tracts of virgin forests, marshes, bogs, taiga and tundra untouched by the bulldozer. This will hopefully remain so for a long time.

It is hoped that this checklist will encourage more study of the fascinating butterfly fauna of Manitoba. Any comments and criticism of this list and the notes following it will be appreciated.

The sequence of taxa follows the order of the Miller and Brown Catalogue/Checklist (1981), and the species are numbered accordingly.

DISTRIBUTION

Most of Manitoba is covered by boreal forest including many lakes, rivers and bogs. The southern part, especially toward the west, consists of grasslands changing to an aspen parkland region farther north. The area bordering the coast of Hudson Bay contains some tundra.

For practical reasons the following definitions are used:

FN = Far North. An area just southwest of Hudson Bay. Here Churchill and vicinity have been collected quite intensively and most far north records are from here.

N = North. Northern third of the province excepting the far north. This area consists of boreal forest with make lakes, rivers and bogs. Not much collecting has been done in this area.

NW = Northwest. The western half of "N".

NE = Northeast. The eastern half of "N".

C = Central. The middle third of the province running north and south. Geographically this area is like the north. Very little collecting has been done here.

WC = West Central. The western half of "C".

EC = East Central. The eastern half of "C".

S = South. The southern third of the province.

SW = Southwest. The western half of "S". This area consists of dry prairie in the southwest turning to moist prairie farther north and east. A large part of this is in the parkland or transition zone and is broken up by the Turtle Mountain in the extreme south and the Riding and Duck Mountains to the north. Lake Manitoba is east of Riding Mountain. Most of this area is agricultural land with very little virgin prairie left.

SE = Southeast. The eastern half of "S". This area consists of boreal forest in the north, mixed forest farther south with moist prairie along the Red River valley. The southern end of Lake Winnipeg is included in this area. Most of the prairie is now in agriculture.

G = General Distribution. Covers the whole province.

Note: Only those areas for which there are actual records of butterflies have been listed. Some species probably cover a much larger area than is indicated in the checklist below.

CHECKLIST OF MANITOBA BUTTERFLIES (RHOPALOCERA)

Hesperiidae Latreille

Epargyreus Hübner	
clarus clarus (Cramer)—S, C	7a.
Thorybes Scudder	
pylades (Scudder)—G (except FN)	48.
Erynnis Schrank	
icelus (Scudder & Burgess)—G (except FN)	83.
brizo brizo (Boisduval & Leconte)—S, C	84a.
juvenalis juvenalis (Fabricius)—S	85a.
martialis (Scudder)—SE	92.
lucilius (Scudder & Burgess)—S	96.
persius persius (Scudder)—SW, NE, FN	99a.
Pyrgus Hübner	
centaureae freija (Warren)—SE, WC, N, FN	100a.
communis (Grote)—S	104.
Pholisora Scudder	
catullus (Fabricius)—S	115.
Carterocephalus Lederer	
palaemon mandan (Edwards)—S, C	120a.
Ancyloxypha	
numitor (Fabricius)—S, C	142.
Oarisma Scudder	
poweshiek (Parker)—S	144.
garita (Reakirt)—S	145.
Thymelicus Hübner	
lineola (Ochsenheimer)—SE	150.
Hesperia Fabricius	
uncas uncas Edwards—SW	156a.
comma assiniboia (Lyman)—S	158b.
c. borealis Lindsey—NE, FN	158d.
ottoe Edwards—S	160.
leonardus Harris—SE	161.
pawnee Dodge—SW	162.
dacotae (Skinner)—S	169.
sassacus manitoboides (Fletcher)—SE	171b.
nevada (Scudder)—SW	173.

Polites Scudder	
coras (Cramer)—S	174.
themistocles (Latreille)—S	179.
mystic dacotah (Edwards)—S, WC	181b.
Atrytone Scudder	
logan lagus (Edwards)—SW	189b.
Poanes Scudder	
hobomok (Harris)—S	197.
Euphyes Scudder	
ruricola metacomet (Harris)—S, C	217b.
Atrytonopsis Godman	
hianna hianna (Scudder)—S	219a.
Amblyscirtes Scudder	
hegon (Scudder)—SE	235.
vialis (Edwards)—S	245.
Papilionidae Latreille	
Papilio Linnaeus	
polyxenes asterius Stoll—SE	303a.
bairdii Edwards—SW	308.
kahli F. & R. Chermock—SW	306.
machaon hudsonianus Clark—SW, WC, N	310b.
cresphontes Cramer—S	314.
glaucus canadensis Rothchild & Jordan—G	320b.
troilus troilus Linnaeus—SE(?)	325a.
Pieridae Duponchel	
Pieris Schrank	
protodice Boisduval & Leconte—S	334.
occidentalis occidentalis Reakirt—S, FN	335a.
napi oleracea Harris—G	336d.
rapae (Linnaeus)—S, FN	338.
Euchloe Hübner	
ausonides mayi F. & R. Chermock—G	341c.
olympia (Edwards)—SW	344.
Colias Fabricius	
philodice philodice Godart—S, C	351a.
eurytheme Boisduval—S, FN	352.
alexandra christina Edwards—SW, WC	355e.
hecla hela Strecker—FN	357b.
boothii Curtis—FN	358.
nastes moina Strecker—FN	360c.
gigantea gigantea Strecker—FN	362a.
g. mayi F. & R. Chermock—SW	362c.
pelidne pelidne Boisduval & Leconte—FN	363a.
interior interior Scudder—S, WC	364a.
palaeno chippewa Edwards—FN	365a.
cesonia (Stoll)—SW	368a.
Eurema Hübner	
mexicana (Boisduval)—SW	380.
Nathalis Boisduval	
iole Boisduval—S	389.
Lycaenidae Leach	
Feniseca Grote	
tarquinius tarquinius (Fabricius)—S	391a.
Lycaena Fabricius	
xanthoides dione (Scudder)—S	395b.

hyllus (Cramer)—S	398.
epixanthe michiganensis Rawson—SE	402b.
dorcas dorcas Kirby—G	403a.
helloides (Boisduval)—S	404.
Harkenclenus dos Passos	
titus titus (Fabricius)—S	417a.
Satyrium Scudder	
acadica acadica (Edwards)—SE	420a.
a. watrini (Dufrane)—SW	420d.
edwardsii (Grote & Robinson)—S	423.
calanus falacer (Godart)—S	424b.
liparops fletcheri (Mitchener & dos Passos)—S	427c.
Incisalia Scudder	
augustus augustus (Kirby)—S, C, N	464a.
polios polios Cook & Watson—S, C, N	466a.
henrici henrici (Grote & Robinson)—SE	468a.
niphon clarki Freeman—S, C	470b.
eryphon eryphon (Boisduval)—N	471a.
Strymon Hübner	
melinus humuli (Harris)—S	478b.
Everes Hübner	
comyntas comyntas (Godart)—S, C	503a.
amyntula albrighti Clench—SW, WC, N, FN	504c.
Celastrina Tutt	
ladon lucia (Kirby)—G (except FN)	505b.
l. argentata (Fletcher)—SW	505c.
Glaucopsyche Scudder	
lygdamus couperi Grote—G (except FN)	514b.
l. afra (Edwards)—SW	514c.
Plebejus Kluk	
Argyrognomon scudderii (Edwards)—SW, WC, FN	516e.
a. nabokovi Masters—SE	516l.
melissa melissa (Edwards)—SW	517b.
m. samuelis Nabokov—SE	517a.
saepiolus amica (Edwards)—G	518a.
optilete yukona (Holland)—C, N, FN	525a.
franklinii franklinii (Curtis)—FN	526a.
f. lacustris (Freeman)—C, N	526b.
f. rustica (Edwards)—S	526e.

Heliconiidae Swainson

Agraulis Boisduval & Leconte	
vanillae incarnata (Riley)—SW	555b.

Nymphalidae Swainson

Euptoieta Doubleday	
claudia (Cramer)—S	562.
Speyeria Scudder	
cybele pseudocarpenteri (F. & R. Chermock)—S	565d.
aphrodite aphrodite (Fabricius)—SE	566a.
a. manitoba (F. & R. Chermock)—S	566d.
idalia (Drury)—S	567.
edwardsii (Reakirt)—SW	569.
callippe calgariana (McDunnough)—S	572p.
atlantis atlantis (Edwards)—SE	574a.
a. hollandi (F. & R. Chermock)—S, WC	574c.

a. dennisi dos Passos & Grey—SW	574u.
mormonia eurynome (Edwards)—SW	576i.
Boloria Moore	
eunomia dawsoni (Barnes & McDunnough)—G	578c.
selene atrocostalis (Huard)—S, WC, FN	579f.
bellona bellona (Fabricius)—S, WC, N	580a.
frigga saga (Staudinger)—G	581a.
improba improba (Butler)—FN	582a.
polaris stellata Masters—FN	585b.
freija freija (Thunberg)—G	586a.
titania boisduvalii (Duponchel)—FN	589a.
t. grandis (Barnes & McDunnough)—G (except FN)	589c.
chariclea arctica (Zetterstedt)—N	590a.
Chlosyne Butler	
gorgone carlota (Reakirt)—S	605b.
nycteis nycteis (Doubleday)—S	606a.
n. reversa (F. & R. Chermock)—SW	606c.
harrisii harrisii (Scudder)—S	607a.
h. hanhami (Fletcher)—S, WC	607c.
Phyciodes Hübner	
tharos tharos (Drury)—G	623b.
batesii (Reakirt)—S, C	624.
Euphydryas Scudder	
phaeton phaeton (Drury)—SE	635a.
Polygonia Hübner	
interrogationis (Fabricius)—S	636.
comma (Harris)—S	637.
satyrus neomarsayas dos Passos—S	638b.
faunus faunus (Edwards)—S, WC	639a.
gracilis (Grote & Robinson)—N, FN	643.
progne (Cramer)—S, N, FN	645.
Nymphalis Kluk	
vau-album j-album (Boisduval & Leconte)—S	646a.
californica californica (Boisduval)—S	647a.
antiopa antiopa (Linnaeus)—G	648a.
milberti milberti (Godart)—S, WC, FN	649b.
Vanessa Fabricius	
virginiensis (Drury)—S, FN	650.
cardui (Linnaeus)—S, WC, FN	651.
atalanta rubria (Fruhstorfer)—S, C, N	653a.
Junonia Hübner	
coenia Hübner—S	656.
Limenitis Fabricius	
arthemis arthemis (Drury)—SE	663a.
s. rubrofasciata (Barnes & McDunnough)—S, C	663b.
archippus archippus (Cramer)—S, WC	664a.

Satyridae Boisduval

Lethe Hübner	
anthedon Clark—S	711.
eurydice eurydice (Johansson)—S	713a.
Euptychia Hübner	
cymela cymela (Cramer)—S, C	723a.
Coenonympha Hübner	
inornata inornata Edwards—SW, C	728d.
i. benjamini McDunnough—S	728e.

Cercyonis Scudder	
pegala olympus (Edwards)—S	732e.
Erebia Dalman	
rossi ornata Leussler—FN	737a.
disa mancinus Doubleday & Hewitson—G	738a.
discoidalis discoidalis (Kirby)—G	741a.
theano sofia Strecker—FN	742a.
epipsodea freemani Ehrlich—SW, WC	744b.
Neominois Scudder	
ridingsii ridingsii (Edwards)—SW	748a.
Oeneis Hübner	
macounii (Edwards)—S	751.
chryxus calais (Scudder)—C	752b.
uhleri varuna (Edwards)—SW	753a.
alberta alberta Elwes—S	754a.
bore ssp.—FN	756.
jutta ascerta Masters & Sorensen—SE	757b.
j. ridingiana F. & R. Chermock—SW, WC	757c.
j. harperi Chermock—N, FN	757d.
melissa semplei Holland—FN	758c.
polixenes polixenes (Fabricius)—FN	759a.

Danaidae Duponchel

Danaus Kluk	
plexippus (Linnaeus)—S, WC	760.

NOTES

C. palaemon mandan—Type-locality—"Lake Winnipeg", restricted to Pine Ridge by F. M. Brown and L. Miller, is common in most wooded areas of southern Manitoba.

T. lineola, first recorded from Manitoba in the early 1970's, is now firmly established in Winnipeg and east of there (Preston and Westwood, 1981).

H. comma borealis from Churchill, should perhaps have another subspecific name.

P. asterius polyxenes is rare in southeastern Manitoba.

P. kahli—Type-locality—"Riding Mtns., Man.", is found mostly in the Riding Mountain and Duck Mountain area, but some are found as far east as the Red River. There seems to be some intergradation between this and the latter species and *P. machaon*.

E. ausonides mayi—Type-locality—"Riding Mtns., Manitoba".

C. hecla hela—Type-locality—"above Fort Churchill".

C. nastes moina—Type-locality—"above Fort Churchill".

C. g. gigantea—Type-locality—"west coast of Hudson Bay above Fort York".

C. g. mayi—Type-locality—"Riding Mtns., Manitoba".

L. d. dorcas—Type-locality—"Lat. 54°", restricted to The Pas, Manitoba, by Ferris.

H. t. titus—In southwestern Manitoba some specimens perhaps belong to *immaculosus*.

S. a. acadica flies in the southeast and *watrini* in the southwest.

S. liparops fletcheri—Type-locality—"Manitoba".

C. ladon argentata—Type-locality—"Cartwright, Manitoba", flies in southwestern Manitoba, while *lucia* is found in most of the rest of the province.

G. lygdamus afra—Type-locality—"Deer River country", restricted to vic. Brandon, Man. by F. M. Brown, flies in southwestern Manitoba with *couperi* in the rest of the province. They are quite hard to tell apart as they are variable in size and in the ventral spots and color.

P. argyrognomon scudderii—Type-locality—"Lake Winnipeg, Manitoba", flies in western Manitoba. The bands of submarginal orange lunules, both ventral and dorsal, are on the average more complete than in *nabokovi* which is found in the southeastern part of the province. The subspecies are very variable and so difficult to tell apart.

P. m. melissa flies in south and central Manitoba with *samuelis* in the southeastern corner.

P. f. franklinii is found in the Churchill area.

P. f. lacustris—Type-locality—"Norway House", is in central Manitoba.

P. f. rustica occurs in southern Manitoba.

S. aphrodite manitoba—Type-locality—"Sand Ridge", which is east of Riding Mountain. These formerly went under the name of *mayae* and occupy most of southern Manitoba. *S. a. aphrodite* is in the extreme southeast.

S. a. atlantis is sometimes found in the extreme southeast.

S. a. hollandi—Type-locality—"Riding Mtns., Manitoba", flies in most of southern Manitoba.

S. a. dennisi—Type-locality—"Beulah, Manitoba", closely resembles *lais* from Saskatchewan. It was known by that name for some time. It probably intergrades with that subspecies. In the Riding Mountain area, *hollandi* flies in the wetter areas and *dennisi* in the drier, more open areas, but adults feed at flowers in the same places. Should these belong to different species?

B. polaris stellata—Type-locality—"Churchill, Manitoba", flies in the Churchill area in odd-numbered years.

B. titania grandis flies in southern and central Manitoba.

B. t. boisduvalii from the north is abundant at Churchill.

C. nycteis reversa—Type-locality—"Riding Mountains, Manitoba", refers to most specimens from Manitoba, however some are like subspecies *nycteis* in facies.

C. harrisii hanhami—Type-locality—"Bird Hill, near Winnipeg, Manitoba", flies in southern Manitoba. There seems to be some intergradation with the subspecies *harrisii*, as some specimens are like the ones from Ontario in facies.

L. arthemis rubrofasciata—Type-locality—"Manitoba, Saskatchewan, Alberta", is common in southern Manitoba with some *arthemis* found in the eastern part, where they intergrade.

L. eurydice, formerly known as *transmontana* in this area, is quite distinct as the ground color very pale, almost white in some specimens, as compared to the dark specimens found in eastern Ontario.

C. i. inornata—Type-locality—"Lake Winnipeg", emended to "Saskatchewan River between Lake Winnipeg and The Pas, Man.", by F. M. Brown, flies mostly in the parklands area and *benjamini* on the prairies in southern Manitoba. *C. ochracea* probably does not fly in the province.

E. rossii ornata—Type-locality—"Churchill", is abundant in the Churchill area most years.

E. theano sofia—Type-locality—"Fort Churchill, Manitoba" was formerly known as *canadensis*, is locally common at Churchill most years.

O. bore ssp., flies at Churchill in even-numbered years. It is quite rare most years, but locally more common, in some. It is quite variable and has a darker ground color than bore *hanburyi* from Baker Lake, N. W. Territories, Canada.

O. jutta ascerta flies in eastern Manitoba. It is dark and the orange bands are less developed or even lacking in some males. It is found in the odd-numbered years with the rare exception.

O. j. ridingiana—Type-locality—"Riding Mountains, Manitoba", is found mostly in even-numbered years in western Manitoba, but some fly every year. The orange bands are well developed.

O. j. harperi—Type-locality—"Gillam, Manitoba", is a little smaller than the two preceding subspecies. It is quite variable with the orange bands in some females well developed to faint in others. It resembles *alaskensis*. It is common at Churchill every year.

Some butterflies have, over a number of years, been taken very rarely in Manitoba. The following are probably strays from the south: *P. cresphontes, P. t. troilus, C. cesonia, E. mexicana, N. iole, A. vanillae, S. idalia* and *N. californica*.

There are also some species that, although rare, apparently breed in the province. Some of these may be seen to be more common after the areas have been more extensively collected. Here is a list of these: *P. catullus, O. poweshiek, H. ottoe, H. dacotae, H. nevada, A. logan, P. bairdii, E. olympia, L. epixanthe, I. eryphon, S. melinus, S. edwardsii, S. callippe, E. phaeton, P. gracilis, J. coenia* and *N. ridinsii.*

A small number have been included that maybe should be deleted from the list. *Papilio bairdii* is included based on records from Beulah and Birtle and records of *bairdii oregonia* from Beulah. The author suspects that these may be misidentified specimens of *machaon* or *kahli.* The latter is quite variable. *C. boothii, C. pelidne* and *B. improba* have been recorded from "north Manitoba". *C. boothii* and *B. improba* could occur northwest of Churchill and *C. pelidne* could be found east of there. *B. chariclea* is recorded from Kettle Rapids. Formerly *Boloria titania* from Manitoba were called *chariclea titania.* As there is no proven reason to the contrary, the above specimens are all included in the checklist.

The following species, included in older lists, have been deleted: *H. comma manitoba,* no records for Manitoba.

P. zelicaon probably does not occur in the province. The records possibly refer to *machaon* or forms of *kahli.*

E. ausonides coloradensis is supposed to fly in southeastern Manitoba. I cannot see any difference between the *mayi,* type-locality, "Riding Mtns., Man.", and the *ausonides* from the rest of the province.

P. zephyrus recorded from Aweme and Beulah probably were misidentified *Polygonia.*

S. cypris = ethene and *S. a. columbia* included in older lists probably are *S. a. manitoba,* which they closely resemble.

S. lais, included in old lists flies in Saskatchewan and Alberta and intergrades with *dennisi* in Manitoba.

S. calanus calanus recorded as *calanus* is deleted as the subspecies that flies in the province is *falacer.*

S. heathii, also omited, because it is an aberration of the latter.

S. liparops strigosa does not occur in the province. Although some specimens of *fletcheri* from Manitoba closely resemble *strigosa* with no orange spots on the fore-wings, these occur in the same populations together with specimens having orange patches covering one-half of the front wings. This subspecies is very variable.

Mitoura spinetorum probably does not fly in Manitoba.

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THE LIFE HISTORY AND BEHAVIOR OF *EPIMARTYRIA PARDELLA* (MICROPTERIGIDAE)

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ABSTRACT. Adults of *Epimartyria pardella* (Walsm.) are rather sessile and exhibit a clumped distributional pattern. Moths are active during the day and usually closely associated with liverworts. Larvae from eggs deposited in the lab feed on liverworts. There are three larval instars and in captivity 1.75 years were spent in the larval stage. Collection of wild larvae suggest that 2 years are also required to complete development under natural conditions.

The family Micropterigidae is recognized as the most primitive group of Lepidoptera known. The adult moths are the only Lepidoptera with functional mandibles which they use for feeding on pollen. Micropterigidae are aglossate, jugate moths whose closest relatives are believed to be the Heterobathmiidae. Chapman (1917) and Hinton (1946) placed the Micropterigidae in their own order, the Zeugloptera, because of the primitive characters the larvae express, but Common (1970), Kristensen (1971) and Richards and Davies (1959) treated the Zeugloptera as a suborder of Lepidoptera. Fossil micropterigids in lower Cretaceous amber indicate that relatively little change has occurred in the group during the last 135 million years (Whalley, 1977, 1978).

In the United States this unique suborder is represented by the new world genus *Epimartyria* Walsm. (1898) that consists of two species. A great deal of work has been done on the systematics and evolutionary status of the micropterygids (Hinton, 1958; Common, 1975; Heath, 1976; Whalley, 1978; Kristensen and Nielsen, 1979), but observations dealing with their behavior and habitat are for the most part lacking. In this paper, information is presented on the biology and habitat of *Epimartyria pardella* (Walsm.).

The type series of *E. pardella* consists of five specimens which were collected near the coast in southern Oregon during early June 1872. The description that Walsingham (1880) published is brief and accompanied by a color illustration. The moth (Fig. 1) has a wingspan of 10 to 11 mm. The forewing is metallic brown with three distinctive gold spots, while the hind wings are only metallic brown. The fringe of both

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fore and hindwings is yellow and brown. The abdomen and thorax are gray-brown; the legs and a portion of the head are golden yellow. From the head to the posterior tip of the abdomen the moth measures just under 3.5 mm.

Last Instar Larva

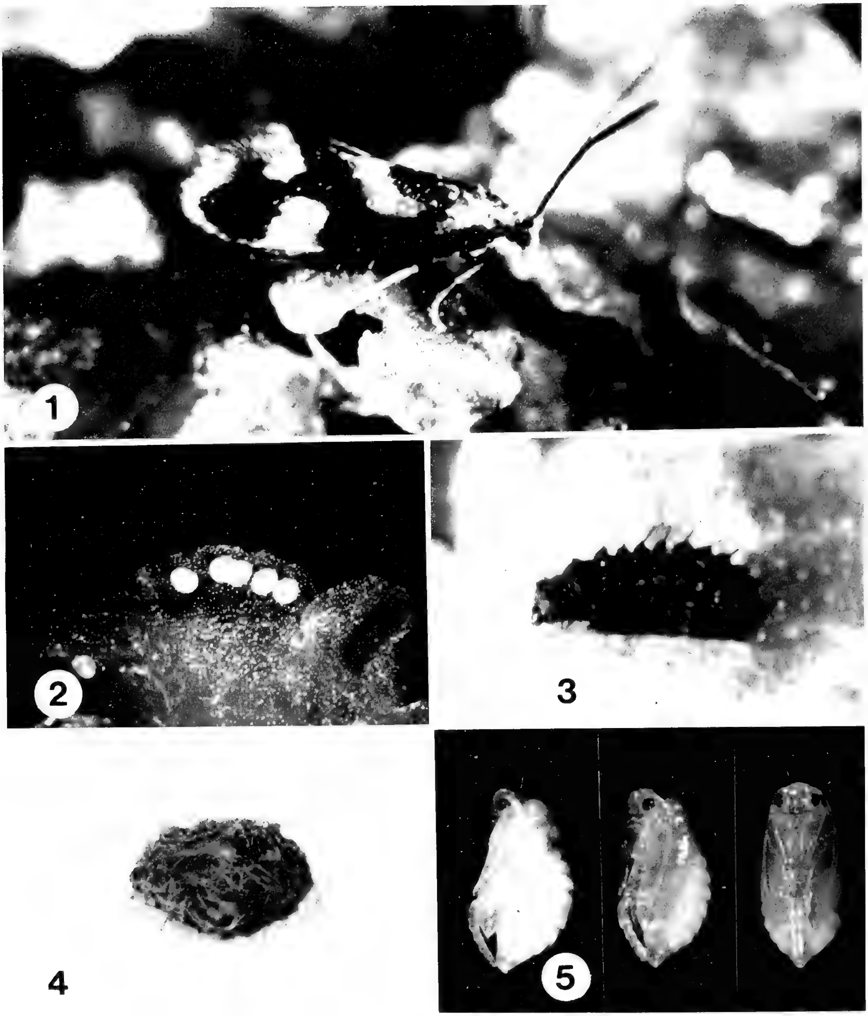
Head. Length 0.5 mm, diameter 0.27 mm. Brown. Antennae prominent, trisegmented and situated on small tubercles located on dorsal lateral portion of head (Fig. 3). Stemmata with 5 facets and located at the base of the antenna. Labrum simple with a pair of trisegmented palpi. Mandibles simple and dark brown.

Body. Length 4.3 to 4.6 mm; width 1.4 mm; height 1.2 mm. The body tapering at both ends with highest and widest point at abdominal segment 4. Dorsal and lateral surface brown to dark brown, ventral surface light brown. Prothoracic shield with 10 peg-like setae, 8 on the anterior and lateral border and 2 dorsally. Prothorax distinctly narrower than mesothorax. Mesothorax with 8 setae, 6 on dorsal and lateral anterior portion of gray brown pigmented area, and 2 just ventral to this pigmented area. Setae of metathoracic segment similar to those of mesothorax except subdorsal seta is greatly reduced in size. All thoracic segments have additional small micro-seta just dorsal to each true leg. True legs brown, with 3 segments and simple claw. Abdominal segments (A) A1 to A8 (and T2 and T3) with sawtooth-shaped knobs which form a dorsal and lateral ridge, areas between ridges concave. The middorsal area concave and small dark depression occuring on posterior of segments T2 to A8. Segments A1 to A8 each with one dorsal seta (0.18 mm) atop dorsal ridge. Segments A1 to A8 with reduced, almost microscopic subdorsal seta (0.04 mm) and prominent lateral seta (0.12 mm) on lateral ridge. Dorsal, subdorsal and lateral setae occur in brown pigmented area which has rough and wrinkled appearance. Dorsal and lateral intersegmental area constricted and may contain series of 8 to 20 microscopic dots. Ventral to lateral ridge, cuticle smooth and light brown. Series of brown dots form pattern around fixture that usually support a small seta. Conical ventral "prolegs" occur on segments A1 to A8 and small sclerotized protuberance appears on ventral surface of each. Segments A9 and A10 fused and with enlarged simple sucker. Spiracles posterior and ventral to lateral setae. Head diameter of first and second instar larvae 0.11 and 0.22 mm, respectively.

Habitat

Observations were made in Prairie Creek State Redwood Park, Humboldt County, California. All locations where adults were observed or captured were within a few km of the ocean and at relatively low elevations. Although some moths were found along creeks and moist hillsides in the redwood-fir forest, the preferred habitat appears to be steep-walled, moist canyons near the coast which are dominated by ferns and bryophytes (Fig. 6). The prominent bryophytes that are associated with the adults and larvae are, *Conecephalum conium*, *Pellia* sp., *Hookeria lucens*, and *Atrichum undulatum*. Other plants in the immediate area include: bracken fern, *Pteridium aquilinum*; sword fern, *Polystichum minitum*; deer fern, *Blechnum spicans*; and five-finger fern, *Adiantum pedatum*.

Climatic conditions in this area are moderate and stable. Weather records from Prairie Creek Campground, located about 4 km east of the beach at an elevation of 160 m indicated the mean daily temper-



FIGS. 1–5. **1,** Adult male *E. pardella* (14×); **2,** ova on underside of liverwort thallus (8×); **3,** last instar larva (9×); **4,** cocoon (5×); **5,** pupa (9×).

ature for January (9.5°C) and July (15.5°C) of 1981 differed by only 6°C. Although the summer months (June to September) are relatively dry, approximately 140 cm of rain falls between October and May. During the 1980–81 rainy season (October to May) there were 12 days when the temperature dropped below 0°C (32°F); the lowest temperature recorded during that time was −1.5°C (28°F). Barbour et al. (1973) suggested that seasonal temperature fluctuation reaches a min-

FIG. 6. Habitat of *E. pardella* in Northern California.

imum in this area because of off shore upwelling. They indicated that the mean monthly air temperature normally changes only a few degrees between the coldest and warmest months, and the ocean temperature changes very little.

Adult Behavior

The flight season begins in late May and continues to early or mid-July, with the peak adult density in June. The moths are active during the day, generally between 0900 and 1930 h, but this is influenced by temperature, humidity, and light intensity. When abundant, adults may be observed perched on vegetation; at low densities the best means of locating a colony is by sweeping suitable habitat with an aerial net. Behavioral notes were made on the activities (*in situ*) of individual moths that were observed from one to seven hours.

In areas protected from wind, adults frequently perched on the upper surface of fern fronds or other plants near patches of liverworts growing on canyon walls or beside creeks. Adults exhibit a clumped distributional pattern and, where common, densities reached 6 moths/m^2. When windy, or if the humidity is low, adults find shelter among the moist bryophytes with which they are always closely associated. The antennae are held at a 45 to 60 degree angle above the midline of the body while the moths are perched (Fig. 1). As they walk, the antennae wave up and down often touching the substrate. The hind legs of *pardella* are almost equal in length to that of the entire moth, and are occasionally used to jump or hop a few centimeters. Adults may remain motionless for hours and then walk or fly a few centimeters and perch again. During a single two and one half hour observation, a moth traveled 25 cm in a sporadic pattern and came to rest for the evening less than 5 cm from where it was first observed. Another moth less than 50 cm away walked less than 15 cm during this time. Most moths in 1981 were observed from one to three hours and traveled less than 30 cm. In 1982, five moths were carefully observed for a total of 29.2 hours. Again, the adults were extremely sessile, often remaining for hours in the same position. During the 29.2 hours, 16 flights were observed with an average distance of 21 cm per flight; they walked an average of 17 cm. Moths changed positions to perch in sunny locations, to avoid predators, and in the case of females, to oviposit. Adults are the prey of various small predators. One moth was captured in a spider web and another chased by a small hunting spider of the genus *Theridion*. A third moth was stalked but not captured by a small Olympic salamander (*Rhyacotriton olympicus*). Moths fly when disturbed but normally flight is infrequent and brief; the flight pattern is fluttery and weak but usually direct.

Adult micropterigids of other genera are reported to feed on pollen rather than nectar and have unique mouthparts. The mandibles are well developed, and the hypopharynx is concave on the upper surface. As pollen grains are ingested they are ground by the action of the mandibles against the hypopharyngeal spines and then digested (Tillyard, 1923; Hannermann, 1956). European species have been collected at the blooms of many plant species, including: Compositae, *Acer*, *Carex*, Scrophulariaceae, *Quercus*, and *Ranunculus* (Heath, 1960). Although various *Ranunculus*, Compositae, and Scrophulariaceae were near by and in bloom, no moths were observed at the flowers. Adults were frequently observed drinking water. Since they lack a proboscis they lower their head to the droplet of water by extending their mesothoracic legs to the side of their body. This lowers the head and raises the abdomen, allowing the moth to drink. If deprived of moisture moths die in less than two days, but when provided with water, they survived in captivity from nine to 18 days, and females deposited ova.

The only mating pair of moths was found just prior to 1000 h. In captivity females laid an average of 8.2 eggs per day. Ova were deposited on the underside of the liverwort thalli singly or in small clusters containing up to five ova (Fig. 2). The females generally remained on the upper surface and would simply swing their abdomen under the edge of the thallus to oviposit.

Immature Stages

The ova are flattened, circular and smooth when first deposited but become spherical in a short time and are covered with a series of small white projections (Fig. 2). The ova are white and measure 0.40 × 0.44 mm. At 22°C the eggs hatch in 21 days. The first instar larvae emerge from the side of the egg and are about 0.75 mm long. They vary from light brown to light gray and appear to have the same setal pattern and shape as mature larvae but have the ability to flatten themselves when at rest.

Larvae were reared in either a terrarium or petri dishes. Although both species of liverwort (*Conocephalum* and *Pellia*) were available, the larvae showed a marked preference for *Pellia,* the smaller of the two species. Mature larvae are active primarily at night but early instar larvae may be active at any time. While feeding, the margin of the liverwort is not damaged, rather the underside of the living thallus is eaten away but not through. Many micropterigid species feed on bryophytes, but the work of Luff (1964) and Lorenz (1961) indicates that some species do not.

In captivity the larvae are rather inactive, avoid intense light, and are usually found on the underside of the thalli during the day. In the field larvae were also found under living thalli during the day. Their coloration and size allowed them to blend well with the dead thalli which occur under the living growth. As the larva walks the true legs grasp the substrate; from above it appears to glide across the surface as the rhythmic undulations of the ventral surface are not apparent. When disturbed or inactive the head may be withdrawn so that only the prothoracic shield is visible; when extended the antennae which are located above the eyes are prominent (Fig. 3).

Unlike the European species which have a one year life cycle (Heath, 1976; Lorenz, 1961), *pardella* appears to have a two year cycle. In captivity eggs deposited in June 1981 became adults in June 1983. In the field, second instar larvae were commonly collected each year during the adult flight period. These larvae must represent the offspring from ova deposited the previous year, as reared larvae one year old were also in the second instar. Davis (pers. comm.) observed that *E. auricrinella* (Walsm.) from the eastern United States also has a two year life cycle.

Pupation occurs close to the ground among vegetation. The brown cocoon, which measures 5.5 × 4.5 mm, is oval, thin walled and tightly woven (Fig. 4). Strands of coarse silk attach the cocoon to vegetation. The exarate pupa is white to light brown (Fig. 5).

Based on the illustration of *Micropterix calthella* (L.) larvae by Lorenz (1961), the larvae of *E. pardella* exhibit a number of differences.

The setae of *calthella* are club-shaped and apparently uniform in length. The larvae of *pardella* have peg-shaped setae which vary in length according to their location. In addition, the distribution of the larval setae and pupal setal patterns also differ. A preserved pupa, cocoon, and larvae were deposited in the collection of the California Academy of Sciences, San Francisco.

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A NEW *ACANTHOPTEROCTETES* FROM THE NORTHWESTERN UNITED STATES (ACANTHOPTEROCTETIDAE)

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ABSTRACT. *Acanthopteroctetes aurulenta* Davis, new species, is described from Oregon and Utah. Both male and female are illustrated.

Recent collecting in central Utah by Ronald W. Hodges resulted in the discovery of the male of an undescribed species of *Acanthopteroctetes* previously mentioned in the literature (Davis, 1978:96, 129) but not named. The availability of both sexes of this species now enables me to name this insect, which constitutes only the fourth species described for the family.

Acanthopteroctetes aurulenta, new species

Length of forewings. ♂, 7.4 mm; ♀, 5.1 mm (Fig. 1).

Head. Vestiture rough, pale yellowish brown to nearly white. Antennae with 43 segments; vestiture of scape extremely rough with prominent pecten of more than dozen

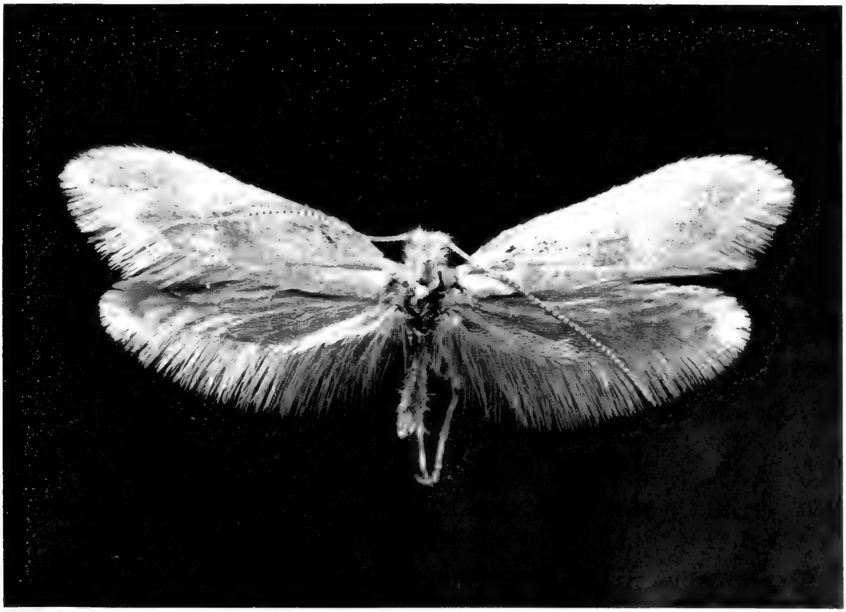
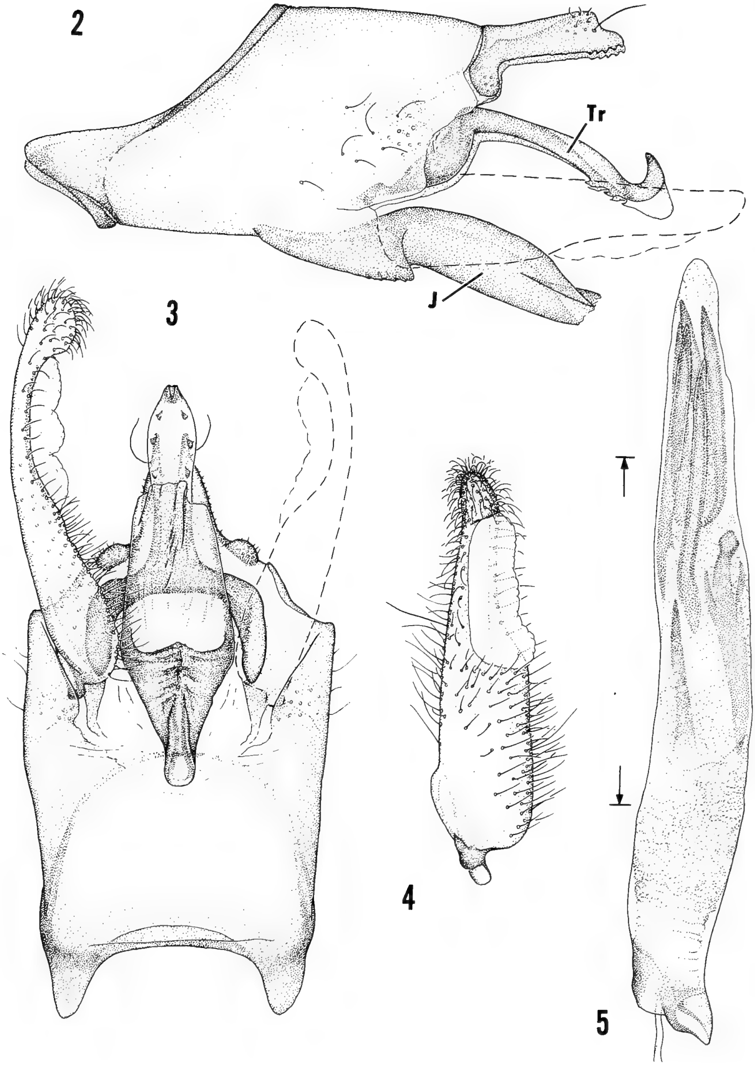


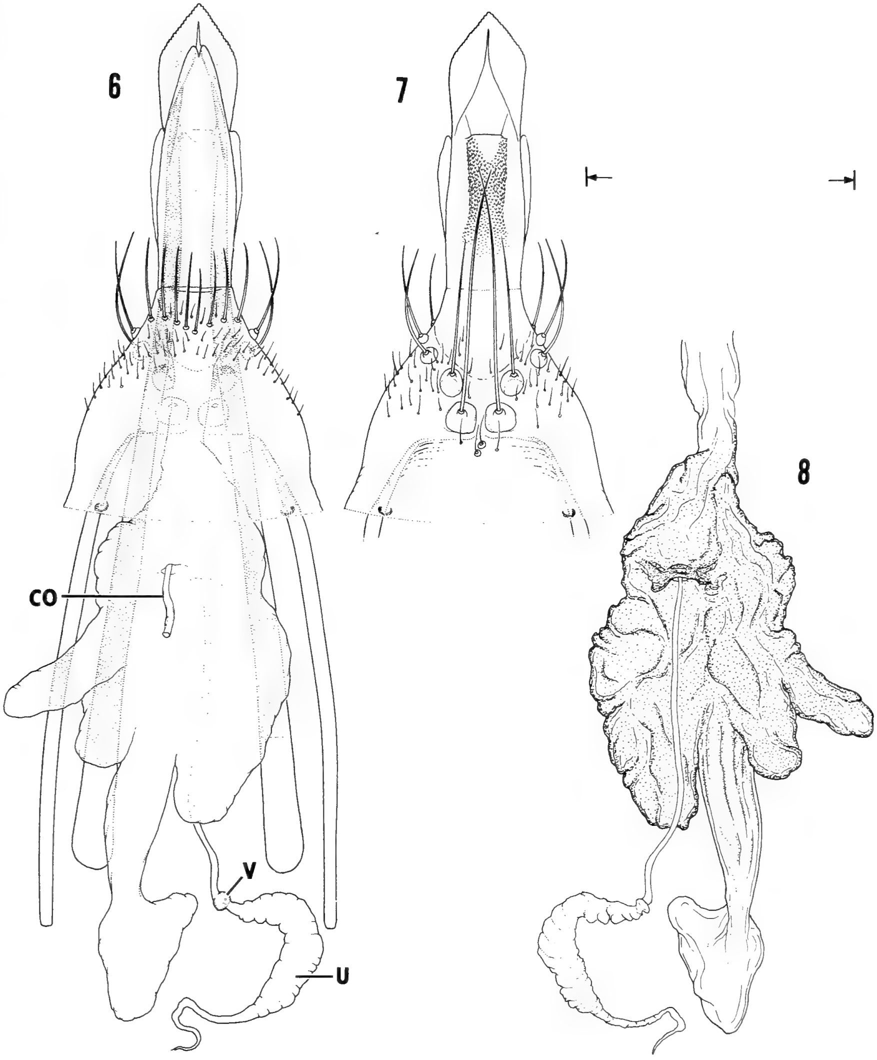
FIG. 1. *Acanthopteroctetes aurulenta*, new species. Holotype ♂, wing expanse 15 mm.



FIGS. 2–5. *Acanthopteroctetes aurulenta*, new species, male genitalia: **2,** lateral view, (J = juxta; Tr = transtilla); **3,** ventral view; **4,** valva, mesal view; **5,** aedoeagus. Scale = 0.5 mm.

long whitish hairs extending over eye; flagellum smooth, uniformly banded with white and pale brown scales. Haustellum naked except for scattered, fine setae. Maxillary palpi greatly lengthened, 5-segmented, geniculate; vestiture white. Labial palpi considerably shorter than maxillary palpi, covered with whitish scales.

Thorax. Pronotum covered with smooth, golden brown scales; central tuft of approximately one dozen elongate golden hairs present. Forewings uniformly pale golden brown,



FIGS. 6–8. *Acanthopteroctetes aurulenta,* new species, female genitalia: **6,** ventral view (CO = common oviduct, U = utriculus, V = vesicle); **7,** dorsal view; **8,** vestibulum and bursa copulatrix, dorsal view. Scale = 0.5 mm.

slightly lustrous; R_4 slightly variable, either connate with $R_{4+5}+M_1$ or shortly stalked. Hindwings more thinly scaled, uniformly pale gray. Venter of thorax white. Legs mostly white; epiphysis absent.

Abdomen. Sparsely covered with pale golden brown scales above, more whitish beneath. External glands absent. Caudal margin of eighth segment in female with encircling ring of elongate sensory setae; median setae longest with setae decreasing in length ventrally.

Male genitalia (Figs. 2–5). Uncus slender, minutely bifid, with 5 minute, subapical serrations along ventral margin. Ninth segment relatively long cylinder, about twice length of uncus, without lateral separation between tegumen and vinculum. Both anterior and posterior margins of vinculum deeply excavated. Median process of transtilla with 3 pairs of ventral serrations. Juxta elongate, length over 2.5× its width; basal half darkly sclerotized. Valvae slender, greatest width (at base) 0.25× its length; saccate membrane arising from elongate pouch along distal half of cucullus. Aedoeagus elongate, exceeding genital capsule in length; prominent cluster of approximately 6 elongate cornuti present.

Female genitalia (Figs. 6–8). Apex of ovipositor broad, depressed, triangular in outline, with approximately 15–17 serrations bordering lateral margins. Posterior apophyses stouter than anterior pair. Vestibulum enlarged, extremely irregular in outline, and with highly folded, thickened walls. Spermatheca with minute spherical vesicle at posterior end of elongate, slightly inflated utriculus; spermathecal papillae not sclerotized. Corpus bursae reduced in size, membranous.

Types. Holotype ♂: Head Ephraim Canyon, 10,000–10,300 ft [3049–3140 m], Senpete Co., UTAH, 1 Aug 1981, R. W. Hodges, blacklight, USNM 100671. Paratype: Baker, Oregon, Spring Creek, 1♀, 8 Jul 1966. J. H. Baker (USNM).

Distribution. North~~we~~eastern Oregon and central Utah.

Remarks

The uniformly light golden brown forewings of *A. aurulenta* easily distinguishes it from the other darker, banded-wing species in the family. This characteristic color pattern has suggested the specific name, derived from the Latin *aurulentus* (golden, ornamented with gold). The valvae of *A. aurulenta* are also unusual in possessing a very distinct, thinly sclerotized pocket from which arises the peculiar saccate membrane found in all members of the genus.

The Spring Creek, Oregon habitat can be characterized as a pine-sagebrush association with *Ceanothus* (the host of *A. unifascia* Davis (Davis and Frack, in press)) occurring nearby. The type locality in the Wasatch Mountains of central Utah, which has been heavily grazed in recent times (D. C. Ferguson, pers. comm.), is an open, subalpine plateau.

ACKNOWLEDGMENTS

I wish to thank my assistant, Ms. Biruta Akerbergs Hansen, for preparing the illustrations for this paper, and Dr. Ronald Hodges of the Systematic Entomology Laboratory, USDA, for his efforts in collecting this species.

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TWO INTERESTING ARTIFICIAL HYBRID CROSSES IN THE GENERA *HEMILEUCA* AND *ANISOTA* (SATURNIIDAE)

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ABSTRACT. Two crosses were reared to the adult stage with saturniid moths from different areas of the United States. These were *Hemileuca lucina* ♂ × *H. nevadensis* ♀ reared in Massachusetts and Texas on *Salix*, and *Anisota senatoria* ♂ × *A. oslari* ♀ reared in Connecticut on *Quercus coccinea*. Larvae and adults of both crosses were intermediate. Descriptions and figures of the hybrids are given. Several isolating mechanisms between the parent species were tested and are discussed.

Dozens of artificial crosses in the Saturniidae have been successfully reared since the previous century, but virtually all of these have involved species of the subfamily Saturniinae. This paper deals with two remarkable crosses obtained by the junior author utilizing small saturniid moths belonging to the subfamilies Hemileucinae and Ceratocampinae.[2] In both crosses, species native to the Southwest were reared in the Northeast and females from those rearings attracted congeneric diurnal males native to the Northeast. The species involved were *Hemileuca lucina* Henry Edwards, *H. nevadensis* Stretch, *Anisota senatoria* (J. E. Smith) and *A. oslari* W. Rothschild. For information on the adult morphology, wing pattern, immature stages, hostplants, reproductive behavior, and geographical distributions of these four parent species, the reader is referred to works by Ferguson (1971) and Riotte and Peigler (1981).

Hemileuca lucina ♂ × *H. nevadensis* ♀

In mid-September 1977 two virgin females of *H. nevadensis* (stock from Escondido, San Diego Co., California) were placed on twigs of *Salix gracilis* Anderess at the edge of a wet meadow in Groton, Middlesex Co., Massachusetts, which supports a sizable population of *H. lucina*. The emergence time of the reared *H. nevadensis* in Groton coincides with the flight time of *H. lucina*, i.e., mid-September through early October. The females emitted pheromone, and males of *H. lucina* were attracted. We assumed that pheromone from wild females

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of *H. lucina* was also present in the air, and therefore we concluded that males of *H. lucina* may not discriminate between pheromones of the two species. No behavioral isolation was observed as is often the case in achieving cross-matings of Saturniidae; there was no hesitation by the males nor resistance to them by the females.

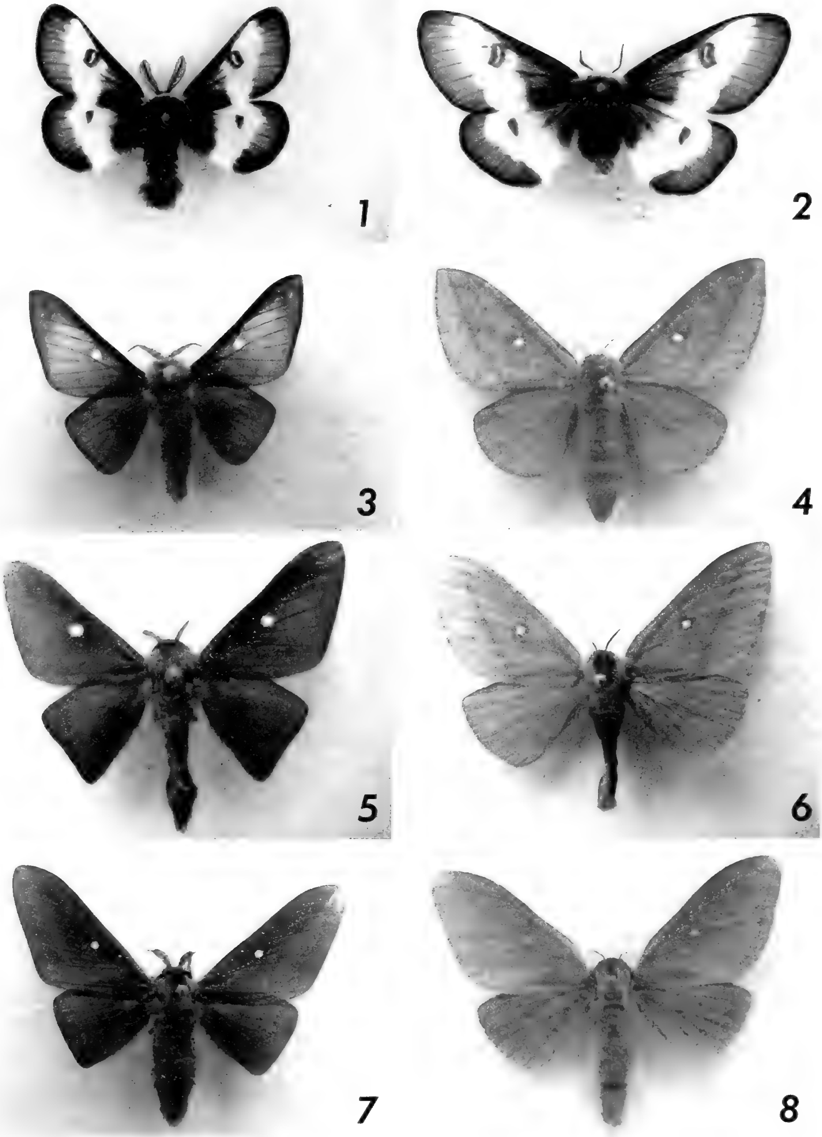
Each female produced an egg ring around a twig, each ring consisting of ca. 100 eggs. The egg is the overwintering stage in most species of this genus. One egg ring was sent to the senior author. The following spring eclosion of both egg rings was near 100 percent, and both authors reared broods successfully to the adult stage. In Groton the larvae were reared on *Salix gracilis* under a cloth bag, surviving an unseasonal 25 cm snowfall on 10 May while in the second instar. In Brazos County, Texas, the senior author reared his brood on *Salix* sp. (probably *nigra* Marshall) under cloth bags. Adult emergence in 1978 in Texas and Massachusetts differed, probably as a result of differences in photoperiod between the two regions where the pupae were kept. In Texas males emerged 21 July through 24 August peaking in the middle of August; females appeared during the second half of August and early September. The hybrid brood in Massachusetts yielded males from 6 September to 8 October and females mostly during the second week of October. A brood of pure *H. nevadensis* (Escondido, California) reared alongside the hybrids in Texas produced adults of both sexes in September, too late to permit attempts to backcross the hybrids, but coinciding with the emergence pattern of pure *H. nevadensis* in Massachusetts as mentioned above.

Hybrid females of both broods were sterile, based on the fact that their abdomens appeared to contain few or no ova. In both broods most adults expanded their wings normally after emerging, but some specimens, especially among females, failed to spread their wings partially or totally. This problem is encountered in several species of the genus with reared material and is not considered to indicate reduced viability resulting from hybridization.

Only the final instar larva is described, this one showing greatest divergence from parent species, but *H. nevadensis* and *H. lucina* hardly differ structurally. Pupal differences were difficult to find between the parent species also, so that those given below may not be reliable. Adults of this group do not exhibit sexual dimorphism; thus, the sexes are not described separately.

Description

Mature larva. Integument intermediate: black with numerous dull white oval flecks,[3] many converging but all individually distinct except around spiracles; in *H. lucina* flecks smaller and more widely separated; in *H. nevadensis* flecks larger and converging to



FIGS. 1–8. **1 & 2,** hybrid pair of *Hemileuca lucina* ♂ × *H. nevadensis* ♀; **3 & 4,** pair of *Anisota senatoria* from Pomfret, Connecticut; **5 & 6,** hybrid pair of *Anisota senatoria* ♂ × *A. oslari* ♀; **7 & 8,** pair of *Anisota oslari* from Santa Cruz Co., Arizona.

form yellowish white areas on integument, especially dorsally. Two dorsal rows of tufted-spine scoli stramineous with black tips as in both parents. Subdorsal and subspiracular branched scoli black with whitish tips in hybrid and both species.

Pupa. Anterior rim of each abdominal segment wider as apparently for *H. nevadensis*. Cremaster with stouter curved spines as in *H. lucina*; *H. nevadensis* apparently with thinner, straighter spines, and possibly fewer than in *H. lucina*. Head and thoracic characters of both parent species and hybrid indistinguishable.

Adult (Figs. 1 & 2). Elongated white scales on meso- and metathorax sparsely distributed among black scales, these white scales more numerous than in *H. lucina* but much less numerous than in *H. nevadensis*. Whitish band of forewing agreeing with that of *H. lucina* by being wider on ventral side than on dorsal side, but more like *H. nevadensis* by having crenulate outer margin curving parallel with outer wing margin. Discal mark in hindwing containing white slit as in father species, this mark often solid black in *H. nevadensis*. Black portions of wings more opaque and coal-black than either parent species.

Anisota senatoria ♂ × *A. oslari* ♀

A freshly emerged female of *A. oslari* was permitted to emit pheromone in an exposed location at Pomfret, Windham County, Connecticut, during a clear, cool, and windy day in mid-July 1978. The undersized moth had been reared on scarlet oak (*Quercus coccinea* Muenchh.) from eggs received from Madera Canyon, Arizona the previous year. *Anisota senatoria* flies in southern New England from mid-June through mid-July, whereas reared specimens of *A. oslari* have emerged from mid-July through mid-August. Males of *A. senatoria* seek females from ca. 1130 to 1530 h EST, and the circadian flight time of *A. oslari* is also known to be during midday hours. A male of *A. senatoria* arrived but had considerable difficulty locating the female due to gusty wind. He persisted for ca. 1 h before making physical contact, at which time copulation readily occurred. Attempts to obtain this cross the previous year had apparently failed due to the normally larger size of the females of *A. oslari*, which prevented the males of *A. senatoria* from achieving copulation.

After mating, the female of *A. oslari* oviposited freely. Eclosion of the eggs was virtually 100 percent. The hybrid larvae were vigorous, and several were reared to maturity under cloth bags on scarlet oak. The following year the female hybrids emerged during the last few days of May, whereas their male siblings appeared from 9 June through 19 July. Females were apparently sterile, having shrunken abdomens as mentioned under the previous cross.

Description

Mature larva. Head brown with bold black markings on each side (head of *A. senatoria* solid black; head of *A. oslari* solid brown; the two-colored head of hybrids remarkable because all known species of *Anisota* have solid colored heads in all instars). Prothoracic tergite black as in *A. senatoria*. Body color black with bold orange stripes on sides and two broken orange stripes on top. Anal plate and anal prolegs orange with black markings (solid black in *A. senatoria*, solid brown in *A. oslari*). Pattern of spines on body more as in *A. senatoria* but size and arrangement of spines on anal plate intermediate between parent species. Median caudal spine long as in *A. oslari*.

Male (Fig. 5). Overall appearance strikingly intermediate. Wingshape as in *A. senatoria* but large size as in *A. oslari*. Ground color dark purplish brown, forewings having brownish orange overtones. Postmedian line weak; barely discernable transparent patch in forewing (absent in *A. oslari*, well-developed in *A. senatoria*). White discal mark large. Forewing with sparse sprinkling of dark spots. Outer margins of hindwings straight.

Female (Fig. 6). Intermediate in most characters. Wingshape closer to *A. oslari*. Ground color light brownish orange with pinkish suffusion in postmedian area as in father species and on hindwing as in mother species. Postmedian line weak in forewing, very faint in hindwing. White discal mark surrounded by purple as in *A. senatoria*. Forewing with a few dark spots.

DISCUSSION

Hybridization experiments such as these provide data on isolating mechanisms and degree of phylogenetic divergence. Aside from the obvious one of allopatry, other isolating mechanisms tested by these crosses include mechanical, behavioral, viability of immature stages, and fertility of adult hybrids. Remarks on each of these were given above for both crosses. The differing emergence times between the sexes of an individual hybrid brood were proposed by Peigler (1981) as an isolating mechanism, because this reduces frequency of F_2 or backcross matings when hybrid broods are produced in nature (when primary isolating mechanisms fail). This phenomenon, now widely recognized in hybrid Lepidoptera, is well illustrated in the two present crosses. We use the term "isolating mechanism" in the traditional sense as did Solignac (1981), notwithstanding the valid arguments put forth by Key (1981) that several independent principles are encompassed by the term.

Genetic compatibility between two taxa, which is to some extent correlated with phylogenetic divergence, falls along a continuum. The pairs of species in the present study are demonstrated to have an intermediate affinity when compared to the following two extremes. Minimal compatibility of parent species would be seen if eggs fail to eclose or larvae die in the first instar. This was demonstrated by the cross *Hemileuca nuttalli* (Strecker) ♂ × *H. eglanterina* (Boisduval) ♀ in the studies of Collins and Tuskes (1979), which might be expected because the parent species are sympatric. On the other hand, what appears to be total genetic compatibility in Saturniidae is illustrated by crosses (both reciprocals) between the Indian *Antheraea roylei* Moore and the Chinese *A. pernyi* (Guérin-Méneville). The parent species have chromosome numbers of $n = 30$ and $n = 49$ respectively, and the hybrid ($n = 30$) has been reared through more than 20 generations, maintaining its increased vigor over the parent species (Jolly, 1974, 1981). Most known crosses of Lepidoptera result in more or less vigorous F_1 hybrid adults with reduced fertility, especially in females.

It is our hope that this paper will encourage lepidopterists to exploit every opportunity to achieve interspecific matings of species that they rear. When fertile eggs and viable larvae result, records and descriptions should be kept, results published, and material deposited in museums.

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We are grateful to J. Steve McElfresh of San Diego, California, for supplying eggs of *H. nevadensis* and *A. oslari*. Our figures were made by Thomas Marion Hill of Greenville, South Carolina. Drs. W. D. Winter, Jr. and Joseph E. Eger, Jr. made color photographs of living larvae of the hybrids and/or pure species which aided formulation of the larval descriptions. Material supplied by Earll M. Brown of San Diego also was useful in this study. Specimens of both crosses, including the four hybrids figured, have been deposited in the Los Angeles County Museum of Natural History, and a pair of the *Hemileuca* cross is in the American Museum of Natural History.

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[2] Lemaire (1978:23) explained in detail why the name Ceratocampinae is to be used instead of Citheroniinae.

[3] Tuskes (1976) stated that these flecks are circular, but in all material we have seen, consisting of several species of the genus, these are distinctly oval.

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SPERMATOPHORE PERSISTENCE AND MATING DETERMINATION IN THE GYPSY MOTH (LYMANTRIIDAE)[1]

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ABSTRACT. Spermatophores were detectable in all female gypsy moths dissected within 1.5 h following inception of copulation. After 1.5 h, the percentage of detectable spermatophores decreased with time; by 4.5 h, no spermatophore could be detected in any mated female moth. The percentages of detectable spermatophores did not differ significantly among three gypsy moth populations (laboratory-reared, high and moderate density natural populations) for intervals timed from inception of copulation. Examination of the bursa copulatrix for the presence of a spermatophore can be useful for rapid determination of female gypsy moth mating success.

The spermatophore of the gypsy moth, *Lymantria dispar* (L.), is formed within the female bursa copulatrix during the first 10 min of copulation (Klatt, 1920; Leonard, 1981). It consists of an oval sperm sac with a tapered neck that extends into the ductus bursae and a proteinaceous mass secreted by the male accessory glands. Proteolytic enzymes produced by the female begin to dissolve the spermatophore shortly after its formation (Chapman, 1971; Engelmann, 1970).

However, little is known of the fate of the gypsy moth spermatophore between formation and disintegration. Taylor (1967) reported that the spermatophore disintegrates within one or two hours of copulation but did not state whether this is time accrued from inception or termination of copulation. The distinction is essential since copulation averages 60–73 min (range = 20–198 min) (Forbush and Fernald, 1896; Doane, 1968; Waldvogel et al., 1981). Because the gypsy moth spermatophore is not persistent, determination of female mating success relies on examining eggs for embryonation several weeks after deposition or examining the female reproductive system for the presence of sperm (Stark et al., 1974). This paper presents, for the first time, data on the persistence of the gypsy moth spermatophore, with implications for rapid determination of female mating success.

MATERIALS AND METHODS

Laboratory-reared virgin gypsy moths were mated, uninterrupted, in arenas described by Waldvogel et al. (1981). The time *in copula* was recorded for each pair. To obtain data on the persistence of the

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TABLE 1. Percentages of spermatophores detectable at intervals timed from inception of copulation for three gypsy moth populations: laboratory-reared, and high and moderate density natural populations.

Hours following inception of copulation	% spermatophores detectable			
	Laboratory-reared	High density	Moderate density	Total
1.5	100.0 (11)[a]	100.0 (9)	100.0 (10)	100.0 (30)
2.0	81.8 (11)	66.6 (9)	70.0 (10)	73.3 (30)
2.5	70.8 (24)	50.0 (10)	40.0 (10)	59.1 (44)
3.0	16.7 (24)	44.4 (9)	30.0 (10)	25.6 (43)
3.5	0.0 (19)	11.1 (9)	10.0 (10)	5.3 (38)
4.0	— (0)	0.0 (9)	10.0 (10)	5.3 (19)
4.5	— (0)	— (0)	0.0 (9)	0.0 (9)

[a] Values in parentheses are numbers of mated female moths dissected. Percentages did not differ significantly (Chi-square test, Fisher's exact test; $P > 0.05$) among populations at each time interval.

spermatophore, females were dissected under a microscope at 30× magnification, at intervals timed from inception of copulation. A medial incision through the abdominal terga provided access to the bursa copulatrix. The bursa copulatrix was then dissected *in situ* and its contents compared with those of an unmated female. All matings and dissections were performed at room temperature.. These procedures were repeated with virgin moths that emerged from pupae collected from moderate density (ca. 3000 egg masses/ha) and high density (ca. 70,000 egg masses/ha) natural populations in Clearfield County, Pennsylvania. Egg mass densities were estimated by the method of Wilson and Fontaine (1978).

RESULTS AND DISCUSSION

Duration of copulation averaged 87 ± 2.3 min for all mated pairs ($n = 213$, range = 22–218 min). The percentages of spermatophores that remained detectable at intervals timed from inception of copulation are presented in Table 1. For each time interval, the percentages of detectable spermatophores did not differ significantly among populations (Chi-square test, Fisher's exact test; $P > 0.05$). Within 1.5 h following inception of copulation, 100% of the spermatophores in all populations could be detected. During this period, the shiny white spermatophore was visible through the wall of the bursa copulatrix. After 1.5 h, the percentage of detectable spermatophores decreased with time; the spermatophore was rarely visible through the bursa copulatrix wall, and dissection was necessary to determine its presence. At 3.5 h following inception of copulation, the spermatophore was detectable in less than 12% of the moths examined from any population. By 4.5 h, the contents of the bursa copulatrix of all mated females were indistinguishable from those of an unmated moth.

These data eliminate the ambiguity arising from Taylor's (1967) report. His observations, if timed from termination of copulation, roughly agree with our findings. In other species of Lepidoptera, where the spermatophore may persist for several days or more, the bursa copulatrix can be examined for the presence of a spermatophore to determine whether a female has mated (Burns, 1968; Snow and Carlysle, 1967; Taylor, 1967). Although the gypsy moth spermatophore is not persistent, it can be useful for rapid determination of female mating success, which may be required in some precopulatory behavioral studies. Examination of the bursa copulatrix for a spermatophore is highly reliable within 1.5 h following inception of copulation. The presence of a spermatophore indicates female mating success and establishes that mating occurred less than 4.5 h prior to examination. Unfortunately, the absence of a spermatophore does not establish that the female gypsy moth is unmated. When no spermatophore is detectable, the most immediate recourse is examination of the spermatheca for the presence of sperm (Stark et al., 1974).

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GENERAL NOTES

INSECT PARASITES AND PREDATORS OF HACKBERRY BUTTERFLIES (NYMPHALIDAE: *ASTEROCAMPA*)

During the course of collecting and rearing immature stages of hackberry butterflies (Nymphalidae: *Asterocampa*) over the past five years, a number of arthropod parasites and predators were encountered. These arthropods have been preserved or their behaviors recorded in hopes of understanding some of the selective pressures which might affect the courses of evolution for *Asterocampa* species. This note is a report of insect species which have a greater or lesser effect on survival of the various stages of the butterflies.

Identifications were made by the author with the aid of the cited references and the reference collection at Texas A&M University. Help in the collection or identification of specimens, or review of the manuscript was provided by L. G. Friedlander, P. Davis, D. and D. Paschley, and Drs. H. R. Burke, J. C. Schaffner, and R. Wharton.

The most frequently encountered parasites of hackberry butterflies are the scelionid egg parasites, which occur in all *Asterocampa* observed. Stink bugs, such as the one figured by Langlois and Langlois (1964, Ohio J. Sci. 64:1–11, fig. 11), are the most common predators. Only one other insect (at the generic level) has been positively reported to attack *Asterocampa*, the larval parasite, *Hyposoter fugitivus* (Say) (Hym.: Ichneumonidae) (Townes, 1945, Mem. Amer. Entomol. Soc. No. 11, Pt. II, pp. 479–925).

Parasites Reared from Eggs

1. Hym.: Eulophidae: *Tetrastichus* spp. (Boucek, 1977, Bull. Entomol. Res. 67:17–30): *A. clyton* (Boisduval & Leconte) egg masses (TEXAS: Brazos Co., 14-VII-79; Menard Co., 20-VI-79).

2. Hym.: Scelionidae: *Telenomus* spp. (Masner, 1976, Mem. Entomol. Soc. Canada No. 97, 87 pp.): *A. argus* (Bates) egg mass (MEXICO: Oaxaca, 11-VII-81); *A. celtis* (Boisduval & Leconte) eggs (TEXAS: Hidalgo Co., 4-VI-81); *A. clyton* egg masses (ARIZONA: Pima Co., 23-VIII-80; TEXAS: Brazos Co., 14-VII-79; Menard Co., 20-VI-79; San Patricio Co., 3-VI-81; Travis Co., 14-X-77; Waller Co., 8-VII-79; VIRGINIA: Westmoreland Co., 22-VI-80); *A. leilia* (Edwards) eggs (TEXAS: Starr Co., 6-VI-81).

Parasites Reared from Larvae

1. Dip.: Tachinidae: *Euphorocera* prob. *floridensis* Townsend (Aldrich and Webber, 1924, Proc. U.S. Natl. Mus. 63:1–90; Cole, 1969, The flies of western North America, Univ. Calif. Press, Berkeley and Los Angeles, 693 pp.): *A. celtis* last stage larva (TEXAS: Austin Co., 6-VIII-79).

2. Dip.: Tachinidae: *Lespesia* prob. *aletiae* (Riley) (Beneway, 1963, Univ. Kansas Sci. Bull. 44:627–686; Cole, 1969, loc. cit.): *A. clyton* late stage larvae (TEXAS: Gonzales Co., 30-IX-79).

3. Hym.: Braconidae: *Cotesia* spp. (Mason, 1981, Mem. Entomol. Soc. Canada No. 115, 147 pp.): *A. clyton* third stage larvae (TEXAS: Gonzales Co., 21-IX-79; Hidalgo Co., 13-XI-77; Jeff Davis Co., 15-VIII-81; Uvalde Co., 23-IX-79).

4. Hym.: Braconidae: *Meteorus* spp. (Tobias, 1966, Entomol. Rev. 45:348–358): *A. clyton* larvae[1] (TEXAS: Goliad Co., 6-VI-81; Travis Co., 29-V-78, 20-VII-79).

5. Hym.: Eulophidae: *Elachertus* sp. (Peck et al., 1964, Mem. Entomol. Soc. Canada No. 34, 120 pp.): *A. celtis* last stage larva (TEXAS: Travis Co., 21-VI-78); *A. clyton* middle stage larvae (TEXAS: Brazos Co., 14-VII-79; Travis Co., 28-X-77).

6. Hym.: Ichneumonidae: *Microcharops tibialis* (Cresson) (Townes, 1969, Mem. Amer. Entomol. Inst. No. 13, 307 pp.; Townes and Townes, 1966, Mem. Amer. Entomol. Inst. No. 8, 367 pp.): *A. clyton* third stage larva (LOUISIANA: St. Tammany Parish, 30-III-82).

Parasites Reared from Pupae

1. Hym.; Chalcidiae: *Brachymeria* sp. (Howard, 1885, U.S. Dept. Agric., Bur. Entomol., Bull. No. 5, 47 pp.): *A. clyton* pupa (TEXAS: Gonzales Co., 15-X-77).
2. Hym.: Ichneumonidae: *Itoplectis conquisitor* (Say): *A. clyton* pupa (TEXAS: Dimmit Co., 21-IV-79).

Predators

1. Hem.: Pentatomidae: *Apateticus cynicus* Say (Slater and Baranowski, 1978, How to know the true bugs (Hemiptera-Heteroptera), Wm. C. Brown Co. Publ., Dubuque, Iowa, 256 pp.): *A. clyton* early stage larvae (TEXAS: Travis Co., 26-III, 24-V, 18-X, 31-X-77).
2. Hem.: Pentatomidae: *Apateticus lineolatus* (Herrick-Schaeffer) (det. J. Eger): *A. clyton* larvae (TEXAS: Cameron Co., 13-III-79).
3. Hem.: Pentatomidae: *Podisus maculiventris* (Say) (Slater and Baranowski, 1978, loc. cit.): *A. clyton* early stage larvae (TEXAS: Travis Co., 24-V, 1-VI, 23–28-X-77, 23-V-78).
4. Hem.: Reduviidae: *Sinea* prob. *sanguisuga* Stal: *A. clyton* second stage larva (TEXAS: Travis Co., 29-V-78).
5. Hem.: Reduviidae: *Sinea spinipes* (Herrick-Schaeffer) (Slater and Baranowski, 1978, loc. cit.): *A. clyton* early stage larvae (TEXAS: Travis Co., 28-X-77).
6. Hym.: Vespidae: *Polistes exclamans* Viereck: *A. celtis* fifth stage larva (TEXAS: Travis Co., 24-IV-78); *A. clyton* third stage larvae (TEXAS: Travis Co., 25-X-77).
7. Hym.: Vespidae: *Vespula* sp.: *A. clyton* third stage larvae (TEXAS: Travis Co., 31-X-77).

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[1] None were reared from larvae. One female *Meteorus* was observed to oviposit in *A. clyton* larvae. One female hyperparasite of *Meteorus* was observed to oviposit in larvae of the same species. One of these hyperparasites was reared from *Meteorus* cocoons taken in close association with *A. clyton* larvae.

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ITHOMIINE BUTTERFLIES ASSOCIATED WITH NON-ANTBIRD DROPPINGS IN COSTA RICAN TROPICAL RAIN FOREST

Adult females of *Mechanitis* and the allied genus *Melinaea* (Brown, 1977, Syst. Entomol. 2:161–197) feed on the fresh droppings of birds (primarily antbirds) that follow swarms of army ants through tropical rain forest in Costa Rica (e.g., Ray and Andrews, 1980, Science 210:1147–1148). These authors conclude that bird droppings resulting from birds following army ant swarms provide a predictable nutrient resource for these female butterflies, and that the exploitation of this resource may be related, in some yet to be studied way, to egg production. In this note I extend the findings of Ray and Andrews (op. cit.) to the association of female ithomiines of various genera to fresh droppings of bird species not associated with army ant swarms in Costa Rican tropical rain forest. I conclude that fresh bird droppings of any kind in such a habitat provide a resource exploited by ithomiines on an opportunistic basis.

Between 1972 and 1980, I conducted several studies of various butterfly species in a small parcel of relatively undisturbed mixed primary and secondary-growth tropical rain forest (premontane tropical wet forest) at "Finca La Tigra", near La Virgen (220 m elev.), Heredia Province, Costa Rica. The site is about 20 km from the "Finca La Selva"

FIG. 1. Female *Godyris zavelata caesiopicta* feeding at fresh bird dropping at a light gap in the forest habitat at Finca La Tigra in northeastern Costa Rica.

study site of Ray and Andrews (op. cit.). During this lengthy period, I observed ithomiine butterflies feeding on fresh bird droppings splashed on leaves of understory plants, particularly along foot paths and light gaps in the forest. This was not a deliberate search for butterflies, but rather accidental encounters within an approximately 500-square meter area usually visited three or four months each year. *Mechanitis* spp. and *Hypothyris euclea leucania* (Bates) were the most frequently observed ithomiines exhibiting this behavior. These ithomiines are very abundant, relative to others, at this locality (Young, 1976, Pan Pacific Entomol. 53:104–113; Young, 1979, J. Lepid. Soc. 33:68–69; Young and Moffett, 1979a, Amer. Midl. Natur. 101:309–319; 1979b, Deutschen Ent. Zeitschr. 26:21–38). A less numerous ithomiine, *Godyris zavelata caesiopicta* (Niepett) was also observed feeding on fresh bird droppings at various times in the same period (Fig. 1). In my experience, encounters of such behavior consisted of usually one or two butterflies, either both on the same dropping or on separate droppings in the case of two or more. Large aggregates of ithomiines on bird droppings were not encountered. At the same times, however, I did not notice any swarms of army ants in the same areas, or in adjacent open areas such as a cacao plantation forming the border to the forest study site. In one instance with *Godyris* (10 July 1982 at 1600 h) I noticed a single butterfly feeding at a dropping for close to forty minutes but with frequent interruptions by several flies (Diptera) that chased it away temporarily. *Godyris zavelata* females are easily distinguished from males by wing colors (Young, 1974, Entomol. News 85:227–238). It is by no means as abundant locally (in this area) as *Mechanitis* and *Hypothyris*. Several other bluish clear-wing ithomiines (undetermined) also visited fresh bird droppings in the same forest patch.

Based upon these preliminary observations made at irregular intervals over several years at the same forest patch in northeastern Costa Rica, I suggest that the females of several genera of ithomiine butterflies routinely exploit, on an opportunistic basis, fresh bird droppings splashed on understory vegetation. Areas of tropical rain forest with disruptions in the canopy, such as light gaps and foot paths, are particularly attractive gathering places for various species of birds, perhaps because many insects, potential prey, and other arthropods are also found in these microhabitats. In turn, bird droppings occur there frequently, although perhaps in an unpredictable fashion, selecting for opportunistic foraging by female ithomiines. When large concentrations of bird droppings become available, such ithomiines, at least *Mechanitis* and *Melinaea,* may exhibit deliberate orientation to such food resources and become abundant there, as reported elsewhere (Ray and Andrews, op. cit.).

I thank Luis Poveda for identification of the *Godyris* larval food plant, and Dr. J. Robert Hunter for allowing access to Finca La Tigra.

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SATYRIUM KINGI (LYCAENIDAE) TAKEN IN MARYLAND

At 1600 h on 22 July 1982, after spending a discouraging time collecting in three areas in Wicomico and Worcester Counties in Maryland, I caught a *Satyrium kingi* (Klots and Clench) near Millville, Worcester County. This capture represents a significant northward extension of the known range of this species on the coastal plain.

The orange cap on the blue spot on the hindwing ventrum showed the identity of this rare find. Its abdomen was thin, and its long tails were gone, but the slight roundness of its wings and the fact that it landed on a sweetgum sapling at about 5–6 feet above the ground corresponded with the description of Gatrelle (1974, J. Lepid. Soc. 28:33–37) of the flight habits of females. Its flight was slow, due possibly to its age, the lateness of the hour, or the deep shade in the area, but it does agree with the "sluggish" adjective used by Covell and Straley (1973, J. Lepid. Soc. 27:144–154). The very late date and the condition of the specimen (Fig. 1) indicated that this was possibly the last survivor of the season's brood.

FIG. 1. **Left:** *S. kingi,* male. Suffolk, Nansemond County, Virginia, July 1, 1974, lower aspect; **Right:** *S. kingi,* female, Millville, Worcester County, Maryland, July 22, 1982, lower aspect.

The specimen was taken along a damp trail from a sandy road, where the vegetation consisted primarily of sweetgum (*Liquidambar styraciflua* L.), red maple (*Acer rubrum* L.), white cedar (*Chamaecyparis thyoides* (L.), loblolly pine (*Pinus taeda* L.), sweet bay (*Magnolia virginiana* L.), tassel-white (*Itea virginica* L.), blueberry (*Vaccinium* sp.), and sweet pepperbush (*Clethra alnifolia* L.), which was just coming into bloom. This habitat resembles in some respects that designated as Group A for *kingi* by Gatrelle (1974).

Only three worn *Megisto cymela* (Cramer) and one fresh male *Wallengrenia otho* (J. E. Smith) were seen in the same area on the date of capture. *Incisalia henrici* (Grote & Robinson) was common and *I. augustus* (Kirby) rare in the previous spring, the only other time I had collected there.

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THE IDENTITY OF WING HAIRS IN MEGALOPYGIDAE

The wings of Megalopygidae were described as being covered with long, wrinkled or wavy hairs that gave them a wooly appearance.

By making transparent impressions of the upper surface of the front wings of both male and female *Megalopyge opercularis* (J. E. Smith), using the replica method described by Khalaf (1980, Fla. Entomol. 63(3):307–340), it became clear that the wings were covered with scales that were deeply divided (Figs. 1 & 2); the apices were attenuate; and the branches formed the so-called "hairs". The base of the scales was cuneate (attenuate) as in other moths.

This investigation received support from the Academic Grant Fund of Loyola University.

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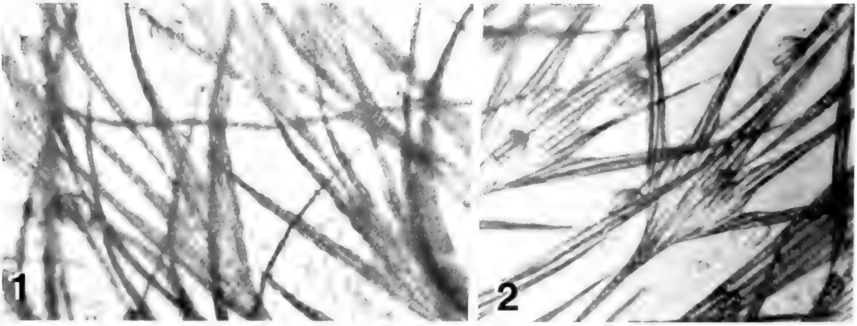

FIGS. 1 & 2. Light micrograph of replica of the front wing of *Megalopyge opercularis* (J. E. Smith), showing deeply divided scales: **1,** female; **2,** male.

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POPULATION OUTBREAK OF PANDORA MOTHS (*COLORADIA PANDORA* BLAKE) ON THE KAIBAB PLATEAU, ARIZONA (SATURNIIDAE)

The pandora moth (*Coloradia pandora* Blake) is fairly widespread in the pine forests of the Rocky Mountains, and occasionally exhibits large population outbreaks as noted by Ferguson (1971. Moths of America North of Mexico, Fascicle 20.2A, E. W. Classey, Ltd., London). Such an impressive outbreak was noted on a visit to the Kaibab Plateau of northern Arizona in August 1982. During a field trip to the plateau, thousands of adult pandora moths were observed flying about or landed upon tree trunks in yellow pine (*Pinus ponderosa*) forest in the daytime hours. While driving a northsouth transect the full length of the Kaibab Plateau on 15 August 1982, the greatest concentrations of pandora moths were noted within a two–three mile zone surrounding the Jacob Lake Junction, on State Highway 89 (Alt.) and Highway 67. Hundreds of adult moths (many freshly emerged) and thousands of eggs were noted on the buildings and tree trunks at Jacob Lake, especially near outside lights that were kept on at night.

Adult males and females were active in large numbers nocturnally as well as diurnally, because "black lighting" at night produced heavy catches near the North Rim of the Grand Canyon on 16 August. Wygant (1941. Jour. Econ. Entomol. 34(5):697–702) noted in Colorado that the peak emergence of adults was in July, every-other-year, because of a two-year life cycle, and the primary food plant was lodgepole pine (*Pinus contorta*). In another area, Oregon, yellow pine was reported to be the principal food plant of the pandora moth by Packard (1914. Mem. Nat'l. Acad. Sci. 12:1–276). Since the yellow pine predominates on the Kaibab where pandora moths were observed to be most abundant in August 1982, this pine is probably the most important food plant there.

Several hundred eggs were oviposited by freshly collected females placed in glassine envelopes. The ova were glossy blue-green spheres which hatched in early September three to four weeks after oviposition. This fits with Ferguson's notation that the young larvae overwinter, mostly in the second instar, on the pine branches at the base of needles. Attempts to rear the larvae on *Pinus palustris* (which was available to the author) failed.

Adult pandora moths are clearly strong flyers, since one was observed flying across a barren desert landscape some 45 miles west of the edge of the Kaibab Plateau and the nearest pine trees. Undoubtedly, during large population outbreaks, some individuals wander great distances in search of suitable food plants to oviposit upon.

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TWO LARGE COLLECTIONS OF MACROLEPIDOPTERA TO THE MILWAUKEE PUBLIC MUSEUM

The Milwaukee Public Museum in recent years has received two major Lepidoptera collections, the William E. Sieker Collection of Sphingidae and the James R. Neidhoefer Collection of Macrolepidoptera of several families.

A donation from the wife of the late Mr. Sieker and daughter Marie, the Sieker Collection was acquired by the Milwaukee Public Museum in September 1982. Amassed over almost fifty years, this outstanding collection totals over 9000 prepared Sphingidae representing some 150 genera, 1000 specific and subspecific taxa, and includes some type material. All major faunistic regions are well represented. Mr. Sieker acquired a major portion of the collection through exchange and donations from biologists conducting field research in different parts of the world. The collection includes all of the known Wisconsin sphingid species, the result of Mr. Sieker's own collecting and his strong association with other naturalists in the state over the years. There are also several hundred prepared *Catocala* moths (Noctuidae), an additional several thousand papered specimens, associated field notes, several hundred reprints of important works on sphingids and other groups, and reference books.

William E. Sieker was born in 1912 in Milwaukee, Wisconsin and died in Madison, Wisconsin in January 1982 at age 70. Although a tax attorney by profession, he pursued a second career of collecting and studying sphinx moths, particularly in the northern reaches of Wisconsin. His interest in Sphingidae was fused with a dedication of helping conservation efforts, particularly in Wisconsin. Mr. Sieker was a founder of the Wisconsin Entomological Society and a past president of that organization as well as of the Madison Audubon Society. He was also legal counsel for the Wisconsin Chapter of Nature Conservancy and helped that organization acquire the Ridges Sanctuary at Baileys Harbor in Door County.

The museum acquired the James R. Neidhoefer Collection in January 1976, a collection which includes about 95,000 specimens of Macrolepidoptera (approx. 45,000 prepared and 50,000 papered specimens) of which approximately 1200 are gynandromorphs, sexual mosaics and aberrations (structural and color). The collection is particularly strong in Papilionidae, Nymphalidae, Heliconiidae, Ithomiidae, Morphidae, Pieridae, Saturniidae and Sphingidae. All of the major faunistic regions are represented, with particular strengths in the Neotropical and Indo-Australian Regions. Mr. Neidhoefer's donation also included 132 insect storage cabinets with 105 drawers, and an extensive library of rare books, reprints, and monographs on the Lepidoptera. At the time the collection was donated to the museum, Mr. Neidhoefer also financed the renovation of a collection storage room in the Invertebrate Zoology Section (which includes entomology).

Mr. Neidhoefer acquired his collection over forty years, through buying and exchanging specimens with collectors all over the world, and through field expeditions (i.e., Brazil) financed by him and for the purpose of collecting. With the cooperation of a former curator of the Milwaukee Public Museum, Kenneth MacArthur, Mr. Neidhoefer was instrumental in acquiring other Lepidoptera collections for the museum, most notably the George Berg Collection (which includes a good series of Nicaraguan Rhopalocera), the P. Gagarin Collection (Brazil), and others.

James R. Neidhoefer was born in Milwaukee in 1917 and became an avid naturalist at an early age. He received an undergraduate degree in zoology from Marquette University and did a thesis on the freshwater sponges of Wisconsin. He took over the family carpet business in Milwaukee but continued to pursue his interests in natural history by collecting Lepidoptera and teaching his 12 children about insects. Prior to moving to Miami, Florida in 1981 to pursue a new retirement job as president of a wholesale pet distributorship, Mr. Neidhoefer was very active in local nature organizations and the Boy Scouts, as well as the Milwaukee Public Museum. As an honorary curator for the museum, he now collects Lepidoptera and other invertebrates in Florida during his spare time.

With the acquisition of the Neidhoefer Collection, and through grants from the Institute of Museum Services and the Friends of the Milwaukee Public Museum, a major collection reorganization and upgrading of facilities was initiated by the museum's full time curators in the Lepidoptera area, myself and Susan S. Borkin. With the acquisition of the Sieker Collection, and combined with further collecting efforts in Wisconsin and also from ecological studies in the Neotropical Region, one of our goals is to make these outstanding collections of use to curators, systematists, and biologists working on groups represented in them.

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ARE CHAIN-LINK FENCES BARRIERS TO BUTTERFLIES?

During the summers of 1982 and 1983, I regularly collected European cabbage butterflies, *Pieris rapae* Linnaeus from the Fenway Victory Gardens, Boston, Massachusetts, and Dunback Meadows, Lexington, Massachusetts. From 24 June to 18 August 1982, and 2 June to 1 August 1983, I observed 27 confrontations between free flying *P. rapae* and chain-link fences. On each occasion the butterfly flew within 5–10 cm of the fence, back and forth over a 1 to 1.5 meter area, and then added a vertical movement of equal distance. Three times *P. rapae* succeeded in flying over the fence. Once a male flew to the end of the fence and around it, and once a butterfly proceeded after a 2–3 second delay to pass through the fence after I tried unsuccessfully to capture it. On 21 occasions *P. rapae* changed their flight direction nearly 180° after confronting chain-link fences. On one occasion an alfalfa butterfly, *Colias eurytheme* Bdv. was observed to change direction approximately 90° after confronting a fence. A 90° change was also observed once for a *P. rapae* after physically striking a fence. The openings in a chain-link fence measure approximately 7 cm in height and width. The mean wing spread of *P. rapae* is only 3.8 cm. On several occasions I have seen individual *P. rapae* squeeze their folded wings through 1.3 cm wire screening of a flight cage in the laboratory; and in the field, I have observed individuals fly without hesitation through thin wire fences with openings of 12–15 cm. Even though chain-link fences have openings through which a *P. rapae* could physically pass without contact, the butterfly rarely does so. Perhaps *P. rapae* can not accurately judge the opening size; it may appear small and likely to damage wing tips; or perhaps the thick shiny wire on all sides of the butterfly may be distorted by the butterfly's visual system and perceived as a nearly solid barrier.

Chain-link fencing is used widely to keep would-be intruders out of areas or keep in desired objects. Mountain alpine areas are under increasing pressures from human visitors each summer. Some parks have posted personnel to keep visitors on established trails, others have begun to rope off areas. Chain-link fences have been proposed as a means to save badly trampled alpine areas.

The construction of chain-link fences and other obstacles may have a variety of effects on butterfly populations depending on the species involved and the habitat. Williams (1930. The migration of Butterflies, Oliver and Boyd, London. 473 pp.) states that *Belenois severina* and *Vanessa cardui* usually fly over obstacles with little or no lateral deviation from their line of flight. Feltwell (1982. Large White Butterfly The Biology, Biochemistry, and Physiology of *Pieris brassicae* (Linnaeus), Dr. W. Junk Publishers, The Hague, 535 pp.) reports that *P. brassicae* typically flies over obstacles rather than around them. However, *Andronymus neander* predominantly flies laterally with little or no vertical rise when confronted by an obstacle in its flight path (Williams, 1930. ibid). Generally, alpine lepidoptera fly very low to the ground to avoid winds. If fences are encountered, movement may be hindered, adding an additional energetic pressure on mountain butterfly populations which are often already low in number. Therefore, there may be serious deleterious effects on alpine butterfly populations if chain-link fences are built in these areas.

These observations are limited in number and species involved. Perhaps a more quantified investigation is merited. Such an investigation should be concerned with the height and opening sizes of fences, with a look at a number of different species in various habitats to determine if the observations reported here can be generalized.

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BOOK REVIEW

CATALOGO SISTEMATICO DE LOS LEPIDÓPTEROS IBÉRICA. (I) MACROLEPIDOPTERA, by M. R. Gomez-Bustillo and M. Arroyo-Varela. 1981. Inst. Nac. Invest. Agrarias, Ministerio de Agricultura y Pesca, Madrid. 499 pp., 6 col. pls. (1200 Pta. [=$9.40]).

Recent catalogs and checklists, including those of Bradley et al. (1972) for England, Karsholt and Nielsen (1976) for Denmark, and Leraut (1980) for France and Belgium, have almost covered the entire Lepidoptera fauna of the most western parts of Europe with up-to-date checklists. The new catalog by Gomez-Bustillo and Arroyo-Varela closes the gap by covering the fauna of Spain and Portugal. Their work is the first of two volumes; the second volume is to cover the Microlepidoptera. The catalog initially strikes one as very different from most catalogs, since the cover has a large color photograph of the pierid *Aporia crataegi* (L.), not what one usually finds on catalog covers. Additionally, there are six color plates near the back of the book with photographs from nature of a representative species of each family in the book. The text is also untraditional inasmuch as bibliographic references are included for each family in terms of literature on the species of the Iberian Peninsula. There is an initial brief summary of the classification adopted for the catalog, generally following recent classifications like that of Common (1970, Insects of Australia), followed by a short introduction on the origins and evolution of Iberian Lepidoptera. The main text treats 39 families of so-called Macrolepidoptera, grouping many primitive families together with the normal macros. This arrangement produces an artificial and utilitarian arrangement for the catalog designed to conform to the older concepts, whereby large-sized moths were placed in "Bombyces". This is not altogether detrimental, since a phylogenetic chart of families is included, but it does maintain the myth that these "Bombyces" are somehow related more than they really are, and it also detracts from a strictly systematic treatment of families from primitive to more advanced. Nonetheless, the catalog is a welcome addition to the works listing the European fauna.

The authors follow a family usage that splits families too much, in my view, but does follow the practice of many European specialists. Thus, such groups as Syssphingidae, Riodinidae, Danaidae, Thaumetopoeidae, Dilobidae, and Ctenuchidae, which many consider only of subfamily status, are here raised to family level. I did not make any detailed checks of nomenclature. In Sesiidae, however, not all synonymies are included for each species, only a few of the major ones. Each family name is provided with authorship and dates, as well as for other higher categories. The specific and generic checklist then follows, with a discussion section and reference list for each family. The species are all listed with their dates of authorship, with parentheses added when the names of species have been recombined. The names of subspecies and forms, however, are not provided with dates. Each species is also given a notation as to its place in a European faunal district; thus, statements are made such as "endemic to Iberia" or "supramediterranean."

The catalog is in spanish, but since the main text involves a checklist of taxa of the Iberian Peninsula, it is easily used by anyone. It is a welcome addition to the growing rank of faunal catalogs and checklists. One can only hope that now, in lieu of a new checklist of the entire Palearctic region, others will follow the lead of the authors and provide additional regional catalogs (e.g., the Balkans, Russia, the Far East), so that in this way we may in time have new lists of all the areas within the Palearctic region.

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NOTICE TO CONTRIBUTORS

Contributions to the *Journal* may deal with any aspect of the collection and study of Lepidoptera. Contributors should prepare manuscripts according to the following instructions.

Abstract: A brief abstract should precede the text of all articles.

Text: Manuscripts should be submitted in *triplicate*, and must be typewritten, *entirely double-spaced*, employing wide margins, on one side only of white, 8½ × 11 inch paper. Titles should be explicit and descriptive of the article's content, including the family name of the subject, but must be kept as short as possible. The first mention of a plant or animal in the text should include the *full scientific name*, with *authors* of zoological names. Insect measurements should be given in *metric units*; times should be given in terms of the *24-hour clock* (e.g. 0930, not 9:30 AM). Underline only where *italics* are intended. References to footnotes should be numbered consecutively, and the footnotes typed on a separate sheet.

Literature Cited: References in the text of articles should be given as, Sheppard (1959) or (Sheppard 1959, 1961a, 1961b) and all must be listed alphabetically under the heading LITERATURE CITED, in the following format:

SHEPPARD, P. M. 1959. Natural selection and heredity. 2nd. ed. Hutchinson, London. 209 pp.

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

In the case of general notes, references should be given in the text as, Sheppard (1961, Adv. Genet. 10: 165–216) or (Sheppard 1961, Sym. R. Entomol. Soc. London 1: 23–30).

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GENERAL NOTES

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16 August 1984

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Cover illustration: Head (antennae mostly missing) of *Paranthrene tabaniformis* (Rottemburg). This drawing was prepared by George Venable, Smithsonian artist, for inclusion in the Sesiidae fascicle for the Moths of America North of Mexico. The dusky clearwing, a Holarctic species, is a borer in the exposed roots, stems and branches of willows and poplars.

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LIFE HISTORIES OF *TAENARIS* (NYMPHALIDAE) FROM PAPUA NEW GUINEA

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ABSTRACT. Descriptions and illustrations of the early stages and ecology of *Taenaris onolaus* Kirsch and *Taenaris catops* Westwood are given with a brief description and illustrations of the early stages of *Taenaris myops* Felder. Adults of both *T. onolaus* and *T. catops* were frequently seen imbibing cycad juices which probably enhances their assumed distastefulness to predators. Their foodplant specializations and aposematic attributes are discussed together with the mimetic relationships of *Taenaris*.

The genus *Taenaris* Hübner in Papua New Guinea numbers 18 species. Together with three species of the genus *Morphopsis* Oberthür and the monotypic genera *Hyantis* Hewitson and *Morphotenaris* Fruhstorfer, these are the only representatives of the Morphinae to be found in the country. A further six species of *Taenaris* and one of *Morphopsis* are known from Irian Jaya. Torres Strait marks the boundary of the distribution of these few closely related genera and species in the Melanesian region. They do not occur on the Australian mainland.

The Morphinae occur widely throughout the Indo-Australian region and number about 100 species. The morphology of the early stages and of the adults indicate their close affinity with the Satyrinae. For example, adults of *Morphopsis albertisi* Oberthür in Papua New Guinea superficially resemble the smaller satyrine *Tisiphone helena* Olliff. from north Queensland, Australia, where no mimicry could be involved.

Adults exhibit little sexual dimorphism, but males tend to be smaller than the females, have a more concave inner margin of the forewing and bear sub-basal androconial tufts on the hindwing.

Little was known of the biology of the Morphinae in the Melanesian region. Rosier (1940) gave some details of the biology of *Taenaris* *horsfieldii* Swains. from Java and D'Abrera (1977) mentioned briefly the early stages and foodplants of *Taenaris catops* Westwood and *Taenaris phorcas* Westwood. D'Abrera stated that a paper describing the life history of *M. albertisi* was in preparation, but until now there has been no detailed study of any species of this subfamily published for the region.

Taenaris onolaus Kirsch

D'Abrera (1977) lists four races of this species, two occurring in Irian Jaya. The description of the subspecies *ida* Honrath fits the butterfly described here and this, therefore, represents an extension of its range from the known type localities for the subspecies in the Huon Peninsula. The 10 km grid square reference in which the subspecies has been found in Bulolo is DN50 at approximately 700 m. The present study was made from October to December 1979.

Egg (Fig. 2). 1.5 mm in diameter; pearly white when laid, changing within two days through cream to deep pink; almost spherical, but slightly tapered towards flattened apex; chorion covered with evenly spaced, shallow dimples. Duration, 14 days.

Larva. First instar. Length 4 mm on hatching, 5 mm at end of instar; head jet black, shiny with fine white setae; thorax and abdomen with fine white setae up to 1 mm in length, initially cream, gradually changing to yellowish green, then orange-red; prothorax with dorsolateral black spots. Duration, 2 days, and a further 5 days of inactivity during pre-ecdysis and ecdysis.

Second instar. Length 10 mm at end of instar; head jet black, shiny, 1 mm in diameter with setae 3.5 mm in length and pair of truncate, slightly forwardly curved horns 0.75 mm in length, each horn with 3 strong spines; thoracic setae 4 mm, abdomen with setae 3.5 mm in length; thorax and abdomen deep pink, abdomen with a dorsal black spot on anal segment. Duration, 4 days, plus 3 days of inactivity during pre-ecdysis and ecdysis.

Third instar. Length 22 mm at end of instar; similar to second but head 2 mm in diameter, horns 1 mm in length, each with 5 spines; thoracic setae 6 mm; thorax and abdomen pink with 4 indistinct, but continuous orange-yellow lines, 2 dorsolateral and 2 lateral. Duration, 6 days, plus 2 days of inactivity during pre-ecdysis and ecdysis.

Fourth instar. Length 35 mm at end of instar; head 3 mm in diameter, horns 1.5 mm, each with 6 spines; thorax and abdomen wine-red, orange-yellow lines slightly more prominent; body setae up to 9 mm in length; below these a layer of strong, sharp, black setae 1.55 mm in length. Duration, 5 days, plus 2 days of inactivity during pre-ecdysis and ecdysis.

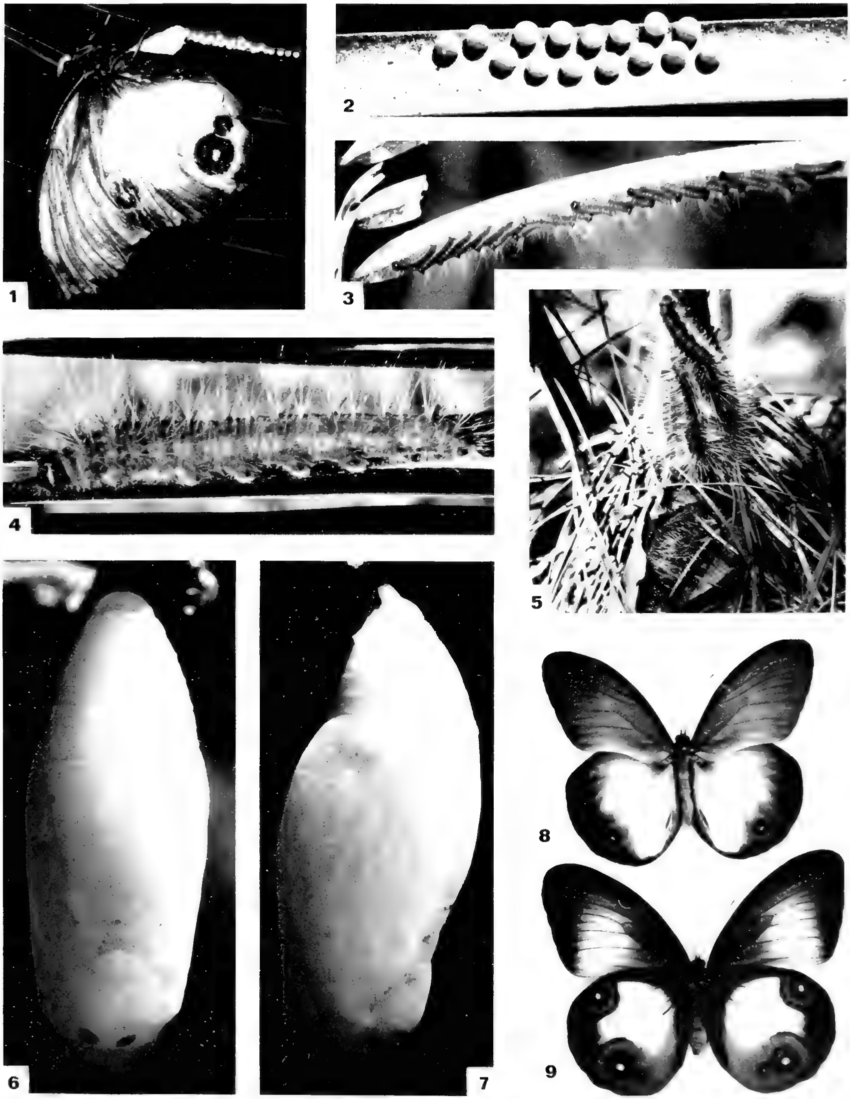
Fifth instar (Fig. 4). Length 60 mm at end of instar; similar to fourth but head 5 mm in diameter, horns 2.5 mm with 6 strong spines (Fig. 20c); body setae up to 10 mm; lower black setae 3 mm. Duration, 8 days, plus 2–3 days spent wandering.

Prepupa. Larval color changes from wine-red to yellow after suspension prior to pupation so that lower black setae and black spots of prothoracic and anal segments become very prominent. Duration, about 1 day of hanging before larva to pupa ecdysis.

Pupa (Figs. 6 & 7). Length 30 mm; ovate, smooth, translucent creamy white; cremaster black; anal rise with 2 black tubercles; apical margin of front bifid, forming 2 short, conical horns above each eye 1 mm in length. Duration, 17–20 days.

Ecological Observations

Foodplant and habitat. The foodplant is, unusually, a gymnosperm, *Cycas circinalis* (L.) Laut. & K. Sch. of the order Cycadales. This,



FIGS. 1–9. *Taenaris onolaus:* **1,** female ovipositing on cycad; **2,** eggs; **3,** second instar larvae; **4,** mature larva; **5,** mature larvae at rest in the leaf litter near the base of their foodplant; **6,** dorsal profile of the pupa; **7,** lateral profile of the pupa; **8,** upperside of male; **9,** underside of female.

however, is not a unique specialization among the butterflies. *Taenaris butleri* Oberthür is known from the same foodplant (T. Fenner, pers. comm.) and also *Luthrodes cleotas* Guérin of the Lycaenidae (Szent-Ivany et al., 1956). Another lycaenid, *Theclinesthes onycha* Hewitson, is also known from *Cycas* in Australia (Sibatani & Grund, 1978).

The foodplant exhibits a well defined distribution in the study area, being restricted to a well drained ridge alongside a gravel road behind the Bulolo Forestry College. The cycads cover about 3 acres which makes the area ideal for the study of a defined population of *T. onolaus.*

Cycas circinalis occurs locally at a quite high density (in places up to six plants per 10 square meters), mainly along the top of the ridge and under a 15 year old *Pinus* plantation. The plantation provides a fairly open habitat with only semi-shading by the thin pine canopy. Saplings of other trees occur sporadically throughout the plantation. These conditions appear to be ideal for the growth of the cycads and may explain why the plant is not found locally outside the area where the scrub becomes thicker. A number of plants were fruiting prolifically during visits to the area in October, November and December 1979, and there were many cycad nuts on the ground.

Oviposition and phenology. Eggs are laid by females in batches ranging in number from 20 to 40 with an average batch size of about 30. The highest number recorded in a single batch was 77. They are deposited close together, but not touching, on the undersides of one (or sometimes two) leaves of the older, tougher, dark green fronds. They are always placed about one third of the way down from the tip of the frond. Occasionally (seen in at least seven batches), there are one or two unfertilized eggs which remain white after the others have changed to pink.

The plants on which the females choose to oviposit are all of about the same height, approximately 1.5 m tall, and with usually 5–15 fronds. Cycads are extremely slow growing, and these plants are estimated to be from 5–6 years old (possibly older). As yet they have little or no trunk, and the fronds of most of them arise directly from the ground. No eggs or larvae were found on the younger plants with only two or three fronds and of smaller overall size at the beginning of the study period.

From observations of two females made late one afternoon in December from 1735 h onwards, it appears that *T. onolaus* only oviposits during the period of about two hours before complete darkness which is at 1900 h, dusk (or half-light) coming at about 1830 h. (This was suggested later by two further observations of females ovipositing at dusk.) One female was discovered at 1745 h below a cycad frond, having laid about 30 eggs. Approximately every two minutes she deposited another egg in the row of four across the cycad leaf. Having completed a row she then moved slowly forward and positioned herself to begin a new row, from side to side. It is estimated, therefore, that a whole batch of about 50 eggs (this particular female had gone by the next morning but laid 45 eggs) would take approximately two hours to lay.

A second female was seen at the same time flying around another cycad, repeatedly settling on the upperside of a frond and then crawling beneath it. She then flew behind some vegetation, which obscured the other half of the same cycad, and settled out of sight. Soon after she was re-located sitting on a batch of about 25 newly laid eggs ready to recommence egg laying. It appears, therefore, that some females take periods of rest away from the cycads on which they are ovipositing then return to lay their eggs at intervals. Both females were still ovipositing in near darkness at 1850 h.

It is possible that females are able to lay further batches of eggs. However, it appears that their ovaries produce a certain number of eggs that are laid as a single batch in a short period of time. They are probably fairly short lived once they have paired and have finished ovipositing. It is also evident that females can detect the presence of eggs or larvae (probably visually) that are already present on the cycad, because when the area was studied in mid-November, no suitable looking plant was found to have more than one batch of eggs or larvae on it.

Eggs of *T. onolaus* were first discovered at the beginning of October 1979 which marked the end of an extremely dry dry-season. This lasted from the end of June for three months. During this time there was no rain recorded for the Bulolo Valley. In October, however, there were a few batches of *T. onolaus* larvae to be found, mainly fourth and fifth instars. Two egg batches were located at this time, which indicates that, even though the climate can be seasonally extremely dry in the area, generations can be continuous throughout the year because of the hardiness of the cycads; their foliage remains constant all the year round. (During the 1979 dry season in the Bulolo Valley, many angiosperms, especially vines, even in fairly dense forest areas, began to wilt and/or ceased new leaf growth. Often the dry season is hardly apparent.)

When the area was again revisited at the end of the first week in November, heavy rains had recommenced during the previous four weeks. At this time all but about eight suitable-looking plants had eggs or larvae, and the approximate census was as follows: 18 batches of eggs, 7 groups of first instar larvae, 5 groups of second instar larvae and 2 of third instar larvae.

During the latter half of December females were still ovipositing, and a number of cycads, even the smaller, single-frond plants, were seen with newly laid egg batches. Some hosted up to three age classes of larvae, all of which fed together. This suggested that the area was now almost saturated with early stages due to the build up in numbers of adults and that intraspecific competition can occur where the species has limited, or finite, food resources. The few suitable cycads with no larvae at this time implied that any eggs laid on them may have been the subject of predation. Although no predators have been seen taking early stages, certain fresh egg batches were often found to have been eaten by the next day. Tetigoniid grasshoppers and predatory bugs are likely to be responsible.

In general, it may be concluded that as *T. onolaus* is a cycad feeder of tropical distribution, it is subject to little periodicity, i.e., that it is continuously brooded all year round, but that any large fluctuation in population numbers is reciprocal of extremes of wet and dry weather. Prolonged dry periods appear to produce aestivative (diapause) pupae and may also retard growth of new cycad fronds, so that the result at the onset of new rains is a large buildup of adults and early stages which compete intraspecifically for foodplants in areas with limited distribution of cycads.

Larval behavior. Larvae of *T. onolaus* are gregarious throughout their feeding period. In the fourth and fifth instars, however, the distance that separates each larva is increased, and they may be found feeding singly, or in sub-groups of up to five. First to third instar larvae spin an almost invisible mat of extremely fine silk on which they rest below the frond of the cycad, so that when the plant is viewed from above they are completely obscured from the observer.

When feeding, early instar larvae begin at the tips of the leaves of the cycad frond and eat each leaf back separately to the base of the main stem. The group will then begin to feed again on the next leaf and progress gradually downwards. They often defoliate a whole frond as they grow. The smaller larvae form very orderly rows when resting or as they feed on the edge of the leaf lamina (Fig. 3). Final instar larvae tend to be cannibalistic on soft, newly formed pupae if many are caged together. One particular batch of about 12 fourth instar larvae were found resting during the day at the base of a frond of one cycad and were thus hardly visible beneath the leaf litter trapped there (Fig. 5). This does not, however, appear to be typical behavior. They were not undergoing ecdysis, and it is possible that these larvae were feeding at night and seeking shelter from predators during the day. All instars have been found feeding at various times during the day with no specific feeding or resting times.

In general, all instars are fairly slow in their movements. When touched they sometimes react by thrashing the head from side to side. This appears to be an effective means of warding off insect predators. Fifth instar larvae tend to curl up and fall off the cycad fronds if handled, behavior which enhances their very moth-like appearance.

Adult behavior and abundance. Females appeared to be most frequent in the study area and were seen at all times flying randomly throughout the pine plantation. Specimens were seen on every visit during the study period although never in great abundance at any one time. Numbers ranged on average from 1-4 (flying in close proximity) seen per hour.

At one time in mid-December a sample census resulted in the sightings during one hour of three males flying in a restricted gully on the border of the study area (one feeding on damp mud), and four females. Two of these females hung inertly beneath a cycad frond (late afternoon) and did not react to rapid hand movements nearby. One was picked up and promptly flew off when released. Invariably, however, adults are very wary and do not allow one to approach to within less than 2 meters if they are at rest and alert on the upperside of broad-leaved foliage.

There are no succulent fruit trees in the pine plantation, and none of the saplings which produce small berries that fall to the ground have proven attractive to adults. However, on a number of occasions both sexes have been seen feeding on the fermenting skins of cycad nuts that have fallen to the ground when brown and ripe.

Competition. Intraspecific competition has been mentioned. However, there also exists in the area, interspecific competition for *Cycas circinalis* between *T. onolaus* and a chrysomelid beetle of the subfamily Criocerinae. The small 1 cm long, orange beetle which is probably *Crioceris clarkii* B. Baly (based on the discussion in Szent-Ivany et al., 1956), feeds as a cream colored larva on the cycads. It has a definite preference for the soft, new, light-green cycad fronds. Therefore, by selecting only the older tougher fronds on which to oviposit, *T. onolaus* probably avoids competition for individual plants. Nevertheless, the beetle does cause much damage to the cycads in the area and can be classed as a successful competitor with *T. onolaus*.

The feeding damage caused by the beetle larvae is very characteristic. Even for a long time after a cycad has been eaten back by either herbivore it is possible to determine whether it was fed on by beetle or butterfly. Whereas *T. onolaus* eats the whole leaf of a frond, the chrysomelid eats only the underside of a lamina and leaves the top waxy cuticle as a window. This soon dries, turns yellow, and is left trailing, still attached to the frond.

Many new, recently unfurled, cycad fronds were the subject of attack by the beetle in mid-December 1979. These beetles also appear to play a significant rôle in controlling the population size of the butterfly. It is possible that they cause a final crash in the numbers of a cohort of *T. onolaus* because, if there are sufficient numbers of the beetle, then growth of cycads in the area may be halted completely. There will not, therefore, be enough fronds which reach maturity for the benefit of *T. onolaus.*

Taenaris catops Westwood

D'Abrera (1977) lists 21 races of this species. As emphasized by Brooks (1950) the named subspecies of *T. catops* may be very artificial as the species is widely distributed in New Guinea, of common status, and exhibits a great phenotypic variability both locally and regionally. Considering for example the supposed subspecies *mylaecha* from Sudest Island which is described by D'Abrera as an "albinotic extreme" (i.e., very white), the same form is now recorded widely from the Western Highlands Province of the mainland (Fig. 22). The other extreme is an extremely dark form of *T. catops,* in which black and dark grey have replaced almost all the white. Supposed subspecies of *T. catops* should, therefore, be accepted with caution and are more likely the result of clinal variation or Müllerian mimetic associations within their genus.

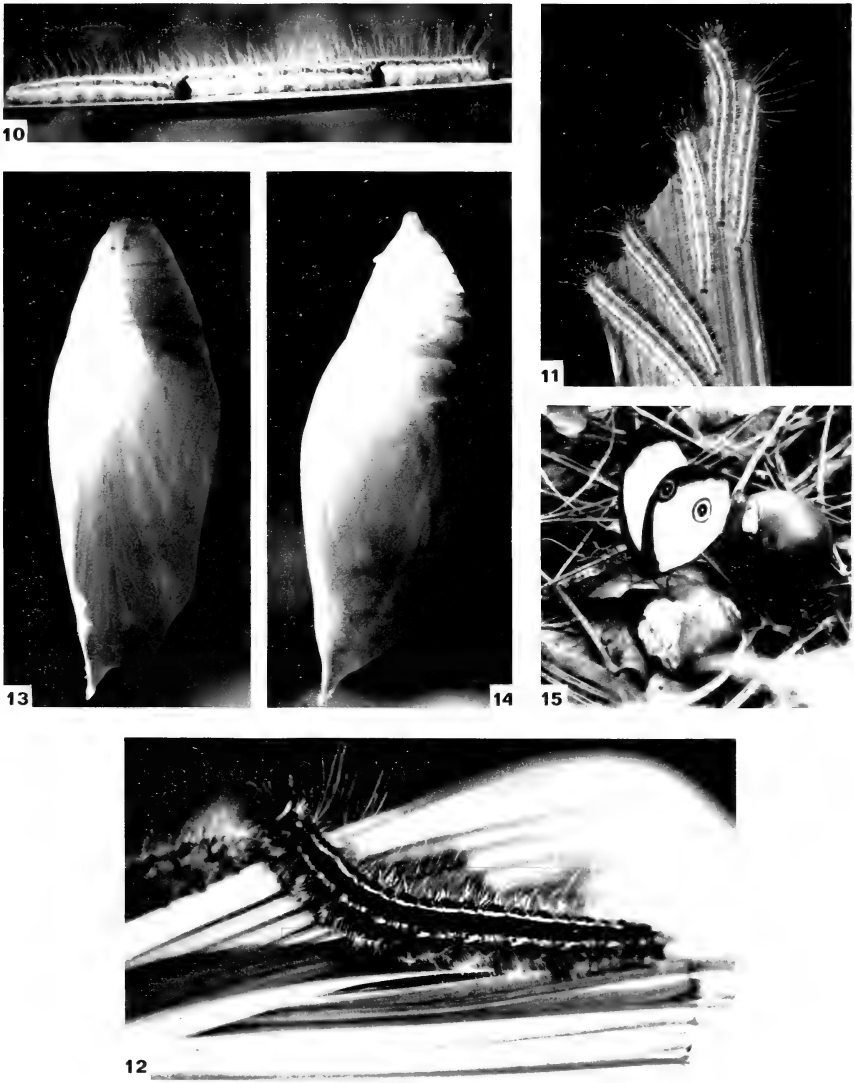
The life history of this species was also recorded from the *T. onolaus* study area in March and April 1980. The egg and first two instars cannot be described as only the third instar onwards were available.

Third instar (Figs. 10 & 11). Larvae grew extremely rapidly from 8 to 25 mm in 3 days; head jet black, shiny, 2 mm in diameter, covered with fine white setae, horns similar to those of *T. onolaus,* 1.5 mm in length; body covered with soft, white setae, longest (5 mm) on the prothoracic and anal abdominal segments, decreasing to 4 mm at body center; thorax and abdomen dark grey with 2 dorsolateral and 2 lateral white lines; spiracles encircled with yellowish orange; claspers laterally yellowish orange, dorsally with black patch surmounted by two short (0.55 mm) pointed tubercles. Duration, 3 days, plus a day of inactivity spent during pre-ecdysis and ecdysis.

Fourth instar. Length 32 mm at end of instar; similar to third but body laterally black with middorsal black line bordered with grey. Duration, 7 days, plus 1½ days of inactivity spent during pre-ecdysis and ecdysis.

Fifth instar (Fig. 12). Length at end of instar 57 mm; similar to fourth but head 4.5 mm in diameter, horns with 8 long, thin spines (Fig. 20a); body jet black but for 2 dorsolateral white lines and 2 lateral yellow lines; spiracles black encircled with orange; soft white setae 7 mm longest; strong, sharp lower setae tan brown, 2.5 mm in length. Duration, 9 days.

Pupa (Figs. 13 & 14). Length 31 mm; smooth ovate, pale green; cremaster pale yellow,



FIGS. 10–15. *Taenaris catops:* **10,** third instar larvae at rest; **11,** third instar larvae feeding; **12,** mature larva; **13,** ventral profile of pupa; **14,** lateral profile of pupa; **15,** adult female imbibing the juices of a damaged cycad nut.

tipped with black. In shape pupa like that of *T. onolaus* but frontal horns slightly longer, more pointed, tipped with yellow and below this is a ring of pale brown; tubercles of anal rise not as prominent as those of *T. onolaus,* only faintly tipped with brown. Duration, 12 days.

Ecological Observations

Foodplant and habitat. The early stages of *T. catops* were discovered at the center of the *T. onolaus* study area previously described. The foodplant is a new record for *T. catops.* It is a 1.5 m tall ground orchid with large, predominantly white flowers, *Phaius tancarvilleae* (Banks in L'Herit) Bl. The plant has been found in the Bulolo Valley at 800 m growing under *Pinus* in the plantation. This may not, however, be the usual foodplant for the species as D'Abrera (1977) states that *T. catops* feeds on the Black Palm (*Caryota rumpha:* Palmae), Betel-nut palm (*Areca catechu:* Palmae) and Banana (*Musa:* Musaceae). Pyle and Hughes (1978) list *T. catops* from *Cordyline terminalis* (Liliaceae) which is used in hedges in many highland areas of the mainland.

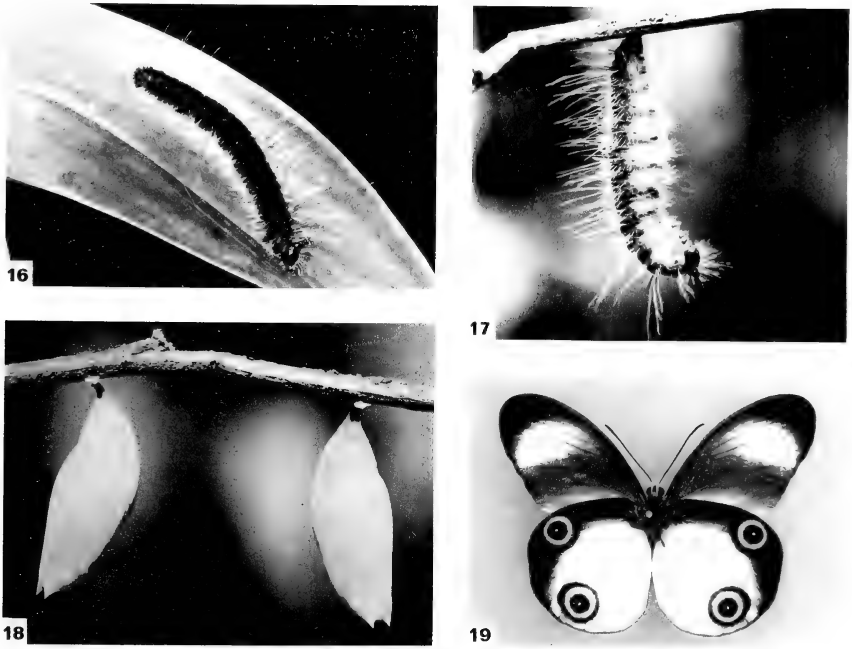
Larval behavior. Like *T. onolaus,* the larvae are gregarious and remain so up to the final instar. They feed in line from the tip of the leaf lamina and eat the blade gradually downwards to halfway or a little less (Fig. 11). The larvae pause at intervals and then move slightly back up the blade to rest.

Adult behavior and abundance. Females of *T. catops,* like those of *T. onolaus,* were more often encountered in the area than males. They were also slightly more abundant than those of *T. onolaus.* Occasionally, up to five at one time were seen in one area.

T. catops has also been found just before dusk hanging inertly beneath foliage. Only at this time can they be approached because they are otherwise always alert and wary when feeding or resting on the uppersides of leaves. In forest areas they prefer to fly in shade. The species has been observed in many localities on the mainland flying just above the leaf litter in search of fermenting fruits on which to feed or probing moist leaf litter.

In spite of their preference for shady habitats, both sexes of *T. catops* can commonly be seen flying through gardens in Bulolo and in straight lines across any open grassland areas in the Bulolo Valley. In sharp contrast, *T. onolaus* has never been observed outside the study area.

It is interesting to note that both *T. catops* and *T. onolaus* were fond of visiting the fermenting husks of cycad nuts on the ground (Fig. 15). At one time a female of *T. onolaus* was seen feeding between two *T. catops* females. At another time five *T. catops* were flushed from beneath two close-growing cycads on which the chrysomelid beetle larvae were feeding. They were seen to probe the fresh green frass of the beetle larvae where it had fallen to the ground. On numerous occasions the cut ends of cycad fronds on the ground which had exuded sap were seen to be extremely attractive to *T. catops*—this is discussed further below.



FIGS. 16–19. *Taenaris myops:* **16,** mature larva; **17,** prepupal larva; **18,** latero-ventral profile of pupae; **19,** underside of male.

Taenaris myops Felder

D'Abrera (1977) lists 13 races of this species. Its full life history was studied from a batch of 37 eggs. These were collected from the underside of the leaf of a monocotyledon, *Tapenochilus* sp., of the Costaceae found in November 1980, growing on a creekside near Eilogo Falls (Port Moresby, Central Province, 10 km grid square EK45). This represents a new foodplant record. However, as the author, after locating the eggs and watching them hatch, had other commitments, the early stages of *T. myops* were reared and photographed by Peter Clark. He noted that, in general, the whole life history was similar to that of *T. catops*.

Egg. Slightly lighter pink but otherwise similar to that of *T. onolaus*.

Larva. First instar. 4 mm long on hatching; head jet black, shiny, covered with fine white setae; body with long fine white setae, up to 1 mm in length; thorax and abdomen opaque creamy white, gut from behind head to last 4 abdominal segments shows as pinkish red line, anal segments with traces of pinkish red.

Second to fourth instars. Larvae at each instar exhibited similar growth rates and maximum sizes as those of *T. catops*. They grew steadily darker so that by fourth instar they were brownish black.

Fifth instar. Length 59 mm at end of instar; head horns with 6 spines (Fig. 20b);

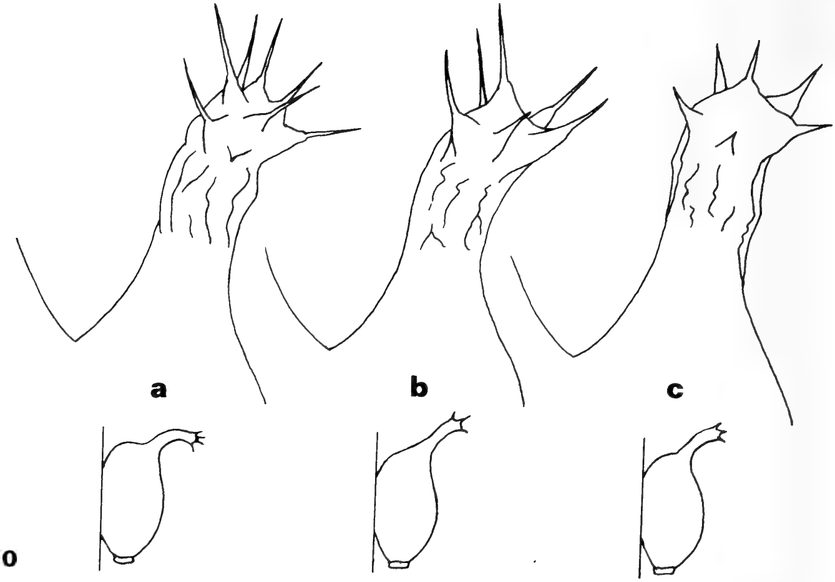


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FIG. 20. Frontal profile of left horn and lateral profiles of *Taenaris* final instar larval head capsules: **a,** *T. catops*; **b,** *T. myops*; **c,** *T. onolaus*.

prothoracic segment wine-red, remainder of thorax and abdomen jet black, not lined as larvae of *T. onolaus* and *T. catops*; spiracles black, encircled with wine-red; body setae soft, long, white, laterally 4 mm, dorsally 10 mm in length; lower strong, black setae 4 mm longest.

Prepupa (Fig. 17). Larval color changed to dark grey dorsally and pale green ventrally after larvae had suspended themselves prior to pupation. Pupation took place 40–42 days after larvae hatched.

Pupa (Fig. 18). 30 mm in length; shape like that of *T. onolaus* but color like that of *T. catops*. Duration, 13 days.

The overall duration from the time that the eggs hatched to the emergence of the adults was 54 days. *T. myops* has been previously recorded in Papua New Guinea feeding on coconut (*Cocos nucifera*) and oil palm (*Elaeis guineensis*) both of the Palmae (Dept. Primary Industry, unpublished).

DISCUSSION

Cycads are known to be toxic and often lethal to cattle. Whiting (1963) discussed the toxicity of cycads in general, and Yang and Mickelsen (1968) have shown that the husk of *Cycas circinalis* is toxic to rats. It is quite probable, therefore, that the larvae of *T. onolaus,* like many "pharmacophagous" butterflies (the *Aristolochia*-feeding swallowtails, for example), can sequester, and store, certain compounds (such as bitter alkaloids) which render them distasteful to birds and other predators. Their bright wine-red color suggests this. The larvae of *T. butleri,* which also feeds on cycads, are also wine-red (T. Fenner, pers. comm.).

It is possible that the larvae of *T. catops* and *T. myops* are more palatable to their predators, because their foodplants are not known to have toxic properties. Other species and their foodplants, which have not yet been mentioned but which are relevant to this discussion, include *Taenaris artemis* Vollenhoven on coconut (*Cocos nucifera:* Palmae) and *T. phorcas* on tanget (*Cordyline:* Liliaceae) (T. Fenner, pers. comm.). Rosier (1960) has found the wine-red larvae of *T. horsfieldii* on *Smilax* (Smilacaceae) and, according to Corbet and Pendlebury (1978), the closely related genus *Faunis* in Malaysia feeds on *Smilax* (Smilacaceae), *Musa* (Musaceae) and *Pandanus* (Pandanaceae). Recent records of other *Taenaris* foodplants sent into the Insect Farming and Trading Agency include *Taenaris dimona* Hewitson on banana (*Musa:* Musaceae) and *Taenaris gorgo* Kirsch on Black Palm (*Caryota rumpha:* Palmae). Both records were from the Maprik area, East Sepik Province. I have recorded the life history of *Taenaris artemis* on *Pandanus* (Pandanaceae) in the Western Province. The larvae were predominantly yellow marked with black.

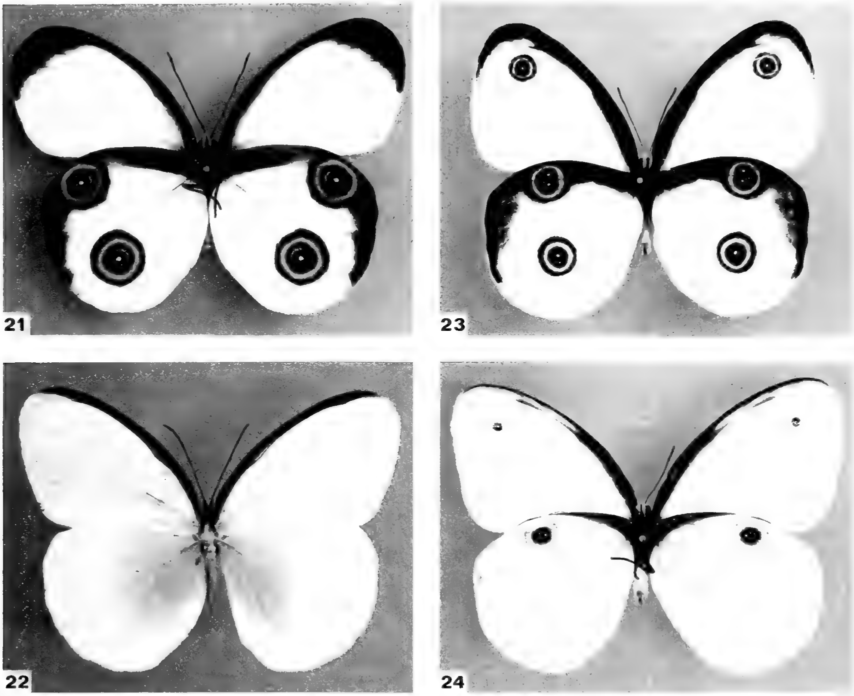
Although *Taenaris* larvae do not appear to advertise their presence, all species nevertheless feed gregariously, which is behavior characteristic of distasteful Lepidoptera. However, on some foodplants the larvae of certain *Taenaris* species may be unable to store adequate secondary plant compounds for their effective protection. If *T. catops* obtains no such protection by feeding on ground orchids, then this may explain why adults were seen to imbibe cycad juices and consequently were so common in the study area. A similar conclusion was reached by Edgar et al. (1976) for danaine butterflies that enhanced their unpalatability by visiting the withered leaves of plants which produced pyrrolizidine alkaloids. The observation that *T. onolaus,* even as an adult, imbibed cycad juices strongly supports the hypothesis that *Taenaris* is a distasteful group of butterflies and that some species enhance this as adults. It may be added that the fermenting skins of cycad nuts have an extremely nauseating smell.

All species of *Taenaris* so far studied in the field have exhibited great wariness and are quick to avoid capture. This, together with their eyespots and the protective hairs and bristles of their larvae, may be considered to be secondary lines of defence if they have been retained from an ancestral form that was more cryptically colored and in which these characters were of primary protective function. Such an ancestor may have looked like the small, dull, species of *Faunis* found in Malaysia today. The general trend to enhance the aposematic attributes of *Taenaris* appears to have been for the butterflies to increase in size, to become lighter, and for the eyespots to become enlarged and highlighted with broader orange borders. Of the cycad feeding species so far studied, the ground color is predominantly black, and the extent of the orange has been greatly increased so that it is highlighted as a warning color. It is interesting to note that the same also appears to be true of the cycad feeding lycaenid *Luthrodes cleotas* from Papua New Guinea which has large patches of orange on the upper and underside of its hindwings in both sexes.

It is possible that the ability of certain *Taenaris* species to feed on cycads as larvae is a recent evolutionary advance. J. Holloway (pers. comm. in discussion) suggested that the initial transfer to these primitive gymnosperms may have been a result of the similarity in the appearance of cycad fronds and those of coconut palms, for example, so that some *Taenaris* females began to oviposit on them by mistake. Alternatively, the transition from angiosperms, such as palms, to the cycad gymnosperms may have been through other angiosperms (such as *Cordyline* or *Tapenochilus*), that acted as "bridges," i.e., they contained secondary substances that were common (or similar) to both. These may have acted either as oviposition cues to the females or phagostimulants to the larvae. The fact that adults of *T. catops* imbibe cycad juices could be taken to imply a closer link of this species with cycads in the past; however, it is also indicative of a chemical similarity between its normal foodplants and cycads.

T. catops exhibits a wide range of geographical forms and it is probable that it is a Müllerian mimic of its close relatives. A recent sampling of *Taenaris* in the Cape Rodney area, Central Province, revealed what appears to be a Müllerian mimicry complex involving four species of morphines (pers. obs., Dec. 1979). These were *Hyantis hodeva* Hewitson, *Taenaris mailua* Grose-Smith, *T. catops* and *T. myops*. They were all extremely alike, and in particular, *T. catops* was more heavily marked than usual with extended black margins to the apices of the fore and hind wings. *T. mailua* differed in the area from the form of the nominate race and was slightly less heavily marked with black. It appears, therefore, that there was a convergence of the phenotypes of all the species in the area. All four species looked identical on the wing.

Müllerian mimicry within the Morphinae appears to be a widespread phenomenon throughout New Guinea in general, and another good example has been recorded from Minj in the Western Highlands Province between *H. hodeva* and *T. catops* where the extremely white form of *T. catops* is predominant (Figs. 22 & 24). *H. hodeva* in the area is almost white, lacks its usual heavy black apical margins and has



FIGS. 21–24. Müllerian mimicry in female morphines: **21,** normal *Taenaris catops* from Bulolo; **22,** albinotic *T. catops* from Minj; **23,** normal *Hyantis hodeva* from Bulolo; **24,** albinotic *H. hodeva* from Minj. (Males from the two localities are like their females.)

reduced eyespots. In and around the Bulolo Valley the same species are also alike, but in this locality they are heavily marked (Figs. 21 & 23) and conform to the more normal and widespread phenotypes.

Other butterflies are probably Batesian mimics of *Taenaris*. For example, the female of *Mycalesis drusillodes* Oberthür is thought to be mimetic of *H. hodeva* (Vane-Wright, 1971). Both model and mimic have been collected from the Torricelli Mountains near Maprik in the East Sepik Province (P. Clark, pers. comm.) and at Mt. Bosavi in the Southern Highlands Province (pers. obs., April 1980). The satyrine genus *Elymnias* is apparently mimetic of certain species of *Euploea* (Danainae), and *Elymnias agondas* Boisduval females are extremely good mimics of *Taenaris bioculatus* Guérin and *T. catops* where the models and mimics occur sympatrically. *Hypolimnas deois* Hewitson (Nymphalidae), in color and pattern, is very *Taenaris*-like and may be mimetic of *T. onolaus* in the Bulolo Valley. It is also assumed that the female form *onesimus* Hewitson of *Papilio aegeus* Donovan (Papilionidae) mimics *T. catops*, and this form is also commonly seen around Bulolo. If this is so, then the female form *amanga* Boisduval of this swallowtail is a good candidate to be a mimic of *T. onolaus*. It has been seen frequently in the study area and strongly resembles *T. onolaus* in flight.

A more detailed study of the foodplant relations and mimetic associations of these butterflies will prove most interesting as further life-histories and the foodplants of other species of *Taenaris* are discovered.

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I am most grateful to Ted Fenner (Department of Primary Industry, Darwin, Australia), Dick Vane-Wright and Jeremy Holloway (British Museum of Natural History, London), all of whom have improved this manuscript by their most helpful suggestions. Also to Peter Clark (Insect Farming and Trading Agency, Bulolo, PNG) for his assistance in completing the rearing and the photography of *T. myops*.

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A NEW SPECIES OF *SIMILIPEPSIS* AND TAXONOMIC PLACEMENT OF THE GENUS (SESIIDAE)

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ABSTRACT. A new species of the wasp-like sesiid of the genus *Similipepsis* is described, and the taxonomic placement of this genus into the subfamily Tinthiinae is proposed.

The Section of Entomology of the Carnegie Museum of Natural History (CMNH) maintains a large collection of insects that has been vastly underutilized by systematists. The collection is rich in all insect groups but butterflies and moths are particularly abundant. The diversity of taxa is particularly evident among the collection of unsorted moths in which I found a sesiid specimen with remarkable ichneumonoid resemblance.

Further study of this wasp-like moth revealed that it belongs in the genus *Similipepsis*, a genus described by LeCerf (1911) and heretofore taxonomically unaligned in the Sesiidae hierarchy. Heppner and Duckworth (1981:44) in their recent work made no study of this genus. They listed *Similipepsis* among other "unassigned" sesiid genera, leaving this problem for further research.

My studies of the genus revealed that *Similipepsis* species are characterized by having the abdomen constricted to a slender pedicel at the base, the proboscis normal, labial palpus oblique with the second joint of long hairs, forewing veins R_4 and R_5 stalked and M_1 missing, hindwing with vein Cu_1 from just before angle of cell and widely separated from Cu_2, hind leg wasp-like. The genus is further recognizable by the absence of the scale tuft on the tip of the antennae. According to recent classification (Naumann, 1971; Duckworth & Eichlin, 1977), these two characteristics suggest that *Similipepsis* has affinities and should be placed with genera of the subfamily Tinthiinae.

To date, there are only four known species of *Similipepsis*, *S. aurea* Gaede, *S. lasiocera* Hampson, *S. typica* Strand and *S. violaceus* LeCerf. The genus is paleotropical in origin and is confined geographically to the Ethiopian and Oriental regions. After reviewing specimens and literature of known species (Strand, 1913; Hampson, 1919; Gaede, 1929), I determined that the aforementioned specimen in the Carnegie

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FIG. 1. Adult male (holotype) of *Similipepsis ekisi* Wang, new species.

collection collected from the Cameroons was quite distinctly different and not conspecific with the known species.

I am indebted to Dr. Ginter Ekis for offering me the opportunity to study in the Section of Entomology. I would also like to express my appreciation to Dr. Chen Wen Young, the Collection Manager of the Section, for various courtesies during my six month research visit. I am indebted to Anna Tauber and Pat Vachino for literature and clerical assistance, and also to Vincent Abromitis, Section of Exhibits, for photographic assistance. Dr. Craig Black, Director of the Carnegie Museum of Natural History, provided the financial assistance that made it possible for me to come to the United States.

Similipepsis ekisi, new species

Holotype: Male Metet (Adamaoua), Cameroon (Republic of Cameroon), 15 August 1919. A. I. Good. Carn. Mus. Acc. 6552 (deposited in CMNH, Holotype number 775).

The holotype is associated with the following items: sex label (white, machine print); locality label (white, machine print); collection date label (white, machine and hand print); accession label (white, machine and hand print); CMNH repository label (yellow, machine print); holotype label (red, machine and hand print).

Male. Head: vertex black; frons brown; occipital fringe greyish white; vertex laterally with fringe greyish white mixed with black; labial palpi upturned, first and second segments brown and covered with extended long bushy scales, second segment less expanded than first, with brown scales on both sides and white erect scales on inside border, third segment white and sharply upturned above vertex; antenna brown and bipectinate, devoid of apical scale tuft; proboscis present. Thorax dark brown, tegula brown; metathorax with minute, slender brown and white hairy scales extended from base of hindwing. Abdomen dark brown, first segment expanded slightly, second extremely narrowed and extended into a long stalk, third slightly expanded, fourth and fifth greatly expanded, sixth and seventh narrowed; anal tuft covered with setaceous, V-shaped brown scales; underside of third abdominal segment with ring of V-shaped white scales. Forewing transparent, except on costal margin; stem of R vein covered with dark brown scales, dark brown scales scattered in region of cell; cilia brown. Hindwing hyaline, with few scattered scales; veins and margins brown; cilia brown. Foreleg: front of femur, with long row of compressed brown scales; tibia brown with metallic sheen; tarsus with metallic blue setaceous scales on tarsomere; other tarsal segments white. Mesothoracic leg dark brown, scales metallic blue, green or red. Tarsus brown, with spiny scales on tarsomere, other tarsal segments with mixture of white and brown scales. Hindleg dark brown, with two pairs of long white spurs. Forewing expanse, 26 mm. Adult as shown in Fig. 1.

Distribution: Known only from holotype from Metet (7°05′N, 13°17′E), Adamaoua, Cameroon, in Western Africa.

Remarks: This species is superficially similar to S. *violaceus*. It differs from S. *violaceus* by the narrower costal margin. Also, the ventral side of the abdomen of the S. *ekisi* specimen with V-shaped white band which is distinctly absent in S. *violaceus*.

This species is named in honor of Dr. Ginter Ekis, Curator of Section of Entomology, Carnegie Museum of Natural History at this writing.

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NOTES ON THE LARVA OF *CARGIDA PYRRHA* (NOTODONTIDAE)

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ABSTRACT. The ultimate instar larva of *Cargida pyrrha* (Druce) (Notodontidae) is described. Illustrations of its mandible and hypopharyngeal complex are included. The host plant of *C. pyrrha* is *Condalia lycioides* (A. Gray) Weberb.; an earlier report of *Lycium* may be in error.

Comstock (1959) described the egg and several larval instars of *Cargida pyrrha* (Druce), including what he called ". . . the third or fourth instar . . . ." (see his fig. 2). He succeeded in obtaining a subsequent larval instar, which he noted did not appreciably change in pattern or color from the preceding instar, but it is not certain that he was referring to the ultimate instar. His larvae were reared from eggs that he found in Madera Canyon, Santa Rita Mountains, Arizona, on twigs of *Lycium* (Solanaceae), a questionable host identification. The eggs resembled those laid by captive *Cargida pyrrha* which he had observed earlier, and on that basis he identified the eggs and larvae subsequently described. However, no adults were reared to substantiate his judgement, and the identification cannot be definitely confirmed because of the apparent lack of preserved specimens. According to Donahue (pers. comm.), Comstock saved very few larval specimens during his work and did not give any larvae of *C. pyrrha* to the Los Angeles County Museum of Natural History, the main depository for his material. Based on the similarity of his figured "intermediate" instar from Madera Canyon to the mature larvae of *C. pyrrha* that the late R. G. Beard and I collected in 1967 (see below), it is assumed that his determination was correct. The purpose of this article is to comment on the host plant association of *C. pyrrha* and to describe the ultimate instar as a complement to Comstock's earlier information on this species.

Numerous mature larvae of *Cargida pyrrha* (Fig. 1) were seen defoliating white crucillo, *Condalia lycioides* (A. Gray) Weberb. (Rhamnaceae), on 31 July and 1 August 1967 at 4200 ft in Guadalupe Canyon (Cochise County) in the extreme southeastern corner of Arizona. Actively feeding larvae were collected—several per bush at sunset on both evenings. The range of daily feeding activity is unknown. Within a few days they finished their larval feeding, and from 17 associated moths which emerged in 1968, J. G. Franclemont determined their identity.

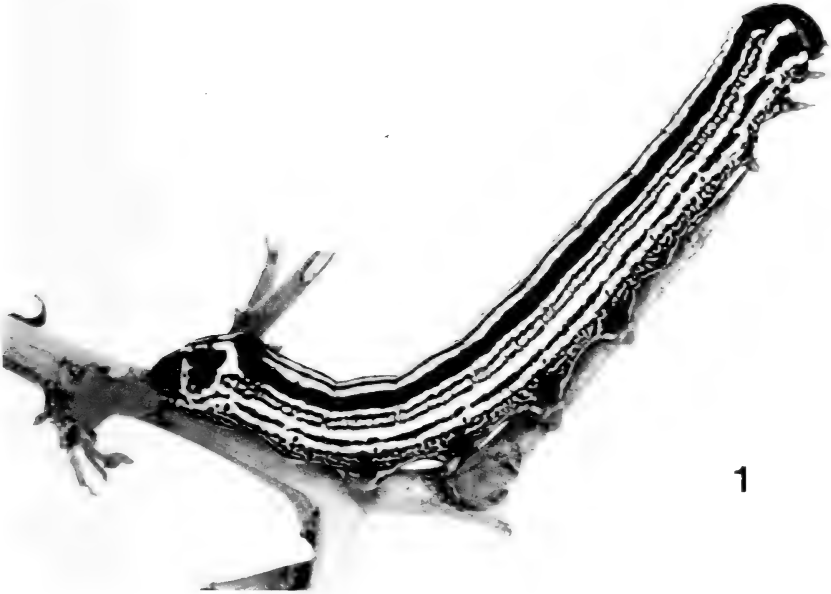


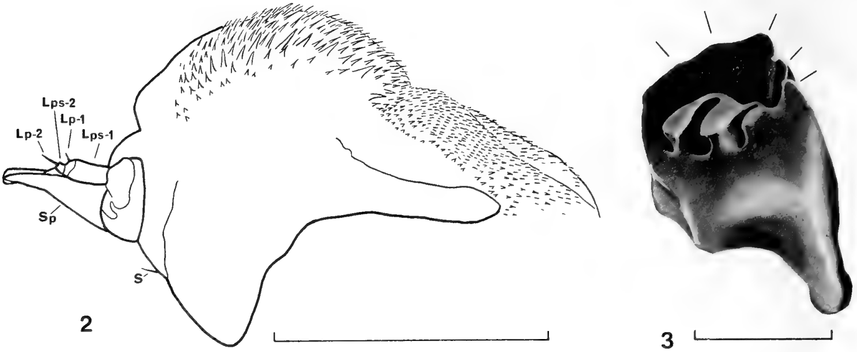
FIG. 1. *Cargida pyrrha,* mature larva, Guadalupe Canyon, Cochise County, Arizona (photo by J. G. Franclemont).

Comstock's record of *Lycium* needs to be verified, because he may have misidentified the host. McFarland (pers. comm.) wrote that the plant illustrated by Comstock looks much like the figure of *Condalia lycioides* in Benson & Darrow (1954, fig. 60A) [*Ziziphus obtusifolia* (Hooker) A. Gray var. *canescens* (A. Gray) M. C. Johnston in Benson & Darrow (1981)] and like the *C. lycioides* growing in his own garden, partly because its leaves are not in fascicles. The leaves of *Lycium* are mostly fasciculate (Kearney & Peebles, 1960). McFarland added that the first time he saw *Condalia lycioides* he was sure that he was looking at a *Lycium.*

Cargida pyrrha (Druce)

General (Fig. 1): Total length 30–38 mm. Chaetotaxy basically noctuoid with extra setae only on lateral aspects of Ab3–6 prolegs. Head: smooth, width 3.3–3.8 mm. Body: integument smooth, velvety in appearance; dorsum of Ab8 slightly humped. All setae simple. Prolegs present on Ab3–6, 10; pairs on Ab3–6 subequal, Ab10's slightly reduced; crochets in uniordinal, homoideous mesoseries. Midventral prothoracic glandular opening present.

Hypopharyngeal complex (Fig. 2): Spinneret tapers distad, about twice length of Lps-



FIGS. 2 & 3. *Cargida pyrrha:* **2,** hypopharyngeal complex, left lateral view (Lp-1 = seta on first segment of labial palpus, Lp-2 = seta on second segment of labial palpus, Lps-1 = first segment of labial palpus, Lps-2 = second segment of labial palpus, S = stipular seta, Sp = spinneret); **3,** left mandible, oral view (leader lines mark positions of the five outer teeth). Scale lines = 0.5 mm. Descriptive terminology follows Godfrey (1972).

1, surpasses tip of Lp-2, dorsal margin of tip U-shaped in transverse cross section, distal lip entire. Stipular seta about half length of Lps-1, twice length of Lp-1 and also of Lps-2, subequal to Lp-2. Distal region separated from proximal region by shallow medial transverse cleft; spines absent proximate to spinneret, becoming numerous proximad. Proximolateral and proximomedial regions uniformly covered by short, thin spines.

Mandible (Fig. 3): Outer teeth low, obtusely triangular, five teeth discernible (appear to be worn in available specimens); three large inner teeth present, flattened distally, adjoined by sinuate bridge. Two outer setae present (not visible in oral view of Fig. 3), insertions widely separated from each other.

Coloration: Head black. Body ground color black; dorsal area black with two yellow stripes continuous to Ab8; subdorsal lines white; dorsal and ventral stripes of subdorsal area white and yellow respectively, both with black dorsal borders; lateral area yellow with black line above spiracles; ventral area mottled black and white with yellow line at level of prolegs and black midventral line; black patches above prolegs. Thoracic legs and prolegs orange. Spiracles black.

Material examined: Six mature larvae: Guadalupe Canyon, 4200 ft, Cochise County, Arizona; 31 July & 1 August 1967; feeding on *Condalia lycioides* (A. Gray) Weberb.; G. L. Godfrey & R. G. Beard, collectors. Hypopharyngeal complex on GLG Slide 2500, John G. Franclemont Collection.

The character of the three, large, adjoined inner teeth on the mandible of *Cargida pyrrha* readily separates this species from other described notodontid larvae in the USA. Nothing comparable was found in the larvae of 26 other genera of North American notodontids that I recently examined. Note also that Gardner (1943) did not mention similar mandibular structuring in any of the Asiatic notodontid larvae, representing 14 genera, that he described. Perhaps this character will prove to be of some phylogenetic importance. However, notodontid larval mouthparts presently are too meagerly documented to evaluate their phylogenetic implications, let alone draw conclusions from the mandible of a single species.

ACKNOWLEDGMENTS

I thank J. G. Franclemont, Cornell University, for his assistance and kind hospitality that made the completion of this paper possible. I also thank N. McFarland, Sierra Vista, Arizona, for his comments on *Condalia* and *Lycium*, and J. P. Donahue, Los Angeles County Museum of Natural History, for his information. P. A. Hyppio, Bailey Hortorium, Cornell University, provided the identification of *Condalia lycioides*. This project was funded in part by USDA AGR RMA Grant No. 12-14-100-8031-(33), Franclemont, Principal Investigator, and by support from the Illinois Natural History Survey. Preliminary drafts of the manuscript were reviewed by Franclemont, McFarland, L. M. Page, J. D. Unzicker, and D. W. Webb.

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THE LARVA OF *AUTOGRAPHA FLAGELLUM* (WALKER) (NOCTUIDAE: PLUSIINAE)

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ABSTRACT. The mature larva of *Autographa flagellum* (Walker) is described and illustrated.

The noctuid genus *Autographa* Hübner (Plusiinae) is represented in North America by sixteen species (Eichlin & Cunningham, 1968). Larval descriptions of only eight species have been published to date. The larvae of our known species of *Autographa* are all semi-loopers, lacking prolegs on abdominal segments 3 and 4. In the past, identification of all our nearctic Plusiinae has been difficult due to the small number of reliable differentiating characters available. Recent investigations have shown that the larval mouthparts, especially the hypopharyngeal complex, offer good separating characters (Eichlin & Cunningham, 1969, 1978). The larvae have been reported as feeding on a wide variety of low plants and trees (Eichlin & Cunningham, 1978).

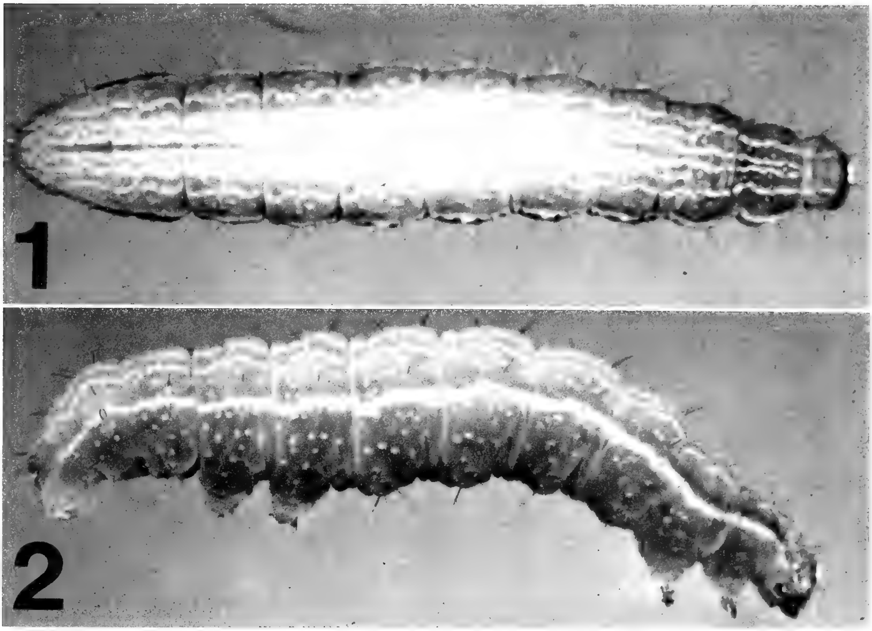
Autographa flagellum was described by Sir Francis Walker in 1857 from material collected at St. Martins Falls, Ontario. *A. flagellum* is a boreal species distributed from Newfoundland west to Alberta (Forbes, 1954) and British Columbia (Llewellyn-Jones, 1951) and in the east, south to Maine and New Hampshire (Eichlin & Cunningham, 1978). Although Tietz (1972) lists *Helianthus* sp. and *Liatris* sp. as host plants, no description of the immature stages has been published.

Ova were obtained from a female *A. flagellum* collected on 4 July 1978 at Belliveau Cove, Digby County, Nova Scotia. Larvae were fed an artificial diet based on that of Hinks and Byers (1976). All larvae grew quickly and had pupated by 1 September 1978. Adults emerged 1–10 October. Under natural conditions, *A. flagellum* overwinters as a third or fourth instar larva, as do most northern Plusiinae (Eichlin & Cunningham, 1978).

This paper describes the mature larvae of *Autographa flagellum*. The terminology and abbreviations used follow Godfrey (1972) and Eichlin and Cunningham (1969, 1978). All illustrations were drawn to scale using a camera lucida and stereomicroscope.

Autographa flagellum (Walker)

General. Head 2.4–2.9 mm wide. Total length 33.5–36.1 mm. Head and body smooth, no microspines or granules present. No vestige of prolegs present on Ab3–4. Prolegs on



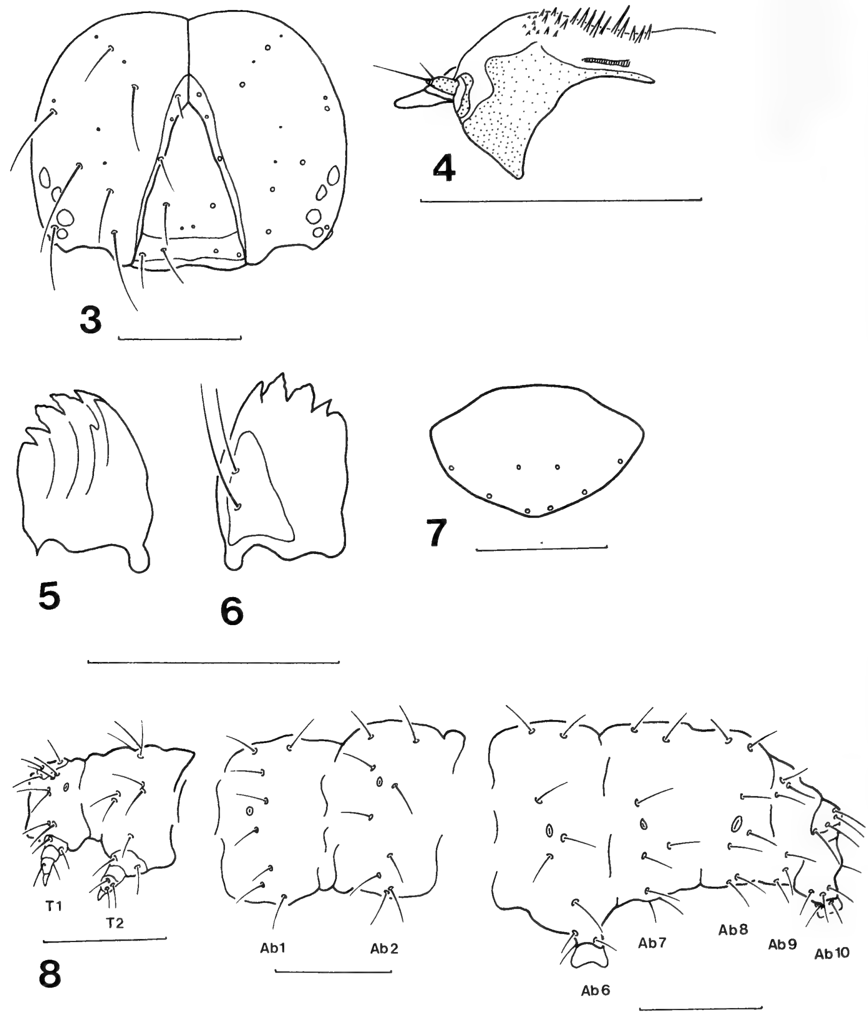
FIGS. 1 & 2. *Autographa flagellum:* **1,** dorsal view; **2,** lateral view (×3).

Ab5 same size as those on Ab6. Crochets biordinal, 21–23 per fifth and sixth abdominal proleg. All setae simple.

Coloration (living material). Head (Fig. 3): Yellowish brown, no coronal freckles or reticulations present. Body (Figs. 1 & 2): Green with white flecks, flecks heaviest in subdorsal, lateral, and ventral areas; ventral half of subdorsal area on T1–3 darker green; dorsal margin of lateral area white; middorsal line green with narrow white line on edges; white lines obsolete on T1; subdorsal area green with narrow white line on dorsal and ventral edges; lines on dorsal edge obsolete on T1–3. Spiracles yellowish brown with darker brown peritremes. Lateral shield of prolegs green, becoming yellowish brown distally. Thoracic legs yellowish brown, darker brown distally. Prothoracic shield yellowish brown.

Head (Fig. 3). Epicranial suture 0.59–0.64 mm long; height of frons (apex to Fa's) 0.75–0.78 mm; distance from F1 to anterior edge of clypeus 0.40–0.42 mm; interspace between F1–F1 0.31–0.34 mm; AFa anterior and AF2 posterior to apex of frons; A1–A3 forming an obtuse angle at A2; P1–P1 0.67–0.71 mm; P2–P2 0.85–0.87 mm. Distance from P1 to epicranial suture about ⅔ that from P1 to L; L posterior of juncture of adfrontal ecdysial line. Ocellar spacing: Oc1–Oc2 0.07–0.09 mm; Oc2–Oc3 0.05–0.07 mm; Oc3–Oc4 0.03–0.04 mm.

Mouthparts. Hypopharyngeal complex (Fig. 4): Spinneret elongate, tapering distally, subequal to Lp2; Lps1 shorter than Lp2; Lps2 less than ⅔ the length of Lp1; stipular setae extremely short, about 1/16 length of Lps1, 1/12 length of Lp1, and about 1/22 length of Lp2; distal and proximal regions of hypopharyngeal complex continuous; distal ⅓ bare, remainder spined, spines becoming much longer and more robust proximally. Raduloid with 18 ridges. Mandible (Figs. 5 & 6): Two well-separated outer setae present; inner surface with three distinct ridges and small, acutely angled inner tooth on rib 2; six outer



FIGS. 3–8. *Autographa flagellum:* **3,** head capsule, frontal view; **4,** hypopharyngeal complex, left lateral view; **5,** left mandible, oral surface; **6,** left mandible, outer surface; **7,** anal shield, dorsal view; **8,** dorsolateral chaetotaxy of prothoracic (T1), mesothoracic (T2), and abdominal segments (Ab1–2 and Ab6–10). Scale lines = 1 mm.

teeth present, first small, second to fifth well-developed and angular; second to fourth serrated on both sides; sixth outer tooth about twice width of fifth, low and rounded.

Thorax. Segment T1 (Fig. 8): Prothoracic shield smooth and weakly sclerotized; SD1 and SD2 setal insertations well-separated from shield; SD1 very fine and hairlike with thickened sclerotized annulus at base; L2 as in SD1 but with annulus thinner and less heavily sclerotized; interspace D1–D1 about 0.67 XD1–XD1; D1–SD2 about 1.34 SD2–XD2; spiracle transversely aligned with posterior margin of prothoracic shield, elliptical, 0.21–0.23 mm high, 0.13–0.14 mm wide; peritreme wider laterally; coxal bases contiguous. Segments T2–3 (Fig. 8): SD1 very fine, but with annulus narrower and less heavily sclerotized than on T1; SV2 obsolete; all setae hairlike, tapering and sharply pointed; coxal bases narrowly separated.

Abdomen. No vestige of prolegs present on Ab3–4. Dorsal and lateral chaetotaxy of Ab1–10 as in Fig. 8. SD1 thicker, not fine as on T1–3. Ab1 and Ab7–8 with SV2 lacking, Ab2–4 with SV1 and SV2 partially fused. Ab4: V1–V1 close together; V1–SV2 about twice the distance of V1–V1. Ab10: Anal shield as in Fig. 7. Dorsal margin convex, posterior margin entire. Length of D1 on Ab6–7 0.57–0.61 mm; D2 0.71–0.72 mm. Asp7 0.22–0.25 mm high, 0.13–0.14 mm wide; Asp8 0.35–0.36 mm high, 0.17–0.20 wide.

Material examined. 10 specimens: Belliveau Cove, Digby County, Nova Scotia. Reared on artificial diet (Hinks and Byers, 1976) from ova obtained from a female collected on 4 July 1978. Adults emerged 1–10 October 1978. Moth collected, determined, and larvae reared by K. A. Neil.

Remarks

Based on the key to the known species of Plusiinae larvae given by Eichlin and Cunningham (1978), *A. flagellum* appears closest to *A. rubida* Ottolengui, as both species have a tooth on the second mandibular ridge. *A. flagellum* differs from that species, however, by its overall green color including the head, the smooth integument, the V1–V1 interspace on Ab4, and by the raduloid which has 18 ridges.

ACKNOWLEDGMENTS

I thank Dr. T. D. Eichlin of the Insect Taxonomy Laboratory, Sacramento, California for reviewing this manuscript and Ronald Long of Simon Fraser University for the photography.

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A NEW HAWKMOTH FROM QUINTANA ROO, MÉXICO

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ABSTRACT. A new species of *Manduca* Hubner is described in its adult stage. This species is similar in maculation to *Manduca morelia* (Druce) and *M. pellenia* (Herrich-Schäffer). Differences in size, wing shape and genitalia prove it to be distinct.

Manduca wellingi, new species
(Figs. 1–5)

Wing length. Males: 41 mm (35–44 mm, n = 64); females: 46 mm (44–50 mm, n = 10). *M. wellingi* two-thirds size of *morelia* (Druce). Rothschild and Jordan (1903:79) treated *morelia* as being synonymous with *pellenia* (Herrich-Schäffer). A review of the original description of *morelia* makes it clear that this is incorrect.

Wing maculation and shape. Color and maculation of *wellingi* very similar to those of *morelia*. Both species show about same degree of color variation when series compared. Forewing of *wellingi* light, sandy brown to tawny, with confluent series of black lustrous patches in median space, forming large, semicircular band, ends of which intersect costal

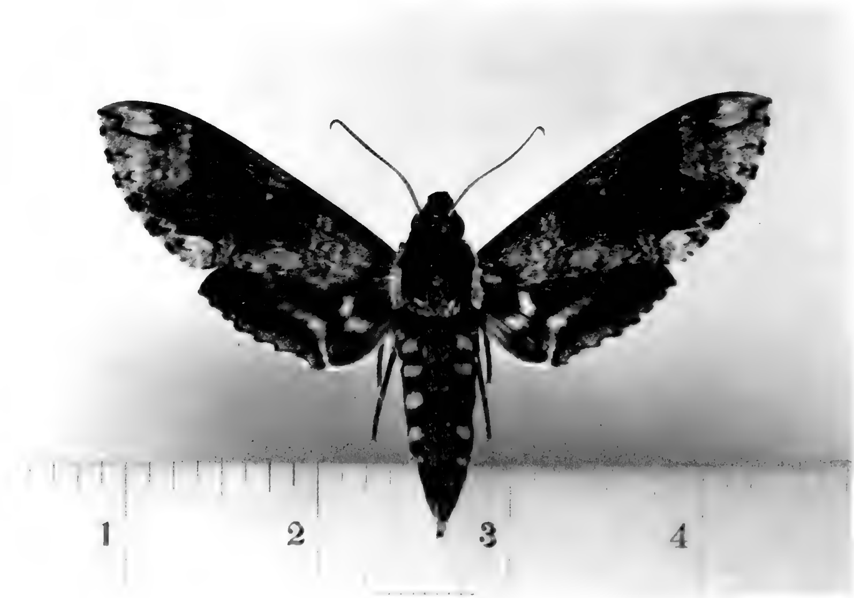

FIG. 1. *Manduca wellingi*, n. sp. Holotype, male, Nuevo X-cán, Quintana Roo, México. 27 Sept. 1981 (E. C. Welling M.; U.S. N.M.N.H.).

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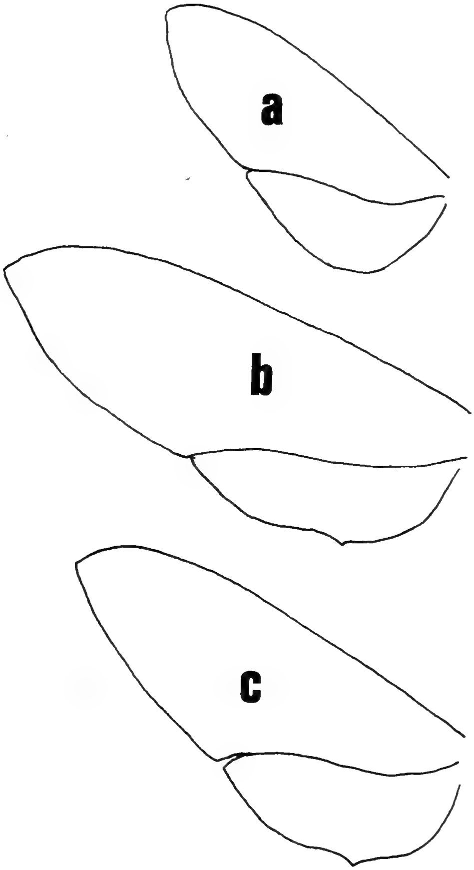

FIG. 2. Wing outline comparison of males (**a**) *Manduca wellingi*, (**b**) *Manduca morelia*, (**c**) *Manduca pellenia*.

margin. Most evident are crescent shaped, off-white stigma, distinct, oblique, zig-zag, black apical dash, crenulate subterminal line that essentially parallels postmedial band, which, as in *morelia*, consists of two, closely parallel lines. Both postmedial and antemedial bands double and may appear triple as they are paralleled on side toward median space by usually less distinct, diffuse, mesial lines. Base pale, with one or two minute tufts of nearly white scales, enclosed by dark basal band that may be bisected by short, diffuse basal dash. Basal space with dark spot near middle. Nearly black hindwing crossed by two pale bands corresponding in position to antemedial and postmedial. Outer one runs from anal angle to costal margin just beyond middle, and inner one is small curved band enclosing black basal area. Light-brown outer margin becomes obscured distally. Forewing beneath is dark gray. In males, entire dark ventral surface heavily sprinkled with light-brown scales except for outer marginal band where light colored scales are wanting. Hindwing below exhibits same features, although light-brown scales dominate entire surface to much greater degree. Dark outer marginal band present and more distinct than on forewing. In females, amount of light-brown scales greatly reduced or

FIG. 3. Genitalia, *Manduca wellingi*, male.

nearly absent on underside of forewing, and outer marginal band is hardly distinguishable. Hindwing similar to that of males. Both sexes have set of three sinuous dark median lines which arise at common point at anal angle of hindwing and transgress costal margin of forewing. Wing shape of *wellingi* clearly different from that of *pellenia* and *morelia* (Fig. 2).

Other maculation. Thorax dorsally off-white, ventrally dark brown, completely surrounded by heavy black line. Tegula and head essentially concolorous with forewings. Palpus black on segment 3, but segments 2 and 1 mixture of light and dark brown.

Abdomen typical for genus, with dorsal area similar in color to forewings, with distinct, full-length, medial black line; laterally black with large yellow patch on segments. Obsolescent sixth spot, more noticeable in females, sometimes evident. Below and between each yellow patch are small, narrow, white intersegmental bands. Ventral surface off-white with brown scales throughout and usually with medial row of 1 to 4 small black spots.

Genitalia. Genitalia of *pellenia* have been illustrated in Rothschild and Jordan (1903) and Mooser (1940) and are sufficiently different not to be confused with those of either *morelia* or *wellingi*.

In *wellingi* (Fig. 3) apex of sacculus serrated and sometimes narrower than in *morelia*. Process of sacculus acuminate and curved inward more in *wellingi*. Hooked apex of gnathos minimal, unlike that of *morelia*, which has pronounced hooked apex. In female of *wellingi* (Fig. 4), lamella postvaginalis large and posterior margin only slightly indented. Lamella postvaginalis of *morelia* (Fig. 5) reduced in size and posterior margin strongly emarginate, unlike *wellingi*.

Flight period. Adult specimens have been taken each month from 2 April to 2 November, the greatest number being recorded during June.

Types. HOLOTYPE ♂ (Fig. 1) Nuevo X-cán, Quintana Roo, MÉXICO. 27 Sept. 1981, E. C. Welling M. collector. USNM type no. 100721. ALLOTYPE ♀, same locality, 27 July

wellingi

FIG. 4. Genitalia, *Manduca wellingi*, female.

1979, E. C. Welling M. PARATYPES: Same locality, 1 ♂, 1 ♀, 2 Sept. 1960, 1 ♂, 2 July 1963, 1 ♂, 1 ♀, 15 Aug. 1963, 1 ♂, 6 June 1967, 1 ♂, 9 June 1967, 1 ♂, 29 July 1970, 1 ♂, 12 June 1971, 1 ♂, 14 June 1971, 1 ♂, 25 Sept. 1975, 1 ♂, 10 June 1974, 1 ♂, 12 Sept. 1974, 1 ♂, 5 June 1975, 1 ♂, 1 Nov. 1976, 1 ♂, 15 June 1977, 1 ♂, 15 July 1977, 1 ♂, 24 Aug. 1977, 1 ♂, 15 July 1979, 1 ♂, 2 Aug. 1979, 2 ♂♂, 5 June 1980, 1 ♂, 10 June 1980, 1 ♂, 18 June 1980, 1 ♂, 20 June 1980, 1 ♂, 9 July 1980, 1 ♂, 1 Aug. 1980, 1 ♂, 2 Aug. 1980, 1 ♂, 15 Aug. 1980, 1 ♂, 28 Aug. 1980, 1 ♂, 29 Aug. 1980, 3 ♂♂, 1 Sept. 1980, 1 ♂, 2 Oct. 1980, 1 ♂, 1 Apr. 1981, 1 ♀, 5 Apr. 1981, 1 ♂, 25 Apr. 1981, 1 ♂, 27 Apr. 1981, 1 ♀, 4 June 1981, 1 ♂, 9 June 1981, 1 ♂, 12 June 1981, 3 ♂♂, 18 June 1981, 1 ♂, 1 ♀, 22 June 1981, 1 ♂, 1 ♀, 25 June 1981, 1 ♂, 26 June 1981, 1 ♂, 1 ♀, 28 June 1981, 2 ♂♂, 29 June 1981, 1 ♀, 28 June 1981, 1 ♂, 29 June 1981, 1 ♂, 1 ♀, 1 July 1981, 1 ♂, 3 July 1981, 1 ♂, 7 July 1981, 1 ♂, 9 July 1981, 1 ♂, 20 July 1981, 1 ♂, 30 July 1981, 1 ♂, 19 Aug. 1981, 1 ♂, 13 Sept. 1981, 2 ♂♂, 17 Sept.

FIG. 5. Genitalia, *Manduca morelia,* female.

1981, 1 ♂, 20 Sept. 1981, 1 ♀, 22 Sept. 1981, 1 ♂, 1 Oct. 1981. Tintal, Quintana Roo, México, 2 ♂♂, Sept. 1976. Chetumal, Quintana Roo, México, 1 ♂, 11 May 1977, 1 ♂, 12 May 1977. Tikal, El Petén, GUATEMALA, 1 ♂, 18 July 1981.

Holotype and allotype deposited in the U.S. National Museum of Natural History; paratypes in American Museum of Natural History, British Museum of Natural History, Universidad Central de Venezuela, Instituto de Biología, México, D.F., México, and in the collections of E. C. Welling M. and V. A. Brou.

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NATURAL HISTORY NOTES FOR *TAYGETIS ANDROMEDA* (CRAMER) (SATYRIDAE) IN EASTERN COSTA RICA

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ABSTRACT. The early stages and a larval food plant are reported for the first time for *Taygetis andromeda* (Cramer), as studied in eastern Costa Rica. Various aspects of larval and adult behavior, including feeding and egg-placement, are also discussed for this widespread Central American satyrid. The larval food plant is a grass, *Acroceras zizanioides* (Graminae).

Taygetis andromeda (Cramer) is a common butterfly (Fig. 1) of forest and old secondary habitats from 0 to 1500 m on the Pacific and Caribbean watersheds of Costa Rica (A. M. Young, pers. obs.; P. J. DeVries, pers. comm.). The butterfly is also widespread throughout much of Central America and South America. It is one of four species of *Taygetis* reported from Central America, along with different species in Mexico, Central America, and South America which often exhibit distinctive patterns of range separation by habitat and elevation (Ross, 1976; Ebert, 1969; Lamas, 1967; P. J. DeVries, pers. comm.). While some fragmentary information on the early stages of South American *Taygetis* other than *andromeda* exist (Muller, 1886; d'Almeida, 1922), the present paper constitutes the first report of early stages and larval food plant for *T. andromeda*.

METHODS

The majority of observations were made at two localities on the Caribbean or Atlantic watershed of eastern Costa Rica: "Finca La Tigra," near La Virgen (10°23′N, 84°07′W; 220 m elev.), Heredia Province (described as "premontane tropical wet forest"); "Finca Experimental La Lola," near Siquirres (10°06′N, 83°30′W; 30 m elev.), Limon Province (described as "lowland tropical wet forest"). At "La Tigra" I observed *T. andromeda* adults on a pile of rotting bananas placed along a footpath through old secondary forest adjacent to a cacao plantation; the bait was used at wide intervals between 1977 and 1982 to observe this species and other butterflies. At "La Lola" I witnessed egg-placement (oviposition) behavior in *T. andromeda* and conducted a study of the early stages by confining recently deposited eggs in large clear plastic bags along with fresh cuttings of the larval food plant. These cuttings were replaced every two or three days, and the bag was kept tightly shut. A voucher specimen of the food plant was collected

FIG. 1. *Taygetis andromeda,* reared from eastern Costa Rica: dorsal (**left photo**) and ventral (**right photo**) aspects of the adult.

for determination. A careful check of early stages being reared was made to describe each stage, including estimates in days of duration for each stage. The bulk of the rearing was conducted at La Lola, with conditions in the rearing bag being of room temperature, which was the same as the air temperature in the nearby "La Lola" cacao plantation.

RESULTS

Adult Natural History

Taygetis andromeda adults readily come to rotting bananas on the ground in wet forest. Throughout the year at "La Tigra," there is usually a mix of "worn" and "fresh" butterflies, suggesting a continuously breeding population here. The butterfly is often seen on bait with several other butterflies, including *Morpho peleides limpida* Butler, *M. granadensis polybaptus* Butler (see also Young, 1982 for data on the abundances of these two species on banana baits at "La Tigra") (Morphidae), *Caligo memmon* Cramer, *Caligo atreus uranus* H.-Schaff. (Brassolidae), *Caerois* sp. (Satyridae), *Nessaea aglaura* Feld., *Myscelia ethusa* Bsdv., and *Prepona* spp. (Nymphalidae). Within the shaded forest understory, *T. andromeda,* in my experience, generally flies within one meter of the ground. Males are far more common at baits than females, a condition reflected also in the fact that males mostly collected at baits are more commonly represented in museum collections for this species.

Egg-Placement Behavior and Larval Food Plant

On 22 July 1982 at 1400 h, I observed *T. andromeda* ovipositing in an approximately 100 m^2 patch of grasses (canopy height 0.5–1.0 m) in a "light gap" within the "La Lola" cacao plantation. The butterfly alighted cross-wise on a broad blade of the bamboo-like grass used as a larval food plant here. The butterfly then curled the abdomen around to the underside and placed a single egg on the blade. She then flew off and repeated the behavior on nearby individuals of the same plant. The larval food plant, which is also the egg-placement site, is the grass *Acroceras zizanioides* (H.B.K.) Dandy (Graminae), as determined from fresh specimens by Dr. Richard Pohl. This grass species is common in the lowland and premontane wet forest regions of Costa Rica (R. Pohl, pers. comm.). An egg is seldom affixed to the same general area of a grass blade both in the field and when a butterfly is confined to a plastic bag with fresh cuttings of *A. zizanioides* (Fig. 2). Under confined conditions, several eggs are sometimes placed on a single grass blade (Fig. 2), and I obtained a total of 15 eggs in four days by this method. Many eggs are also scattered singly on grass blades under this condition. In the field, *T. andromeda* is active in the late afternoon and at dusk; possibly, the butterfly is also nocturnal, but this behavior has not been studied. During other hours of the day, the butterfly is readily "flushed out" from palmaceous undergrowth in wet forest.

Early Stages

Egg. The egg is spherical, about 1.3 mm in diameter and very pale (almost white) green (Fig. 2). With a 10× hand lens, a very fine surface sculpturing, somewhat resembling the "hexagonal" pattern reported for the egg of *T. ypthima* by Muller (1886), is barely visible. Within a day or two of hatching, the black head capsule of the larva is clearly visible (Fig. 2), and the rest of the egg assumes the pale green color of the larva.

First instar larva. The first instar is about 7 mm long just after hatching, and the body is cylindrical and straight, with a gradual tapering towards the posterior end (Fig. 3). The head capsule is shiny black and conspicuously "lobed" laterally making it wider than the trunk (Fig. 3). The head capsule has six prominent horn-like protuberances arising laterally from the lobed areas (Fig. 4). These are structures that disappear in later instars (Fig. 4). The frontal area of the head capsule has some small black setae, as also noted by Muller (1886) for *T. ypthima,* and a conspicuous patchwork of irregular "fissures" to either side of the epicranial suture. The trunk is pale green and covered with almost translucent fine setae. The forked tail points upward at an angle of about 35°; each fork shaft is pink with a black tip. The terminal trunk segment and anal plate are white.

Second instar larva. Just after the molt from the first instar, the larva is about 10 mm long. The trunk region is now uniformly light green with several longitudinal yellow stripes. The head capsule is strikingly different from that of the previous instar: it is bilobed in general appearance, and light green with yellowish stripes (Fig. 3). The larva

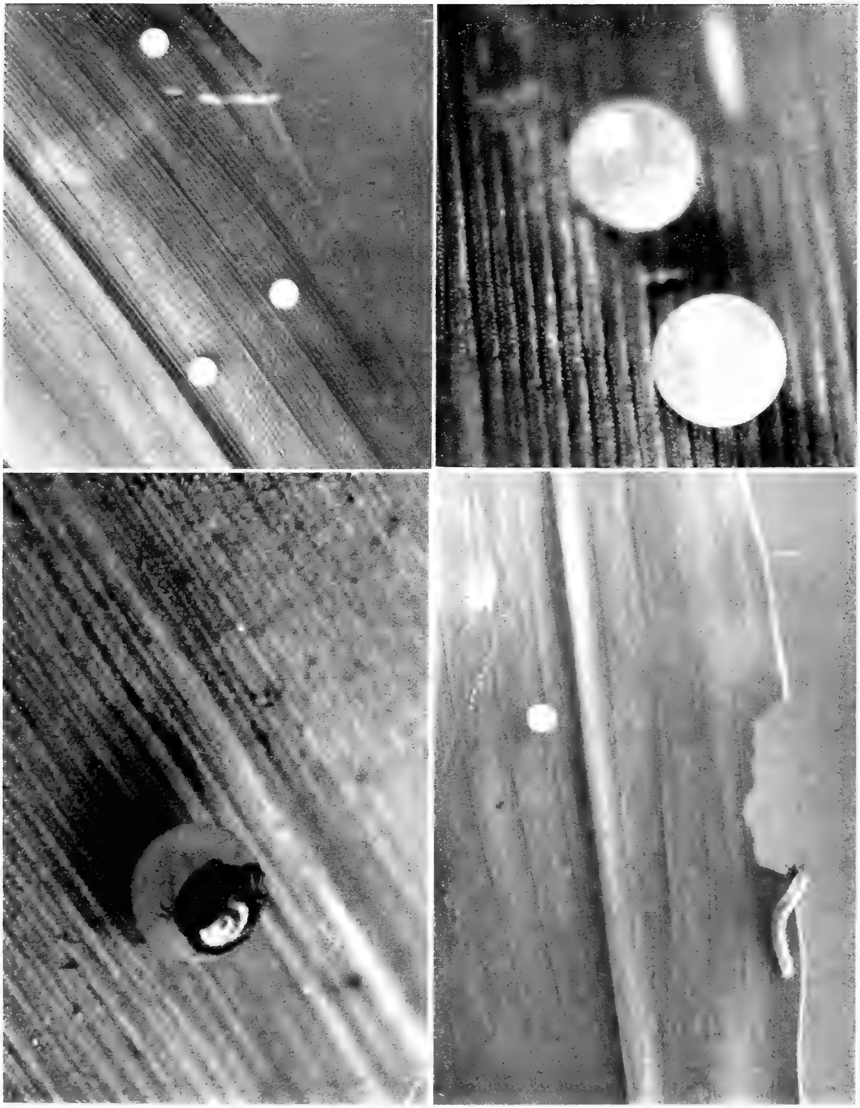

FIG. 2. Egg stage of *Taygetis andromeda,* and first instar larva feeding; clockwise, from upper left photo: three eggs scattered on a single grass blade of the larval food plant, *Acroceras zizanioides* (Graminae) as the result of female butterfly ovipositing in captivity; close-up view of one egg; egg position by female ovipositing in the field, and first instar larva feeding at the edge of a grass blade; first instar larva in initial stages of hatching.

reaches a length of about 16 mm in three days (n = 6 larvae measured), whereas the first instar larva grows to 9 mm in the same amount of time.

Third instar larva. The general appearance of the third instar larva is very similar to that of the previous instar, but the body assumes a thicker profile, and the annulets on the body segments are more prominent. The strongly bi-lobed head capsule (Fig. 4) is now pink, with the protuberances being sculptured and adorned with setae. The basic color pattern and head capsule structure (Fig. 4) of this instar is retained in the subsequent two instars. The third instar larva grows to about 28 mm in three days (n = 4 larvae measured).

Fourth instar larva. This instar (Fig. 5) is very similar to the previous one, and it attains a body length of about 32 mm in five days (n = 4 measured). The head capsule is directed more anteriorly now and bears a pair of very prominent protuberances or tubercles (Fig. 5). The trunk is very noticeably arched (Fig. 5).

Fifth instar larva. This instar is similar to previous ones (Fig. 6) but with considerable change in the configuration of the ornate head capsule (Fig. 4). As in the previous two instars, the background color of the trunk region is bright green with brown latero-ventral (supraspiracular) longitudinal stripes. The head capsule is tan frontally and with a dark brown thick vertical stripe on each side (lateral area). The tan color of the head capsule in the fifth instar larva replaces pink in the previous two instars. The posterior edges of the two prominent "horns" (Fig. 6) are tan, while dark brown both laterally and frontally. The dark brown areas of the "horns" extend down the sides of the head capsule. The broad, latero-ventral stripe on the trunk begins at the first body segment, being at first very faint on the first two segments, and then becoming much darker on later segments. This "stripe" is really a composite of two thick, dark brown lines surrounding a thin, central tan or cream-colored line, the latter barely visible, even with a 10× hand lens. Dorsally the trunk bears another complex pattern of longitudinal stripes: thick lines of green alternate with faint streaks of pink, and the forked tail is also green, and about 5 mm long. The pinkish red longitudinal bands run dorsally; each band is tapered, about 20 mm long and 2 mm wide at the thickest point, and extends from the third to terminal abdominal segments. On the fourth segment, the band on each side is adorned with small, irregularly-shaped black markings, each composed of two parts: a larger oval area anteriorly, followed by a smaller one. Dorsally the thoracic area bears a transverse "ring" of irregular, black markings at the posterior edge of the third segment. This band blends into a few thin longitudinal black lines extending from the third segment anteriorly to the head capsule. The tapered profile, segmental annulets, and overall arched trunk region make the fifth instar very easy to recognize, along with the description of stripes (Fig. 6). The trunk region is covered with a fine, light brown or tan down of setae. The fifth instar grows to about 55 mm in 12 days (n = 4 measured).

Pupa. The larva assumes a "J" position, undergoing little change in color, but with a contraction of body length to about 30 mm, and then molts within a day to the pupa stage (Fig. 7). The pupa is leaf-green all over and very stout in profile; it appears to be "dusted" with a waxy, whitish coat, more evident in some areas than in others. The pupa is 21 mm long by 9 mm thick (dorso-ventral axis through the thoracic area) and 9 mm wide (laterally, also through the thoracic area). A pale fulvous ridge defines the rear marginal areas of the forewing, and there is a pale, whitish blue thin line just below the spiracle area. The spiracles are marked with black. The abdominal area has dorsal, faint, multiple, longitudinal streaks of light green alternating with dark green lines. Of these, the medial, light green line is the thickest. There is a pair of pale yellow dots marking the beginning of two lateral thick whitish lines on the abdomen. These dots are on the first abdominal segment. The lateral and dorsal areas of the thorax have doublets of small, raised, pale yellow, dots; similar dots also occur immediately adjacent to the wing pads. The thoracic area bears a prominent longitudinal ridge which is pale fulvous at the apex. The dorsal area of the head capsule is slightly bi-lobed in the transverse plane. About ⅓ down the leg-case area from the head, there are two lateral pairs of irregularly-shaped white blotches followed by a pair of raised black dots. The wing pads also have several raised dots: one fulvous dot in the subcostal cell of the forewing; one black dot at the distal end of this cell; a whitish blotch between two radials; a small white dot on

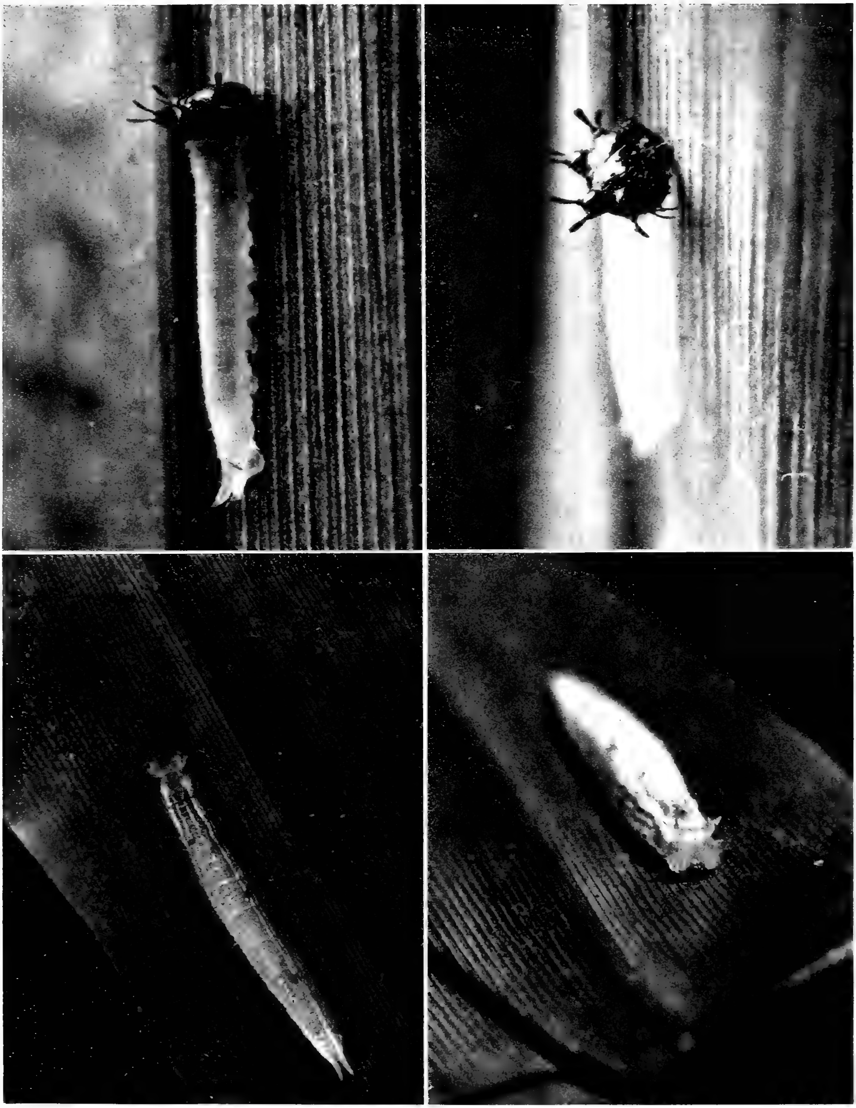

FIG. 3. First and second-instar larvae of *T. andromeda*, emphasizing overall body profile and some details of the head capsule. Clockwise, beginning with upper left photo: lateral view of first-instar larva; head capsule of first instar; frontal view of head capsule in the second instar larva; dorsal view of second instar larva.

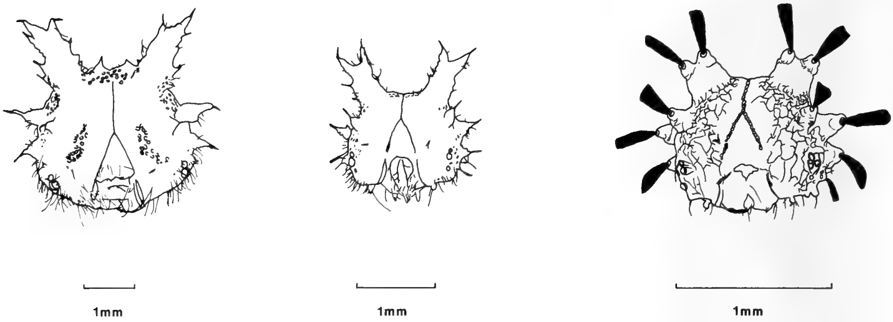

FIG. 4. Schematic drawings of head capsules, all frontal aspects, for three larval instars of *T. andromeda*. From right to left: first, third, and fifth instars, respectively. All three drawings made with drawing-tube attachment to Wild MS binocular microscope.

the subcostal vein near the apex of the wing. The cremaster is green with a brown "hook" for attachment. For three pupae, all adults eclosed (Fig. 7) by 0800 h. On the afternoon and evening prior to eclosions, the pupa darkens considerably, this process beginning in the wing pads. Eclosion is very rapid, with the butterfly fully expanding its wings within ten minutes after leaving the pupal shell.

Egg and Larval Natural History

The life cycle requires about 48 days from egg to adult, with the egg lasting seven days, the larva about 26 days, and the pupa 15 days. As with many other Neotropical butterflies in which individual eggs are scattered among many food plant individuals in an area of habitat, the first instar larva of *T. andromeda* devours its emptied egg shell down to the base immediately upon hatching. In those Lepidoptera which cluster eggs on the food plant, such behavior is conspicuously absent, a trait that appears to function to prevent cannibalism of late-hatching eggs by the larvae of early-hatching eggs in the same cluster. After devouring the egg shell, the larva moves to the edge of the same grass blade and begins feeding on plant tissue and does so from the ventral surface of the blade (Fig. 3). All instars, but most noticeable in the first instar, have the habit of "shooting out" fecal pellets to a distance of about 1–5 cm from the feeding site. When eating, larvae of all instars perch on a thin silk matting on the food plant. The bulk of feeding in all instars is nocturnal, and individual larvae construct silken strands to and from feeding sites. Older instars (instars IV–V) often rest on grass stems rather than on blades when not feeding. The long, slender body profile of the earlier instars (I–III) give the larvae a cryptic appearance on grass blades; the arched appearance so evident in the older instars (IV–V) may enhance their crypsis while perching

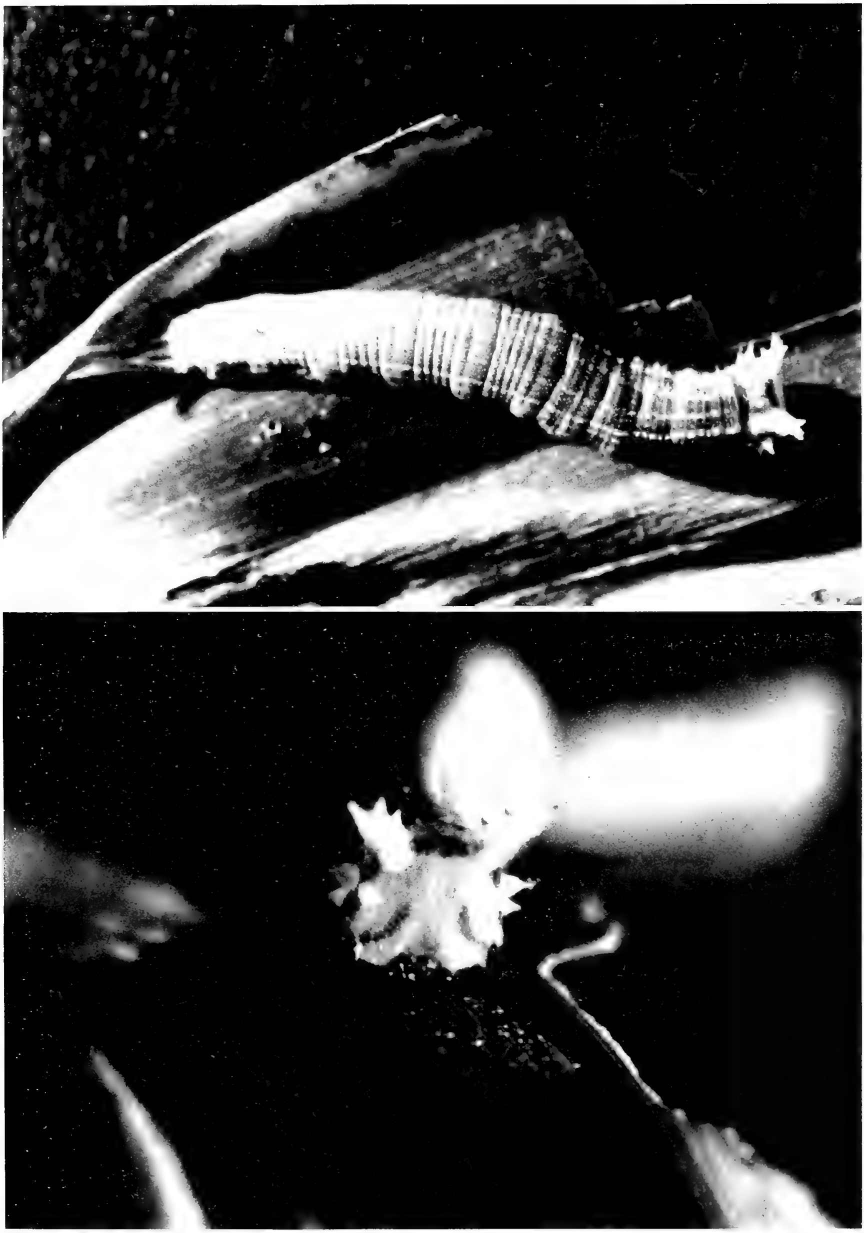

FIG. 5. Fourth instar larva of *T. andromeda:* dorsal aspects (**above**); details of the head capsule, frontal aspects (**below**).

FIG. 6. Fifth instar larva of *T. andromeda*. Various aspects of perching and feeding behavior (**top two photos**); general body profile, head capsule, and silk mat perching (**lower two photos**).

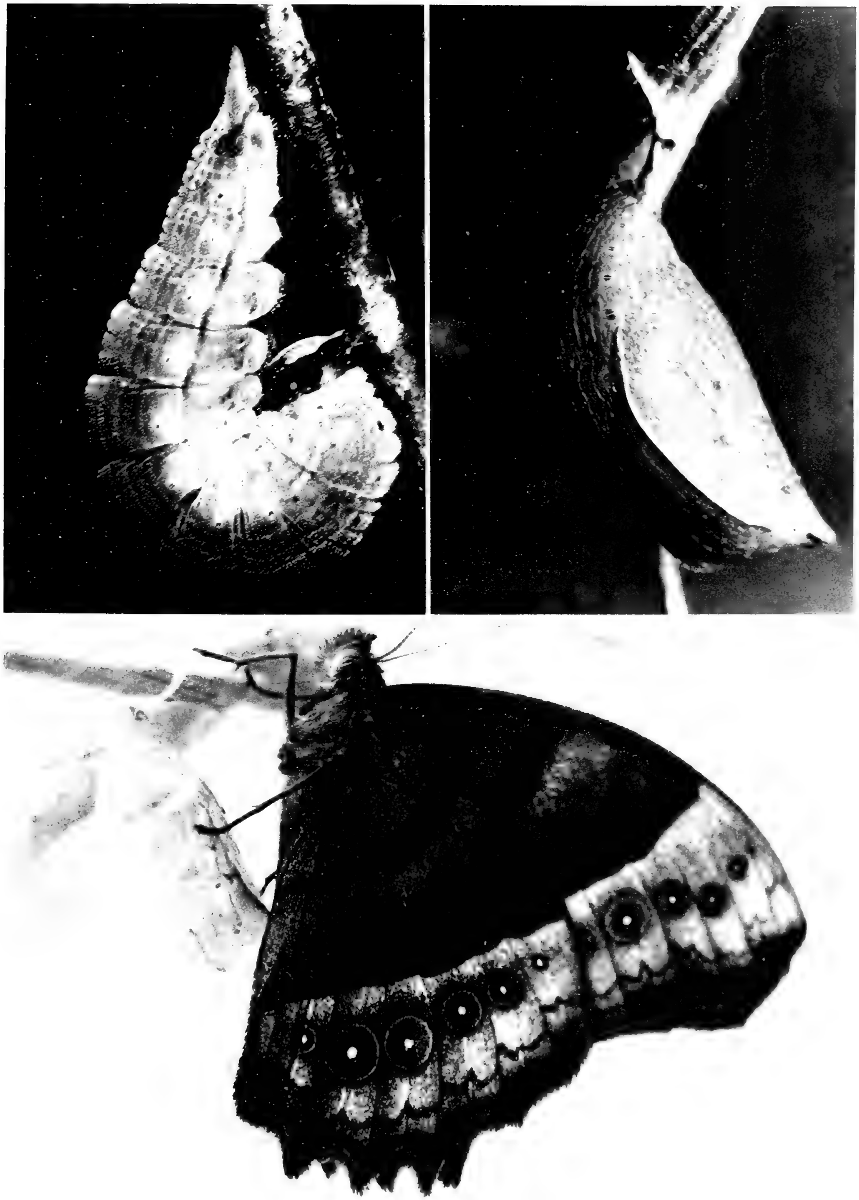

FIG. 7. Pupation and eclosion in *T. andromeda*. **Above:** prepupal position and pupa. **Below:** freshly-eclosed adult perched on the empty pupal shell.

on grass stems. When gently prodded with forceps, larvae of all instars quickly regurgitate a dark green fluid from their mouthparts; presumably, this fluid is a mixture of digestive fluids and partly-digested food plant tissues.

DISCUSSION

The observations on early stages and food plant association of *T. andromeda* presented here generally agree with what is already well documented for other satyrids, including the euptychiines to which this genus belongs. The satyrids in general, for example, are associated with monocotyledons as larval food plants (Ehrlich & Raven, 1965). The observed occurrence of *T. andromeda* in both old secondary forest understory and grassy areas in cacao plantations in eastern Costa Rica point to a butterfly that is already documented as being associated with a variety of tropical habitats (Ross, 1964, 1976). Although I report only one food plant species in this paper, the widespread occurrence of *T. andromeda* throughout Central America (e.g., Monroe et al., 1967) suggests that other grasses might also be utilized as larval food plants by this butterfly.

The description of the first instar larval head capsule for *T. ypthima* by Muller (1886) agrees very well with my description for *T. andromeda* (Muller's fig. 28a, b in Plate 13). Other descriptions of instars in Muller (1886) generally agree with my findings for *T. andromeda*.

While most satyrids are diurnally-active butterflies, some Neotropical forms such as *Taygetis* are crepuscularly-active, and possibly nocturnal. *Taygetis* is commonly found at rotting fruits in lowland tropical wet forest in Costa Rica near dusk (Young, 1972). With the exception of a few species, most *Taygetis* are believed to rely upon olfactory and tactile courtship signals, since wing color patterns are very similar between the sexes (Forbes, 1952). Certainly, the subdued brown coloration of this large butterfly and the cryptic appearance and behavior of the early stages together suggest an insect that is probably quite palatable to potential predators, including arthropods and small vertebrates such as lizards.

While the early stages of *T. andromeda* are similar to those of most other described satyrids (many papers in this journal for both temperate and tropical forms), they exhibit some differences which warrant further detailed consideration, particularly for comparisons with other species of the genus.

ACKNOWLEDGMENTS

This research is a by-product of grants from The American Cocoa Research Institute, and the Friends of the Milwaukee Public Museum. P. J. DeVries and Lee D. Miller offered constructive comments on an earlier draft of the manuscript. Tammy McCarthy prepared Fig. 4. The comments of two anonymous reviewers were most helpful in providing a focus to the discussion section.

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THE LIFE-HISTORY OF *ACTIAS MAENAS* (SATURNIIDAE)[1]

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ABSTRACT. Broods of the Southeast Asian *Actias maenas* Doubleday (=*A. leto*) were reared in Germany and South Carolina utilizing stock from West Malaysia and northern Sumatra. Larvae preferred *Liquidambar styraciflua* and *Rhus* spp. among a variety of hostplants offered. Larval development at 23–28°C required 31 to 40 days; the pupal stage lasted 12 to 15 days. The first instar larva is orange with a black head and black marking on the tergum. The mature larva (fifth instar) is dark lime green with a brown head and green spiny scoli, with yellow bands on the posterior edge of abdominal segments 2–7. Females fly prior to mating. Mating commences 1–2 h before sunrise and lasts only a few hours. The species appears to be polyvoltine, without pupal diapause. Some larvae were killed by a disease caused by the microsporidian *Nosema*.

ZUSAMMENFASSUNG. Die südostasiatische *Actias maenas* Doubleday (=*A. leto*) wurde in Deutschland und South Carolina (U.S.A.) gezüchtet; das Zuchtmaterial stammte aus West Malaysia und Nordsumatra. Die Raupen bevorzugten *Liquidambar styraciflua* und *Rhus* spp. unter den angebotenen Futterpflanzen. Die larvale Entwicklungszeit bei 23–28°C dauerte 31 bis 40 Tage, das Puppenstadium 12 bis 15 Tage. Das erste Raupenstadium ist orange mit schwarzen Kopf und schwarzer Zeichnung. Die ausgewachsene Raupe (5. Stadium) ist dunkel gelbgrün mit braunem Kopf und grossen grünen dornigen Sternwarzen, am Hinterrand der Abdominalsegmente 2 bis 7 mit gelben Streifen. Die Weibchen fliegen vor der Begattung. Die Paarung findet 1–2 Stunden vor Sonnenaufgang statt und dauert nur wenige Stunden. Die Art dürfte polyvoltin sein, ohne Puppendiapause. Etliche Raupen wurden durch Darmkrankheiten getötet, ausgelöst durch *Nosema*-Erreger.

Actias maenas Doubleday (1847) has been known for well over a century and is very popular with collectors, yet the larval stages of this moth are not well known. The species ranges from sub-Himalayan regions of northeastern India through most of the Southeast Asian mainland and on the Greater Sunda Islands, a distribution of more than 4000 km. The biotope covers diverse biomes including tropical rainforest, paratropical rainforest, and notophyllous broad-leaved evergreen forest (Wolfe, 1979).

Adults exhibit striking sexual dimorphism; males (Fig. 1) are bright yellow with brown markings, whereas females (Fig. 2) are light green.

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[1] No. 4 of the series "Contributions to the knowledge of the Saturniidae" by the senior author.

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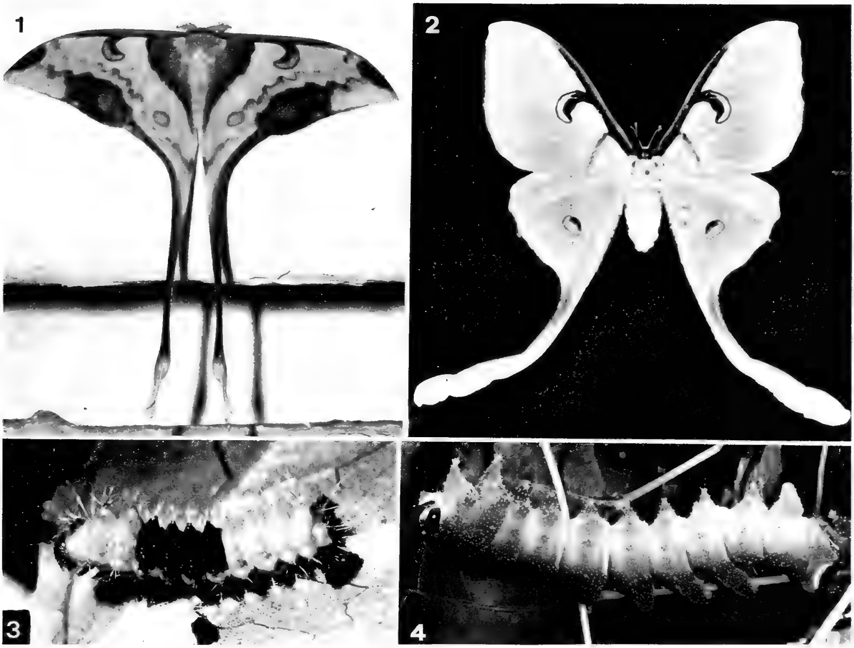

FIGS. 1–4. *Actias maenas*. **1,** male, live specimen in natural repose; **2,** female, pinned specimen; **3,** first instar larva just prior to molting into second instar; **4,** mature larva feeding on sweetgum.

The insect was recently characterized morphologically by Arora and Gupta (1979), including drawings and a detailed description of the male genitalia and wing venation. Narang and Gupta (1981) reported on cytological investigations of this saturniid. Despite these recent studies, a considerable amount of taxonomic confusion persists with *Actias maenas*. For examples, (1) the junior synonym *leto* (Doubleday) continues to appear commonly on lists of dealers and labels of specimens; (2) the genus has been excessively split, with even the recent Indian authors cited above using the generic name *Sonthonnaxia* Watson, whereas other authors (Bouvier, 1936; Allen, 1981; Barlow, 1982) considered this large Asiatic species to belong to the African genus *Argema* Wallengren; (3) the so-called insular subspecies or forms appear to us to be either distinct species (e.g., *isis* Sonthonnax from Celebes, and *ignescens* Moore from the Andamans) or simply subjective synonyms of *A. maenas* (e.g., *saja* van Eecke from Java and Sumatra, and *recta* Bouvier from Sumatra). Satisfactory resolution of these problems must await a modern revision of the genus.

To date virtually no comparative studies have been published on the pre-imaginal instars within the genus *Actias*. The early stages of *A. maenas* were described by Roepke (1918), and Packard (1914, pl. 96) figured the pupa and cocoons. Gardiner (1982, pl. 8) published a color photograph of a mature larva. In the present paper the structure and behavior of the pre-imaginal stages are described in greater detail and compared with related species. Moreover, we present information on courtship behavior, hostplant relationships, diseases, and parasitism.

Rearing Observations

In May 1982 the senior author received six cocoons of this species from Tapah, Perak, West Malaysia. With adults emerging from these cocoons, a mating was achieved and part of the eggs was sent to the junior author. Rearing was successful in both Germany and South Carolina. Additionally, another brood was reared by the senior author during the winter of 1982–1983 utilizing stock from northern Sumatra, Indonesia. Observations and descriptions below are based on the Malaysian material except where otherwise noted.

Emergence of the adults was in the evening in Germany, within a few hours after sunset. In South Carolina, some adults also emerged within 2 hours after sunset, while others of both sexes emerged between 0200 and 0400 h (Eastern Standard Time). Adults have minimal difficulty pushing out of the flimsy cocoons. Wing expansion is complete within 45 min after emergence. During expansion the tails do not begin to elongate until after the forewings have completely expanded. Both sexes are easily excitable, flapping vigorously on the ground or bottom of the cage after being disturbed. The long tails on live specimens are surprisingly flexible and are not easily broken off. In natural resting position these tails are held parallel or nearly so (see Fig. 1), while tails of specimens of *Argema* are frequently crossed in repose. On a vertical substrate the moths rest at an angle, i.e., the longitudinal axis of the body is positioned parallel against the substrate, but is off 20° or more from the vertical, either to the right or the left.

Females fly after wings have hardened but before emitting pheromone, generally shortly after sunset. This character is an unusual one among Saturniidae where females of most species emit pheromone and mate prior to their first flight. However, this character is probably normal for the *Actias* group in general; the junior author observed this in *A. luna* (L.) in nature, and Marten (1955) reported the same behavior with *Graellsia isabellae* (Graëlls) in Spain. Mating probably occurs in treetops with these insects. Several hours after the virgin flight, females emit pheromone. In Germany, the first pairing occurred between 0100 and 0300 h (MEZ)[3] in a cage outdoors. Conditions during

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[3] mitteleuropäische Zeit—Central European Time.

mating were as follows: cloudless, temperature 15.0°C, relative humidity 72%. The pair remained united until after 0700 h. In South Carolina in early August, an F_2 pairing occurred between 0430 and 0500 h (EST), and lasted until ca. 0800 h. The different mating times observed in Germany and South Carolina actually agree in terms of their relation to respective times of sunrise.

Both authors reared larger numbers of *Actias sinensis heterogyna* Mell alongside the broods of *A. maenas*, and both species demonstrated the same respective mating times in Germany and South Carolina, i.e., covering the two hours on either side of sunrise. Attempts to hybridize *A. maenas* with the much smaller *A. sinensis heterogyna* were not successful. We were unable to hand-pair either species (including inter- and intraspecific matings). In South Carolina adults of both species were present in one large cage, and females of both species emitted pheromone simultaneously, but males of both species mated only with conspecific females.

The original female in Germany deposited ca. 170 ova during the first two nights, and laid only ca. 30 eggs total during the following three nights. Most of the last deposited eggs were infertile, as is normal for Saturniidae (cf. Miller & Cooper, 1977). Incomplete data on fecundity recorded for an F_2 female in South Carolina were very similar to the above. In both cases females were killed with a small number of eggs remaining in their abdomens in order to preserve the good condition of these specimens for collections.

Hostplants in nature given by Arora and Gupta (1979) are *Turpinia sphaerocarpa* Hassk. (=*T. pomifera*), Staphyleaceae, and *Schima wallichii* (DC.) Korth., Theaceae.[4] Barlow (1982) cited *Averrhoa bilimbi* L., Oxalidaceae, as a host. A specimen from Bogor, Java, in the Rijksmuseum van Natuurlijke Historie (Leiden, Netherlands) was reared on *Adinandra dumosa* Jack, Theaceae. Roepke (1918) reared his material in Java on *Canarium*, Burseraceae. The moth has also been reared on *Eucalyptus gunnii* Hooker, Myrtaceae (Gardiner, 1982). Since none of these plants were available to us, several alternatives were offered to the larvae. The food which appeared to be most preferred was sweetgum (*Liquidambar styraciflua* L., Hammelidaceae), although larvae in all instars freely accepted staghorn sumac[5] (*Rhus typhina* L., Anacardiaceae) in Germany, and winged sumac (*R. copallina* L.), smooth sumac (*R. glabra* L.), and poison ivy (*R. radicans* L.) in South Carolina. Several species of oak (*Quercus*, Fagaceae) were accepted as well, the evergreen species of which are probably the best choice for rearing during the northern winter. First instar larvae also fed reluc-

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[4] The spelling, synonymy, and family-classification of plants listed follow the work of Backer and Bakhuizen van den Brink (1963–1968).

[5] The North American trees sweetgum and staghorn sumac are grown as ornamentals in Germany.

TABLE 1. Development of F_1 brood of *Actias maenas* on sweetgum in Germany (23–28°C) and South Carolina (25–28°C). Mating occurred 31 May 1982.

	Eclosion	Molt 1	Molt 2	Molt 3	Molt 4	Spinning
Germany	10–14 June	15–18	20–24	26–30	2–6 July	17–23
South Carolina	12–13 June	17–18	22– —	28–30	2–5 July	13–17

tantly on rose (*Rosa*, Rosaceae), black walnut (*Juglans nigra* L., Juglandaceae), and *Staphylea colchica* Stev., Staphyleaceae, although both authors reared larvae mainly on sweetgum. Some of these other plants might be utilized successfully by rearers where sweetgum and sumac are not available. *Actias maenas* has been reared in the Amsterdam Zoological Garden (van Eecke, 1913; W. Hogenes, pers. comm.), but no records of which hostplants were used could be located.

The hostplants accepted in nature and captivity by *Actias maenas* coincide with those known for related species. *Argema mimosae* (Boisduval) from Africa feeds on walnut and certain Burseraceae and Anacardiaceae (Pinhey, 1972), and *Argema mittrei* (Guérin-Méneville) from Madagascar accepts several species of *Rhus* (Villiard, 1969) and certain Myrtaceae (Pinhey, 1972). *Actias sinensis heterogyna* from Taiwan, partially sympatric with *A. maenas*, feeds on *Liquidambar formosana* Hance in nature (Mell, 1950) and *L. styraciflua* in captivity (Nässig, 1980). Walnut, oak, and sweetgum are well-known hosts of the Nearctic *Actias luna*, and are accepted by the Asiatic *A. selene* (Hübner) as well. Sweetgum is also used in nature in Mexico by *Actias truncatipennis* Sonthonnax (Beutelspacher, 1978).

Newly hatched larvae are very active and move quickly about in the rearing container. Larvae show minimal tendency to congregate, even in the first instar. The resting position is with the anterior end of the body held free of the leaf or stem, the typical "sphinx" position for Sphingidae and most Saturniidae. Larval development was rapid under temperatures of 23–28°C, the time from eclosion of eggs to spinning of cocoons being ca. 31 to 40 days (Table 1). Males complete development a few days more rapidly than sibling females, both in the larval and pupal stages, because they are smaller. Equally good results were achieved by rearing in open air (Nässig) and under plastic bags (Peigler) to ensure high relative humidity; both of us reared all larvae indoors on cut food with stems inserted into water.

Structurally, larvae of *A. maenas* are similar to other species of *Actias* and *Argema*. The first instar is orange as in *A. selene* from Bhutan, *A. sinensis heterogyna*, *A. artemis*? (Bremer) from South Korea, and *Argema mimosae* (only *A. luna* is green in the first instar).

In the second instar the body of *A. maenas* becomes yellowish green as in the case of *A. artemis*?; *A. selene* and *A. sinensis heterogyna* remain orange. The third instar is green for all species. The subspiracular yellow stripe of the mature larva of *A. selene* and *A. artemis*? is absent in *Argema* and all other species of *Actias* mentioned above. Mature larvae of *A. maenas* look much more like those of *Argema* than any *Actias* which we have seen. The dark green integument with contrasting short whitish setae are seen in *Argema mittrei* (Villiard, 1969), while the elongated fleshy extensions of the body which support the dorsal scoli are also present in *Argema mimosae* (Pinhey, 1972:pl. 1) and to a lesser degree in *A. selene*. All species of *Actias* and *Argema* for which the larvae are known have a single median dorsal scolus on abdominal segment 8, a character which easily separates the group from several similarly appearing larvae of *Saturnia* Schrank and allied genera in which a pair of dorsal scoli is present on abdominal segment 8.

In the later instars of *Actias maenas*, the scoli bear stout spines, especially the dorsal scoli. These possibly have mechanical defensive benefits, because they lack fluid secretions seen in several other saturniid caterpillars, e.g., *Saturnia pyri* [Denis & Schiffermüller] (Haffer, 1921). In the last three instars the ventral side is a darker green than the dorsal side, this providing a very effective camouflage known as countershading (de Ruiter, 1955).

Dupont and Scheepmaker [1936] stated that larvae of *Actias* reared in Java were very susceptible to disease, a problem also noted by Roepke (1918). All larvae of an F_2 brood in South Carolina succumbed to a disease before reaching the last instar. Of the four main types of pathogens infecting Saturniidae, *viz.* viruses, bacteria, fungi, and microsporidians, outlined by Jolly et al. (1979:61–66), the symptoms agreed with the latter. The pathogen belongs to the genus *Nosema* (Nosematidae). The symptoms include reduced feeding, lethargy, black spots on the integument, darker body color, and stunted growth. A large portion of the F_1 brood of larvae in Germany was also killed by an unidentified disease. Higher humidity is beneficial to Lepidoptera which are native to tropical rainforests, but unfortunately such conditions also promote disease.

Cocoons of *Actias maenas* are attacked in nature by one or more species of *Xanthopimpla* (Hymenoptera: Ichneumonidae) belonging to the *regina* species-group (Townes & Chiu, 1970). We were unable to locate other published records of parasitism for this moth.

Mature larvae spin cocoons among leaves of the hostplant or among dead leaves on the bottom of the cage. There appeared to be no preference in selection of a pupation site. In nature, presumably some

TABLE 2. Behavioral characteristics of *Actias maenas* considered to be of generic level.

First instar larvae move about rapidly
Larvae not gregarious, even in first instar
Pupa with spines on cremaster anchored into cocoon
Pupa frequently active
Females fly prior to emitting pheromone
Adults excitable at all times; copula is broken at slightest disturbance
Adults rest at angle on vertical substrate
Predilection for *Liquidambar* and Anacardiaceae as hostplants

cocoons are formed at ground level while others are spun high above the ground among living leaves. Freshly spun cocoons are white; the silk usually then turns light or dark brown. Most cocoons have small perforations as in the cocoons of *Actias selene*, *A. sinensis heterogyna*, and *Argema mimosae*. A few cocoons of *A. maenas* have less than five discernable perforations and occasionally none at all. Packard (1914) figured an imperforate cocoon alongside one with numerous perforations. The imperforate cocoon was also stated to be a 'valveless' cocoon, but we have not seen cocoons of *A. maenas* which lack the pre-formed exit at the anterior end. The hooked spines of the pupal cremaster are anchored into the posterior end of the cocoon. This undoubtedly facilitates the emerging moth when pulling itself out of the pupal shell. The active pupa is frequently heard rolling in the papery cocoon at any time during the pupal stage, especially when disturbed by an external stimulus (refer to Table 2).

Diapause of some species of *Actias* has been investigated. In general, photoperiod is the primary mechanism which maintains and terminates diapause in temperate species such as *A. luna* (Wright, 1970) and Japanese species (Miyata, 1974, 1976, 1977). *Actias maenas* is a tropical species however, the range of which crosses the Equator. *Actias sinensis heterogyna*, with a slightly more northern range, diapauses only rarely: only one female among ca. 100 pupae in Germany diapaused for six months at 6°C; short-day photoperiod, senescing hostplants, and lower temperatures during larval and pupal stages all failed to induce diapause in *A. s. heterogyna* (Nässig, 1980 and unpubl.; Mell, 1950). These data plus the rapid life cycles indicate that both *A. maenas* and *A. s. heterogyna* are polyvoltine in nature, notwithstanding the presence of a light-detecting "window" on the head of the pupa in each species (see Fig. 5). However, Bouvier (1936:254) indicated that *A. maenas* is bivoltine in northeastern India, a region where mild

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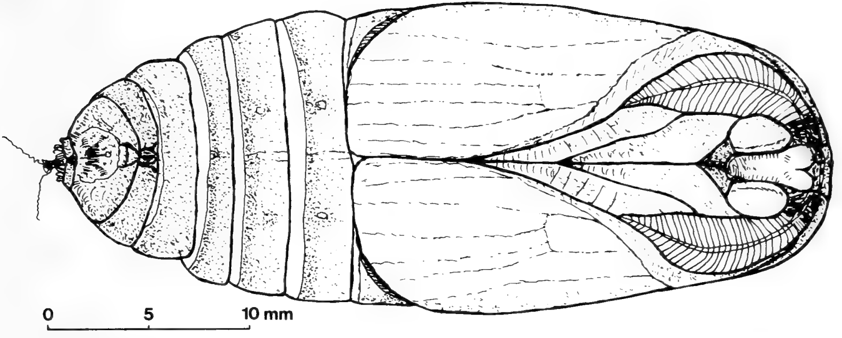

FIG. 5. *Actias maenas*, ventral view of male pupa. Note transparent "window" between eyes and base of antennae, and strands of silk from cocoon attached to cremaster.

winters occur (Wolfe, 1979). No seasonal forms are known for adults of either species.

Descriptions of Immature Stages

The following descriptions are based on living material, freeze-dried larvae, and color transparencies. The minor differences noted between material from West Malaysia and Sumatra are not believed to be taxonomically significant. The photographs and drawing in this paper were all made by the senior author.

Ovum. Length 2.5 mm, width 2.1 mm, height 1.6 mm. (Sizes of eggs from Malaysian and Sumatran material are the same, but Roepke (1918) cited smaller measurements for Javanese eggs.) Coloration whitish brown. Irregular areas of chorion opaque or translucent. Chorionic sculpturing evenly reticulate, average diameter of meshes 0.02 mm. Partially coated with brown secretion for affixing egg to substrate.

Larva. First instar (Fig. 3). Head glossy black, 1.1 mm in diameter. Integument orange; dorsal and lateral area of abdominal segments 1 to 4 black. Thoracic legs, prolegs, and posterior edge of anal plate all black. Scheme of implantation of scoli in six longitudinal rows, with two rows each of dorsal, subdorsal, and lateral, excepting single median dorsal scolus on abdominal segment 8. (Roepke's (1918) statement that there are only four rows of scoli we believe to be erroneous.) Scoli not prominent, concolorous with integument, each with 4–6 short white primary setae, longer ones on thoracic and subspiracular scoli. Larval length reaching more than 1 cm.

Second instar. Head glossy dark brown, lighter frons and clypeus, ca. 2.5 mm in diameter. Integument light yellowish green, with irregular tiny white granulations, each bearing seta. Thoracic legs and dorsal portion of prolegs black to dark brown. Prothoracic plate in some individuals with an irregular black patch, more prominent in Sumatran material. Anal plate dark brown with yellow border. Subspiracular line yellow, connecting subspiracular scoli, less distinct in Sumatran material. Bases of scoli yellow, distally becoming orange or red in dorsal and subspiracular rows, yellow in lateral rows. Each scolus with single black seta arising from center, and 4–7 radial black spines. Larval length reaching 2 cm.

Third instar. Head glossy brown, lighter frons and clypeus, 3.5 mm in diameter. Integument dark lime green, with numerous contrasting white granulations, each with seta. Thoracic legs dark brown. Prolegs dark gray. Prothoracic plate green, concolorous with integument. Anal plate light brown with ca. 20 small black spots, anterior edge yellow; anal prolegs dark brown with anterior edge yellow. Spiracles green, concolorous with integument. Subspiracular stripe yellow. Scoli yellow, becoming green distally, in Sumatran material sometimes all but largest scoli remaining yellow or even orangish with basal red ring, as in other species of *Actias*. Larval length ca. 3.2 cm.

Fourth instar. Same as third instar except head 4.0–4.5 mm in diameter, subspiracular stripe disappearing, scoli all becoming larger, and fleshy extensions of body supporting scoli becoming more prominent. Larval length ca. 6 cm.

Fifth instar (Fig. 4). Same as third and fourth instars except head 5–7 mm in diameter, spiracles dark grayish yellow, scoli each with 4–10 central and radial black spines 0.5–1.5 mm long, best developed on dorsal pairs of meso- and metathoracic scoli plus median caudal scolus (this scolus was lost on specimen figured due to an accident), and posterior edge of first seven abdominal segments with light yellow stripe. Larval length 9.5–10.5 cm.

Pupa (Fig. 5). Color dark brown. Antennal covers small, surrounded by leg covers. Head with transparent (whitish yellow) "window" between compound eye covers. Abdominal segments telescoped to small degree, pair of small protuberances on ventral side of segments 5 and 6 homologous to prolegs (cf. Mosher, 1916). Cremaster with several hooked spines. Length of male ca. 4 cm, female ca. 5 cm, width 1.5–2.0 cm (reared material being smaller than this).

Cocoon. Ovoid, irregular in shape. Length 5–6 cm, width 2.0–3.5 cm. Texture papery, spun between leaves. Coloration light brown with glossy sheen. Usually sparsely perforated. Pre-formed exit opening present at anterior end. Occasionally incomplete net-like inner cocoon is observed.

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MYRMECOPHILY IN THE EDWARD'S HAIRSTREAK BUTTERFLY *SATYRIUM EDWARDSII* (LYCAENIDAE)

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ABSTRACT. Observations on the life history and myrmecophilous relationship of the lycaenid butterfly, *Satyrium edwardsii* (Grote and Robinson) and the ant, *Formica integra* Nylander, are described. *S. edwardsii* departs from other North American Lycaenidae in that the 3rd and 4th instar larvae aggregate during the day (in groups of up to 114 individuals per host) at the base of the host plant (*Quercus velutina* and *Q. coccinea* saplings) within conical structures of detritus (byres) constructed by the ants. The larvae leave the byres at dusk, feed nocturnally, and are usually surrounded by a group of attending ants. A membracid, *Similia camelus* (Fabricius), was abundant on the same host plants and was ant attended. We suggest that membracids associated with *S. edwardsii* larvae may be involved in the symbiotic relationship between *S. edwardsii* and *F. integra*.

Many species of Lycaenidae in North America are myrmecophilous (Downey, 1961, 1962; Harvey, 1980). The larvae are commonly surrounded by a group of ants that groom and palpate them with their antennae. On the 7th abdominal segment of late instar larvae is a dorsal gland, called Newcomer's organ, that secretes honeydew on which the ants feed (Newcomer, 1911; Malicky, 1970; Maschwitz et al., 1975). In addition, there are epidermal glands which secrete substances that attract and appease the ants (Malicky, 1970). In *Glaucopsyche lygdamus* (Doubleday) these attractive substances secure ant defense against parasitoid attack. This protection probably acts as a potent selective force in maintaining the symbiosis between lycaenid larvae and ants (Pierce & Mead, 1981).

The symbiotic relationship between ants and lycaenid larvae has received comparatively little attention for North American species, and in only a few cases have the associated ants been identified. Clark (1932) mentioned an association of *Satyrium edwardsii* (Grote & Robinson) with ants. Later Comstock (1940) reported that the eggs overwinter and that the larvae could be found in "ant nests" at the roots of scrub and scarlet oaks. Other than a brief larval description by Scudder (1889), little additional information is available on the biology of *S. edwardsii*. We here report on some observations of the life history and myrmecophilous relationship of *S. edwardsii* and the ant, *Formica integra* Nylander, in Michigan. It is our hope that this preliminary and somewhat anecdotal account will stimulate further studies on the myrmecophilous relationships between lycaenids and ants.

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STUDY AREAS AND METHODS

S. edwardsii has been reported from several localities in the lower peninsula of Michigan (Moore, 1960). We found this hairstreak to be abundant in the Flat River State Game Area, Montcalm Co., T9N, R7W, Sections 29–30 (Locality 1), and in Newaygo Co., T12N, R12W, Sections 1–2 (Locality 2). In these localities the primary host plants of *S. edwardsii* were black oak, *Quercus velutina* Lam. and scarlet oak, *Q. coccinea* Muench. A few larvae were also found on a *Q. alba* L. sapling in locality 2. Populations of *S. edwardsii* appeared to be closely associated with colonies of *F. integra*. Adjacent localities without *F. integra* did not support populations of *S. edwardsii* even though suitable host plants were present. Most of our observations were made at locality 1 in Montcalm Co. at various intervals (usually once a week) from April through July during 1980 and 1981.

Locality 1. The study area was a second growth woodlot of *Q. velutina, Q. coccinea* and *Q. alba* with a mixture of *Populus tremuloides* Michx., *Pinus strobus* L., and miscellaneus upland hardwood. *S. edwardsii* adults were abundant during July and occurred most frequently within a narrow, irregularly shaped opening of approximately 0.6 hectare. Within the opening were small *Q. velutina* and *Q. coccinea* with base diameters between 1.3 and 10.0 cm (most between 2.5 and 5.0 cm). Additional plants in the openings were *Lupinus perennis* L., *Ceanothus americanus* L., *Rudbeckia hirta* L. and assorted grasses and forbs. *C. americanus* appeared to be the major nectar source for the adults. The soil consists of Graying Sand (Schneider, 1960), a deep sand with low waterholding capacity. Five large (0.3–1.2 m dia.) nests of *F. integra* were in the opening.

Locality 2. This colony was located at the edge of a relict prairie. The same species composition of trees was found as at locality 1. *Q. velutina* saplings were the dominant species within the openings scattered within the second growth forest. Few other plants occurred in the openings other than grasses, forbs, and scattered clumps of *C. americanus*. The *F. integra* nests were smaller (no well defined mounds) and were situated within clearings. The soil was a Grayling Sand.

OBSERVATIONS

Larval, ant, and membracid associations. The eggs of *S. edwardsii* hatched during late April and early May when the oak buds were enlarged and ready to open. The reddish brown 1st instar larvae bored into the buds of *Q. velutina* and *Q. coccinea* saplings and suckers and fed diurnally. The 2nd instar larvae continued to feed on the buds and developing leaves. Buds with 1st or 2nd instar larvae usually had 2–4 larvae, but sometimes 6 or 7 were present. The larvae were frequently near nymphal aggregations of the membracid, *Similia camelus* (Fabricius) and scale insects (Coccoidea). These Homoptera release honeydew and were ant attended. The ants, in turn, defended any oak sapling having these Homoptera. When a sapling or branch was disturbed most ants assumed a defensive posture (reared up on pro- and mesothoracic legs with mandibles open, and sometimes pointed the abdomen anteriorly between the metathoracic legs), frequently moving toward the source of the disturbance. The ants readily attempted to bite any object brought near them. Although the 1st and 2nd instar larvae presumably can not produce honeydew (they do not have Newcomer's organs), ants were usually within 2.5 cm of each larva and appeared to tend them. We found Newcomer's organs only on 4th instar larvae.

Around the roots at the base of the oak saplings were chambers that extended to 7.5 cm below the soil line along the taproot and laterally around the roots up to 10 cm away from the taproot. There was a 1–3 cm space around the roots and a small amount of debris covering the opening at the soil surface. Trenches and tunnels (beneath a loose layer of dried grass and leaves), led away from the chambers to ant nests that were 1–13 m away. No 1st and 2nd instar larvae of *S. edwardsii* or membracid nymphs were found in the chambers with the ants during late April or early May.

By late May the ants had constructed conical structures (byres) of fine pieces of detritus (much like the material covering the ant nests) at the bases of the oak saplings (Figs. 1 & 2). The byres were 10 to 25 cm in dia. and extended 5 to 20 cm upward on the stems of the oaks. The largest byres were around the largest saplings (10.0 and 20.0 cm dia.). There was a 1.0–1.5 cm space between the inner side of the byre and the bark of the sapling confluent with the chambers around the roots (Fig. 2). The upper edge of the byre was contiguous with the bark of the sapling except for a series of 1–4 mm gaps which allowed access of the ants into and out of the byres.

The behavior of the larvae of *S. edwardsii* changed when they reached the 3rd instar (during late May). Although there was considerable evidence of feeding, larvae were not found on the foliage during the day. Instead, the mottled, brownish 3rd and 4th instar larvae remained during the day on the bark in the chambers within the byres at the base of the oak saplings. Only 4 larvae were found outside the byres during the day, and these were on branches of the 10 cm dia. sapling among aggregations of *S. camelus* nymphs and adults. The larvae in the byres were positioned vertically on the stem, at or above

FIG. 1. (**Top**) A 2.5 cm dia. *Q. velutina* with a byre (arrow) at base. (**Bottom**) Six 4th instar larvae of *S. edwardsii* with attending ants and a *S. camelus* nymph (arrow) within a byre at the base of a 1.9 cm dia. *Q. velutina*. The stem of the oak was pulled away from the observer to reveal the larvae in the byre. The membracid nymph is positioned where the upper edge of the byre had been.

FIG. 2. A 3.5 cm dia. *Q. velutina* with a byre at base. A portion of the byre was removed to reveal the larvae and space (arrow) between inner side of byre and bark of sapling.

the soil line (Fig. 1). Between 1 and 114 larvae were found in the byres and the largest larval aggregations were in those byres on saplings with base diameters of 3.8 to 10.0 cm (Table 1). Larvae and byres were not found on *Q. velutina* and *Q. coccinea* with base diameters greater than 20 cm or on other species of shrubs or trees. Between 20 and 100 (an exact count was difficult) ants were in the chambers with the larvae in each of the byres. Only 3 *S. camelus* were found in the byres, although many nymphs and adults (and attending ants) were on the branches of the saplings. One 1.3 cm dia. sapling had 138 *S. camelus* nymphs and adults and 75–100 ants on it. The ants appeared to obtain honeydew from the membracids.

TABLE 1. Number of *S. edwardsii* larvae in byres at bases of *Q. velutina* and *Q. coccinea* saplings at locality 1. Observations were made on 8 June 1980 and 6 June 1981.

Sapling size (dia. at base in cm)	x̄ no. larvae[1] 1980	x̄ no. larvae[1] 1981
1.3	1.0 (2)	4.5 (2)
1.9	8.5 (2)	—
2.5	2.3 (3)	1.0 (1)
3.1	—	9.0 (1)
3.8	2.7 (3)	—
5.0	19.7 (3)	20.5 (2)
6.3	13.0 (1)	22.0 (1)
10.0	60.0 (1)	23.0 (1)[2]
20.0	3.0 (1)	—
>20.0	0.0 (8)	—

[1] Numbers in ( ) are the number of saplings examined in size class.
[2] Ninety-one larvae (out of 114) were removed from this sapling on 31 May.

The 3rd and 4th instar larvae of *S. edwardsii* fed on the foliage of the host only at night. They left the byres within one hour after sunset, crawled up the stem and fed on the foliage until sunrise, and then returned to the byre. On 14 June (1980), 4th instar larvae on a sapling (10 cm dia.) and a sucker clump (17 larvae in byre) were observed. A dim flashlight was used to observe the insects at night. Sunset on 14 June was 2117 h EDT and sunrise on 15 June was 0559 h. At 2140 h (0.5 h after sunset) one larva left the byre on the 10 cm dia. sapling. By 2155 h several more larvae had left the byre and were crawling up the trunk. One larva crawled at a rate of 1.3 cm/min. At 2225 h all 17 larvae on the sucker clump were crawling up the stems. Each larva was accompanied by 1–8 ants as it crawled up the stem. At least one ant was always within 2.5 cm of each larva, and occasionally an ant was observed on the dorsal surface of a larva. By 2300 h the larvae had begun to feed on the oak foliage and continued to feed throughout the night. Between 0605 and 0630 h (5–30 min after sunrise) the larvae began leaving the foliage and crawled down the branches and stems of the host. At 0615 h only 3 of the 17 larvae on the sucker clump were feeding, the rest had either entered the byres or were crawling down the stems. On the 10 cm dia. oak 2 larvae were crawling down the main trunk 2 and 3 m above the forest floor, while another larva was just entering the byre at the base of the oak. During this time the sky was overcast and the temperature was 21°C. No larvae were observed outside the byres after 0700 h. Throughout our observations ants were always on or within 2.5 cm of each larva and appeared to obtain honeydew from them.

On 31 May (1981), 91 larvae (out of 114) were removed from the 10 cm dia. *Q. velutina* for determination of parasitism. The larvae were reared to maturity on fresh *Q. velutina* leaves. Percent parasitism was 26% and was due to Tachinidae and Braconidae. It is not known which larval stadia are attacked or the mode of parasitoid attack.

Pupation. Pupation occurred during late June and early July at the base of the host plant, either on the underside of leaves that were underneath or adjacent to the byre, or on the stem of the host within the byre. On 29 June, of the 17 larvae observed on 14 June, 6 had pupated on the underside of leaves adjacent to or under the byre, 3 were on the main stems in the byre (these were parasitized by braconid wasps), and 3 groups of braconid cocoons were on the underside of the leaves. This accounted for 12 of the 17 observed earlier.

The pupae of *S. edwardsii*, like many other lycaenids (Downey, 1966), produced a faint rattling or creaking sound. The sound was produced only after the pupae were disturbed. Because few ants were present in the byres (1–4) or on the saplings (less than 20) it remains unclear what role (if any) the sounds might play in the myrmecophilous relationship of *S. edwardsii* and *F. integra*. No *S. camelus* nymphs or adults were present, even though adults were abundant on 14 June. This might partially account for the paucity of ants on the saplings.

Adult behavior. One freshly emerged *S. edwardsii* adult was observed on 29 June (1981) and by 9 July adults of both sexes were numerous. Visual count suggested that between 250 and 350 individuals were within the clearing. Adults nectared on *C. americanus* and *R. hirta*. *C. americanus* was the dominent flowering plant at this time and was the major nectar source for the adults. *Harkenclenus titus* (Fabricius), *S. liparops* (Leconte), and *S. calanus* (Hübner) were also nectaring at the *C. americanus* flowers. Males of *S. edwardsii* were usually on leaves at the tops of the larger saplings and shrubs within and bordering the clearing. They frequently engaged in aerial "combat" with other hairstreaks that flew near them. The ants did not display any aggressive behavior towards the adult butterflies. An ant that encountered a female walking on a branch, stopped, palpated her with its antennae, and then walked away.

Oviposition of 2 *S. edwardsii* females was observed between 1330 and 1347 h on 9 July (1981). One female walked along a horizontal branch of a *Q. velutina* sapling, probed her abdomen into a knobby wound in a small fork, deposited an egg, and then flew away. The other female oviposited an egg in a vertical wound about 20 cm above the forest floor on a 3.1 cm dia. sapling. The egg was placed under the rough bark that formed the edge of the wound. During September, several *Q. velutina* saplings were examined for ova. All ova were either in old wounds or hidden under loose bark or dead wood, and occasionally, empty egg shells from the previous year were adjacent to the newly laid eggs. In one wound 4 ova were stacked on top of each other. Most ova were between 0.6 and 1.5 m above the forest floor.

DISCUSSION

S. edwardsii is myrmecophilous as are many North American Lycaenidae. However, *S. edwardsii* departs from its congeners and other Lycaenidae in North America in that the 3rd and 4th instar larvae aggregate during the day at the base of the host within conical structures of detritus constructed by the ant, *F. integra*. The 3rd and 4th instar larvae feed nocturnally on the foliage and are frequently surrounded by a retinue of ants. Other *Satyrium* species are tended by ants, but they do not form aggregations and usually remain on the host leaves or fruit, leaving them only to pupate.

Fourth instar larvae of *S. edwardsii* produce honeydew on which ants feed. The larval aggregations might, therefore, provide a valuable, highly attractive and easily defended food resource for the ants as in many Australian and South African Lycaenidae (Clark & Dickson, 1971; Common & Waterhouse, 1972; Pierce & Mead, 1981). The byres should facilitate protection of larvae by ants and provide the ants with more ameliorating environmental conditions (higher relative humidity). The larvae in turn would gain protection from predator and parasitoid attack. In the riodinid, *Anatole rossi* Clench, "pens" were constructed by ants at the base of the host plant in response to the presence of a larva on the host but only after the honey glands became functional (Ross, 1966). However, it is unclear from the present evidence if the aggregations of *S. edwardsii* larvae provide the stimuli that induce byre construction by *F. integra*. The 3rd instar larvae of *S. edwardsii* which do not have functional Newcomer's organs also rest in the byres.

The membracid, *S. camelus*, and other homopterans associated with *S. edwardsii* larvae may play a role in the symbiotic relationship between *S. edwardsii* and *F. integra*. Membracids release honeydew and thus, become an important energy resource for the ants. The ants in turn become a resource for the membracids because they reduce predation on nymphs (Wood, 1977, 1982b). The effectiveness of ants in promoting membracid survival depends on factors such as the number of nymphs present, the proximity and size of the ant colony, and the longevity of the host plant (McEvoy, 1979; Wood, 1982a, b). Long-lived perennials like *Q. velutina* and *Q. coccinea* provide relatively predictable oviposition sites for female membracids. The nymphal aggregations that result provide a predictable energy resource for the ants. Ant colonies established close to such membracid host plants will promote nymphal survival, as well as increased fitness to the ant colony (Wood, 1982a). The presence of nymphal aggregations of *S. camelus* near *S. edwardsii* larvae may concomitantly benefit the larvae by increasing the number of ants in their vicinity. This may be particularly important for the protection of early instar larvae which are incapable of producing an energy resource (honeydew) for the ants. Compounds produced by the epidermal glands probably facilitate protection of the early instar larvae by keeping those ants already present in their vicinity.

The pupae of *S. edwardsii* produce a faint creaking or rattling sound after being disturbed. Downey (1966) reported sound production in pupae of six additional *Satyrium* species, as well as in many other lycaenids and three riodinids. The stridulatory organs are located between the fifth and sixth abdominal tergites and produce the noise when the abdominal segments are rapidly moved. It is not clear what the function of the sounds is for *S. edwardsii* or other Lycaenidae (Downey, 1966). In *A. rossi* the stridulatory organs in conjunction with pupal glands on the metathoracic segment appear to serve as ant-attractant organs (Ross, 1964, 1966).

The myrmecophilous relationship between *S. edwardsii* and *F. integra* is undoubtedly one of the more advanced symbioses known among any of the North American Lycaenidae and ants. Additional studies are required to ascertain the degree of protection of the larvae offered by the ants from predation and parasitism and to detail the precise relationships between *S. camelus, S. edwardsii,* and *F. integra.*

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THE LIFE HISTORY AND IMMATURE STAGES OF *AGAPEMA HOMOGENA* (SATURNIIDAE)

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ABSTRACT. *Agapema homogena* is a nocturnal, montane species of saturniid. The larvae of *homogena* feed on *Rhamnus californica* in Arizona, and have four instars. The immature stages are black and yellow with numerous white setae. Adults fly from late May to late July in the United States but have been taken as late as mid-September in Mexico. The ova are deposited in clusters, and upon hatching the larvae feed gregariously. In Arizona pupation occurs from September to November.

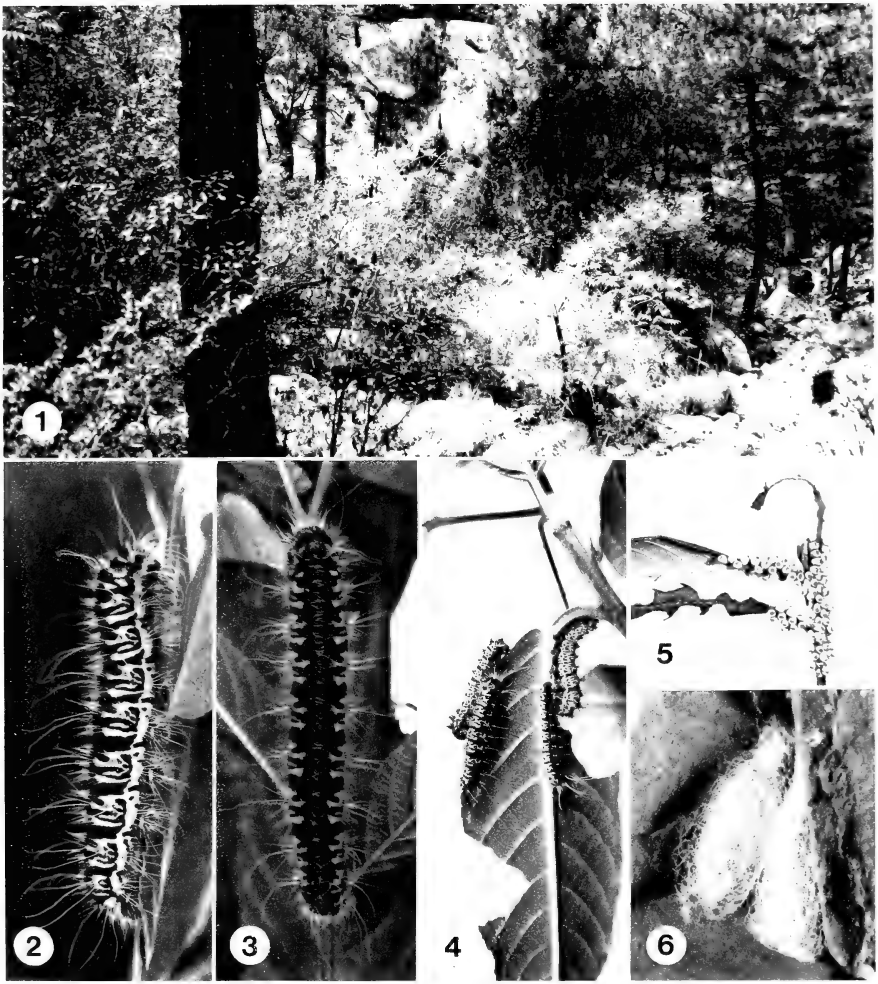
Agapema homogena Dyar is a gray to black saturniid of moderate size that occurs in Mexico, Arizona, Colorado, New Mexico, and western Texas. The species occurs in montane habitats at elevations from 1500 to 3500 m and in Arizona is most frequently associated with mixed oak woodlands (Fig. 1). In this paper the biology of *A. homogena* is discussed and the immature stages described for the first time. Most of our observations are based on a population in the Santa Catalina Mts. north of Tucson, Pima Co., Arizona.

Description of Larvae
(Figs. 2–4)

First instar. Head: Black with short white setae; diameter 0.6 mm. Body: Length 5.2 mm, width 1.3 mm. Ground color black. White setae extend from black scoli. True legs, prolegs and spiracles black.

Second instar. Head: Black with short white setae; diameter 1.4 to 1.5 mm. Body: Length 11 mm, width 3 mm. Ground color black and yellow. Dorsal, ventral, and intersegmental areas black. Segmental area from dorsal scoli to just ventral of lateral scoli yellow with 3 black lines. Black "j"-shaped line begins subspiracularly and extends dorsally to meet second black line that extends ventrally from mid-dorsal area. 3rd black line extends from dorsal area anterior of dorsal scoli, towards dorsolateral scoli but terminates dorsoanteriorly of dorsolateral scoli. All scoli black and compressed with few short black spines and white setae extending from each. White setae extending from dorsal scoli of thoracic segments, abdominal segment VIII, and caudal scoli elongated, measuring 2 mm or more in length. Prolegs, true legs, and spiracles black.

Third instar. Head: Black and covered with short white setae; diameter 3.2 mm. Body: Length 34–38 mm, width 6 mm. Ground color black and yellow. Ventral and intersegmental area black. Yellow subspiracular line encompasses black lateral scoli and extends entire length of larva. Lateral segmental area with 4 vertical yellow stripes. Posteriormost stripe extends from subspiracular line dorsally just past dorsolateral scoli then folds ventrally to form inverted "v" (often broken) that terminates at spiracle. Line 2 extends from spiracle to mid-dorsal area and encompasses dorsolateral and dorsal scoli. On thoracic segments and abdominal segments I, VIII, and IX this line terminates at dorsal scoli, therefore, mid-dorsal area of those segments black rather than yellow. Line 3



FIGS. 1–6. **1,** Habitat of *Agapema homogena* in the Santa Catalina Mts., Pima Co., Arizona. Prominent vegetation includes *Arctostaphylos* sp., *Fraxinus* sp., *Juglans* sp., *Pinus ponderosa, Prunus demissa, Quercus arizonica, Q. emoryi, Q. gambelli, Rhamnus californica* and *Rhus trilobata*; **2,** lateral view of mature larva; **3,** dorsal view of mature larva; **4,** second instar larvae feeding on *Rhamnus*; **5,** wild cluster of eggs from which the larvae have already hatched; **6,** two cocoons found in narrow space between rocks.

anterior to line 2 and extends from posterior edge of spiracle to midway between dorsolateral and dorsal scoli. Fourth line anterior to 3rd and extends dorsally from yellow subspiracular line to point even with dorsal scoli. Tufts of white secondary setae cover mid-dorsal segmental area. All scoli are black and compressed with white setae and few black spines extending from each. Dorsolateral and dorsal scoli each with 1, occasionally 2, setae 5 mm or longer extending from each. Prolegs, true legs, spiracles, and planta black.

Fourth instar. Head: Black and covered with short white setae; diameter 4.2–5.4 mm. Body: Length 58–65 mm, width 11 mm. Ground color black and yellow. Yellow subspiracular line encompasses lateral scoli and extends length of larva. Segmental area with 4 vertical yellow stripes on each segment as in 3rd instar, but with one exception: the 2nd yellow line extends from spiracle dorsally through dorsolateral scoli and terminates at dorsal scoli instead of crossing over mid-dorsal area. Mid-dorsal area black with segmental tufts of white secondary setae. Lateral scoli appear as yellow verrucae with dense clusters of elongated white setae. Dorsal scoli and dorsolateral scoli are distinct but flattened with short black spines and 1 to 3 elongated and numerous short white setae. Small clusters of white secondary setae extend from white or yellow patch on upper lateral surface of prolegs. Prolegs, true legs, and spiracles black. Planta red.

Discussion

In southern Arizona the flight season of *homogena* extends from late May to late July. Records from Colorado and New Mexico indicate a slightly shorter flight period, while specimens from central and northern Mexico have been taken through late September (5 km S Temoris, Chih. VII-16, VIII-28, IX-19-69). Based on limited material available for examination, Ferguson (1972) noted that Arizona specimens are smaller and their wing veins more prominent than those from Texas. The Arizona specimens that he illustrated are smaller than usual, and in general the wing span of material from the two states is similar. The difference in wing vein prominence is probably an artifact of reared vs. wild specimens since scales rub off the forewing veins of an active moth. Material from Colorado to central Mexico has been examined, and no consistent geographical trends were found.

Emergence from the cocoon occurs in the morning. Females begin emitting pheromone between 2100 and 2300 h. The pair remain together for about an hour, after which the female begins her oviposition flight. The ivory eggs are oblong, measure 1 × 2 mm, and are deposited in clusters near the apical growth (Fig. 5). In the Santa Catalina Mts. the larval hostplant is *Rhamnus californica ursina* (Greene), but in Colorado Don Bowman (pers. comm.) has recently collected larvae near Steamboat Springs (Routt Co.) on willow. Each egg cluster contains 45 to 160 eggs. This suggests that females may deposit all of their ova in 1, 2 or possibly 3 clusters with 1 or 2 clusters per female being the norm. Upon emergence the larvae are gregarious and begin feeding on the leaves adjacent to the egg cluster. First instar larvae are black but from the second through last instar they are black and yellow with long white setae extending from the scoli (Figs. 2–4). Larvae lose most of their gregarious tendencies in the last instar. During late August larvae in the second through early last instar can be field collected. There are four larval instars, and the mature larva measure 55 to 65 mm. Mature larvae leave the hostplant and wander prior to pupating in cracks or crevices among rocks, tree trunks, or man-made structures.

Pupation occurs from September to November. Both Mike Collins and Mike Van Buskirk (pers. comm.) have observed that field collected cocoons, which still contain prepupae or newly molted pupae in November or December, were usually parasitized by tachinid flies. Newly spun cocoons are light beige but turn a uniform brown with age; the change may be hastened by moisture. The cocoon (Fig. 6) is loosely woven but somewhat compact. This is in sharp contrast to that of *A. galbina anona* (Ottolengui), which forms a pale brown, bulbous, loose mesh cocoon on its hostplant.

There are many differences between the immature stages of *Agapema* and west coast species of *Saturnia*. Morphologically, the scoli of *homogena* and *galbina* are reduced and bear far fewer and shorter black spines when compared to *Saturnia*. *Agapema* larvae are long and thin with numerous white secondary setae, especially on the dorsal area. The larvae of *Saturnia* are more compact, and although secondary setae are present, they are inconspicuous. The spines of *Saturnia* are urticating, whereas, those of *Agapema* are not. In addition *Agapema* larvae tend to be gregarious, while *Saturnia* larvae feed singly and are cryptic. The evolution of the New World *Saturnia* and *Agapema*, and their hostplant relationships were recently discussed by Tuskes and Collins (1981). In general the larvae of *Agapema*, especially those of *homogena*, are more divergent from those of *Saturnia* than might be expected considering adult characters and their earlier congeneric status (Michener, 1952).

ACKNOWLEDGMENTS

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GENERAL NOTES

HOST RECORDS FOR *PARATRYTONE MELANE* (EDWARDS) (HESPERIIDAE)

Paratrytone melane (Edwards) is one of several species of Hesperiidae that has become increasingly urbanized throughout southern California. According to Thorne (1963, J. Res. Lepid. 2(2):148–149), *P. melane* was not recorded from San Diego County prior to 1941. In that year, it was first encountered near El Cajon and has since become one of our most common urban skippers. In San Diego County, *P. melane* is generally the first skipper on the wing in our residential areas, appearing as early as February. Capture records do not indicate a clear broodedness, but rather several or continuous over-lapping generations each year, with spring, mid-summer, and fall peaks.

In mid-March 1982, a female *P. melane* was observed ovipositing, in what seemed to be an indiscriminate manner, on several species of grass, both weedy and lawn, in southern San Diego city. A single larva was subsequently reared from an egg deposited on goldentop, *Lamarkia aurea* Linnaeus (Moench) (Poaceae), a common weedy introduced species. Development was normal, and the adult emerged following a three week pupal period. "Indiscriminate" oviposition was also observed by Comstock and Dammers (1931, Bull. So. Calif. Acad. Sci. 30(1):20–22), but the behavior was that of confined females.

A last instar larva of *P. melane* was collected and subsequently reared on Saint Augustine grass, *Stenotaphrum secundatum* Kuntze (Poaceae), from a lawn in Encinitas, California (David Faulkner, San Diego Natural History Museum). Noel MacFarland (pers. comm.) also reported rearing *P. melane* on *S. secundatum* from the lawn at his previous residence in the Santa Monica Mountains, Los Angeles County.

Larvae of *P. melane* are known to feed on Bermuda grass, *Cynodon dactylon* (L.) Persoon (Poaceae), in the laboratory (Comstock & Dammers, op. cit.), and observations by William McGuire (pers. comm.) of oviposition by *P. melane* on *C. dactylon* in residential Del Mar, California, suggests its widespread use as a larval host in urban areas.

Native hosts of *P. melane* are poorly known; the single report of oviposition on *Deschampsia caespitosa* (L.) Beauvois (Poaceae) (Emmel & Emmel, 1973, Nat. Hist. Mus. Los Angeles Co., Sci. Ser. 26:80) is the only record of which I am aware. On one occasion the author collected a single last instar larva of *P. melane* on *Carex spissa* Bailey (Cyperaceae). Subsequently, Guy Bruyea of Poway, California, also collected and reared a single *P. melane* larva on *C. spissa*. This native sedge occurs in moist areas generally away from the coast and is probably widely used by *P. melane* in these habitats.

The presently documented larval hosts of *P. melane* are restricted to two monocot families: Poaceae and Cyperaceae. Several species of grass, both native and introduced, are utilized as hostplants or as oviposition substrates. The single known cyperaceous host, *C. spissa*, has exceedingly coarse leaf blades and in this respect seems to indicate that a wide range of leaf textures is tolerated by the larvae of *P. melane*. The ability of *P. melane* to utilize a large number of introduced species has given it the capacity to greatly expand its range throughout the urban areas of southern California.

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THE SPHINGID FRENULUM AS A PREDATOR DEFENSE

Sphingidae, because of their large body size, must present a tempting target to vertebrate predators. It has been pointed out how tibial spurs can be used to discourage would-be predators (Allen, 1982, J. Lepid. Soc. 36:155–157), and in this note I suggest an additional defense mechanism.

As with Dr. Allen, my knowledge of this mechanism came through personal contact. In December 1977, I spent three weeks collecting insects in a remote area of western Panama (IRHE camp at Fortuna, Chiriqui Province). Here moths came to light in abundance, and the largest were several species of Sphingidae. Since I did not have killing jars large enough to hold big moths, my collecting method was to grasp these moths by the thorax below the wings and quickly inject several drops of alcohol with a hypodermic needle.

When I collected the largest sphingids (*Coctyius* and *Eumorpha*) in this manner, my fingers were pricked on several occasions by something extremely sharp. On close examination I found that this was caused by the moth's frenulum. Whenever I grasped the moth directly over the wing bases, my fingers would push the forewings up enough to expose the frenulum, and at this point it was perfectly positioned to stab into the tips of my thumb and forefinger. In the case of the *Coctyius* and the *Eumorpha* species at Fortuna, the frenulum was thick and stiff enough to pierce my skin.

The defensive use of the frenulum is, of course, secondary and probably unintentional. Nevertheless, my experience leads me to believe that, at least occasionally, sphinx moths may be able to escape predators when a well placed jab occurs. The frenulum defense would be most effective if a bat, toad or lizard were to seize the moth from the front or from above. Holding the moth by the front of the thorax would leave the predator out of range of the tibial spurs but the struggling moth might be able to stick the frenulum into the lining of the predator's mouth.

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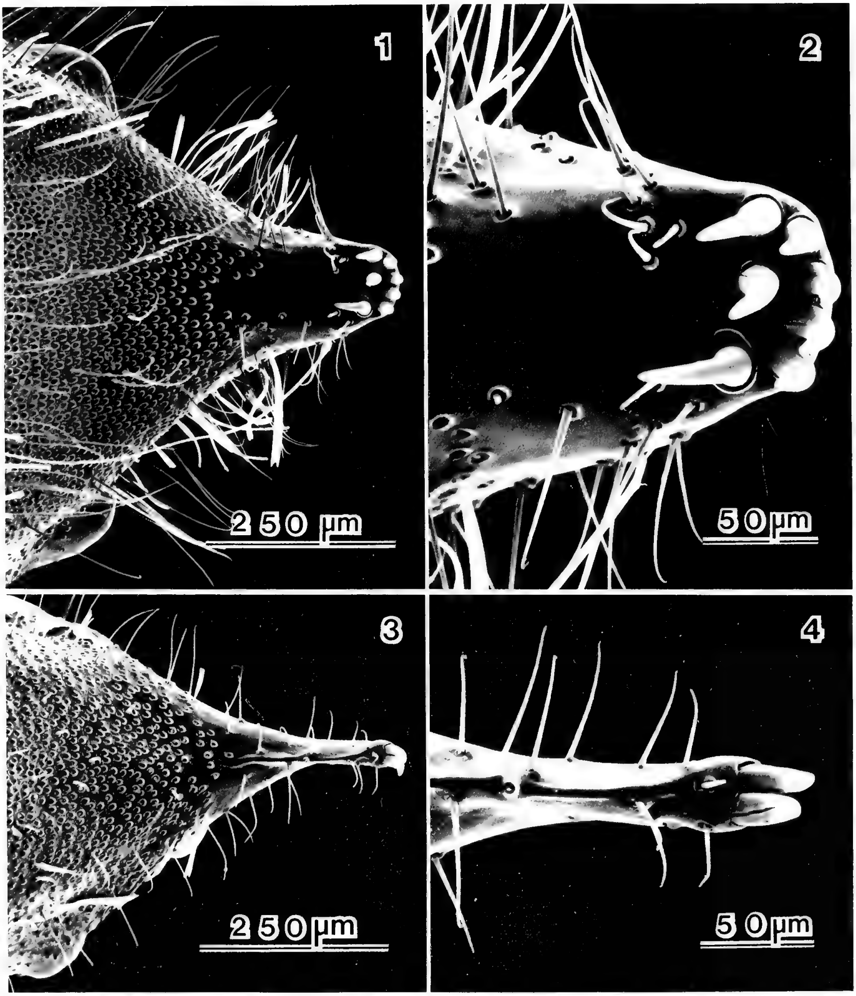
ANOTHER LOOK AT SNOUT BUTTERFLIES (LIBYTHEIDAE: *LIBYTHEANA*)

The two species of snout butterflies of the southwestern United States and Mexico, *Libytheana bachmanii* (Kirtland) and *L. carinenta* (Cramer) are commonly confused in spite of treatments by Field (1938, J. Kansas Entomol. Soc. 11:124–133), Michener (1943, Amer. Mus. Novitates No. 1232), Ehrlich and Ehrlich (1961, How to know the butterflies, Wm. C. Brown Co. Publ., Dubuque, Iowa, pp. 174–175), and Heitzman and Heitzman (1972, J. Res. Lepid. 10:284–286). They are easily separated in males by the shape of the eighth abdominal tergite and less easily (especially in females) by the shape and coloration of the wings. Since the adults have been adequately figured, this note serves to illustrate differences in the male eighth abdominal tergites.

Michener figured the eighth abdominal tergite of *L. bachmanii* in dorsal and lateral views but did not provide a figure of *L. carinenta* for comparison. As can be seen in Figs. 1–4 the species differ in the lateral width of the median apical process and number of setae, but more strikingly, in the number of terminal spines. *L. bachmanii* was found to have between 2 and 4 spines (n = 26, mode of 2), while *L. carinenta* has between 6



FIGS. 1–4. **1 & 2,** Dorsal view of eighth abdominal tergite of male *L. carinenta* (many scales have been removed and a few setae broken during preparation); **3 & 4,** similar view and preparation of *L. bachmanii* (the crease along the median apical process is an artifact from papering the specimen after capture).

and 9 spines (n = 9, mode of 7). The dorsally projecting spines can be seen by using a hand lens or microscope once the overhanging scales have been brushed aside, without having to do any dissecting.

During the morphological investigation of specimens at hand, genitalic dissections were done which revealed consistent differences between the species for both sexes. These will not be reported here owing to the limited number of specimens investigated and must await a comprehensive treatment. However, this look at the terminalia allowed the assignment of all but a few female specimens to one species in preference to the other.

Geographically, *L. carinenta* must be considered a rare find in the United States and is not commonly encountered until well below the Tropic of Cancer. *L. bachmanii* broadly overlaps its distribution along the western side of the Gulf of Mexico and is found as far south as the Rio Tehuantepec in Oaxaca, Mexico.

One can only guess as to the function of the terminal spines of males of these butterflies. Detailed observations of the mating behavior of snout butterflies might provide the answer. Comparative studies of other members of the genus and family of both morphology and behavior need to be done as part of a revision of this interesting group.

I would like to thank Drs. H. R. Burke and J. C. Schaffner, Department of Entomology, Texas A&M University, for making field studies in Mexico possible. J. Ehrman of the Electron Microscopy Center at the University is gratefully acknowledged for his SEM work and photography. L. G. Friedlander reviewed the manuscript.

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COMMUNAL ROOST FIDELITY IN *HELICONIUS CHARITONIA*: COMMENTS ON A PAPER BY DRS. D. A. WALLER AND L. E. GILBERT

In the recent paper by Waller and Gilbert appearing on the pages of this journal (J. Lepid. Soc. 36:178–184), the authors failed to include other substantial data sets on communal roosting in *Heliconius charitonia* and related aspects of this butterfly's population biology which have significant bearing on their conclusions and comments (Young & Thomason, 1975, J. Lepid. Soc. 29:243–255; Cook, Thomason & Young, 1976, J. Anim. Ecol. 45:851–863).

Waller and Gilbert imply that at least a portion of the daily instability in roost membership observed for two other studies of *H. charitonia* in Costa Rica (Young & Carolan, 1976, J. Kansas Entomol. Soc. 49:346–359; Young, 1978, Entomol. News 89:235–243) was due to disturbance of butterflies for marking, something they apparently avoided in their study. This is a serious accusation, one that is not merited as seen by the examination of Young and Thomason (op. cit.) and Cook et al. (op. cit.), two additional Costa Rican studies of the same organism not cited by Waller and Gilbert, and ones that report a significant amount of both population cohesiveness and fidelity to communal roosts.

There is no doubt that butterflies are disturbed to some extent by the handling effects associated with marking, a condition that I seriously doubt even Waller and Gilbert could have avoided entirely in their study. The same techniques associated with marking, however, were used in **all** of the Costa Rican studies cited above, and therefore, any handling effects causing roost disturbance would have been the same for all data sets. Yet Young and Thomason (op. cit.) reported for Roost A in that study, that of 69 butterflies marked, 36 were seen again at least once, and 23 seen from one to three times on subsequent days of observation. We concluded that roost fidelity can be high in *H. charitonia,* but that the spatial distribution of multiple roosts within the same home range area used by the butterflies on any one roost results in considerabe "exchanges" among roosts on a day-to-day basis. Admittedly, this level of roost fidelity is still somewhat lower than the findings of Waller and Gilbert in Mexico, yet higher than observed for other roosts in Costa Rica (Young & Carolan, op. cit.). Furthermore, the study of Cook et al. (op. cit.) on *H. charitonia* population dynamics spanned a period of 155 days and involved the marking of 586 butterflies and concluded that the movement of individual butterflies is regulated largely by the locations of communal roosts and adult and larval food resources. That study also revealed a fractionation of the population into several subpopulations but with considerable interchanges of marked butterflies between areas of habitat occupied by different subpopulations. The obvious inference from such results is the shifting dependency of individual butterflies among several communal roost sites within a relatively small area of habitat. Waller and Gilbert (op. cit.) did not mention the occurrence of other roosts within the vicinity of those adult pollen-source plants visited principally by unmarked individuals of *H. charitonia*. Given the results of Cook et al. (op. cit.), other roosts most likely existed in the general vicinity of the home range area occupied by these unmarked butterflies.

The results of Young and Thomason (op. cit.) indicated that there can sometimes occur considerable **individual** variation in the tenacity of *H. charitonia* to a particular roost site. Genotypic differences among individual butterflies may ultimately explain such patterns (Young and Thomason, op. cit.). In the absence of such data, however, it is safe to conclude tentatively that in some tropical regions occupied by *H. charitonia,* the degree of fidelity to a particular roost site is highly dependent upon (1) the availability of multiple roosts within the area, (2) the positioning of different home ranges occupied by different subpopulations relative to one another, and (3) the abundance and spatial distribution of adult and larval food resources within home range areas. Given the findings of Young and Thomason (op. cit.) and Cook et al. (op. cit.), I believe that it is erroneous on the part of Waller and Gilbert (op. cit.) to suggest that the patterns of roost instability reported in Young and Carolan (op. cit.) and Young (op. cit.) as being due to disturbance incurred while marking butterflies. Waller and Gilbert did not discuss the results of Young and Thomason (op. cit.) relative to their interesting data. Had they done so, they might have been able to suggest that the observed high fidelity of butterflies to the single roost they studied was possibly due to the absence of a second roost within the same home range or at the periphery of a contiguous home range associated with the unmarked butterflies they saw at patches of adult pollen-sources far removed from the vicinity of the roost in question (a projected spatial arrangement of home ranges and roosts that would probably preclude frequent exchanges of marked butterflies among different roosts). In doing so, they would have justifiably assigned an equal weight or error factor to disturbance of butterflies during marking in both their study and the Costa Rican studies discussed here.

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RAINSTORM BEHAVIOR OF PIPEVINE SWALLOWTAILS, *BATTUS PHILENOR* (L.)

While collecting near Laredo, Texas in mid-afternoon, 12 June 1981, we took shelter in our car in advance of a rainstorm approaching from the southeast. The car was parked among mesquite trees, *Prosopis glandulosa* Torr., and we watched as six pipevine swallowtails, *Battus philenor* (L.), buffeted by a brisk wind, came together in a little group on one of the trees from the otherwise sparse population of this butterfly in the area. With the sun in the opposite direction from the storm, no darkening of skies had occurred at the time the assembly was initiated. Individuals were all about 12 feet from the ground, separated from each other by inches to a foot or two. All located themselves on the lee side of twigs, head upward and wings folded together over their backs. After the heavy rain shower they gradually disassembled, fanning their wings before flying away one-by-one. One individual moved for a time to another tree and repositioned itself on a twig but on the side of the continuing southeast breeze, with wings spread apart and not fanning.

In their paper on roost recruitment and resource utilization by *Heliconius charitonia* L. near Vera Cruz, Mexico, D. A. Waller and L. E. Gilbert (1982, J. Lepid Soc. 36:178–184) review hypotheses on communal roosting and comment that *Heliconius* roosting behavior is one of the major remaining mysteries of lepidopteran biology. In relation to our observations, Gilbert (pers. comm.) mentions that the roosts at Vera Cruz, where daily rains were the rule, formed earlier when storms occurred in the early afternoon. He has also seen such roosting in *B. philenor* and *Danaus gilippus* (Cramer) around Catarina, Dimmit Co., Texas.

Our observations were made during a one-day trip and without opportunity for more extended observation. While difficult in south Texas because of sporadic rainfall, further observation of roosting behavior on days with and without afternoon thunderstorms will be necessary to extend and explain our observations for *Battus* and other species. It would be interesting to know whether the butterflies we observed returned to the same place for roosting at night.

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WESTERN RANGE EXTENSIONS FOR *ANISOTA CONSULARIS* (SATURNIIDAE) REPRESENTING NEW STATE RECORDS IN MISSISSIPPI AND LOUISIANA

Until recently, the known distribution of *Anisota consularis* Dyar was limited to a few scattered records from Florida. The inability of reviewers to correctly separate *A. consularis* from its Floridian congeners only further limited our knowledge of the species' range. Kimball (1965, Lepidoptera of Florida, p. 69) readily admitted the limitations of his knowledge of *A. consularis* and Ferguson (1971, Moths of North America, Fascicle 20(2A), Bombycoidea: Saturniidae (Part), pp. 63–84) had difficulty distinguishing between *A. consularis* and *Anisota stigma* Fabricius.

The revision of the genus by Riotte and Peigler (1980(81), J. Res. Lepid. 19(3):101–180) offers the first taxonomic understanding of *A. consularis* and corrects many of the previously published mis-identifications. In addition, they offer records of *A. consularis* from Long and Bulloch counties of coastal Georgia. These captures are the only previously published reports of *A. consularis* occurring outside of Florida.

Several years ago, through the generosity of curator Patricia Ramey, the author examined the *Anisota* in the Mississippi Entomological Museum at Mississippi State University. A previously undetermined female collected by C. C. Greer at Gulfport, Harrison County, Mississippi, on 1 September 1916, was identified by the author as *A. consularis*. This specimen represents a new state record and westward range extension for *A. consularis*.

Recently, the author also examined the *Anisota* in the private collection of Vernon A.

Brou, Edgard, Louisiana. Among the material was a female *A. consularis* collected by Brou on 3 August 1978, at Fluker, Tangipahoa Parish, Louisiana. This capture also constitutes a state record and further extends the western range of *A. consularis*.

It is noteworthy that both collecting locales are from coastal areas. Additional captures of *A. consularis* should be anticipated in those areas of Louisiana, Mississippi, and Alabama, where a mild climate is maintained by the warming influence of the Gulf of Mexico.

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A BILATERAL SEXUAL MOSAIC OF *MITOURA GRYNEUS* (LYCAENIDAE)

A bilateral sexual mosaic of the Olive Hairstreak, *Mitoura gryneus* (Hübner) was collected on 1 August 1981, from Red Cedar, *Juniperus virginia*, near Lynx, Adams County, Ohio. The only other specimen collected on that date was a typical female.

The right half of the specimen is male in appearance and is strongly suffused with gold scales (Fig. 1). The left half has a mixture of male and female characters and is dark brown with a dusting of orange-brown scales, a female characteristic. The right scent pad is oval and measures 1.98 × 0.71 mm (Fig. 2). The left scent pad is sickle-shaped and measures 1.54 × 0.39 mm. A small sample (n = 8) of typical scent pads from southern Ohio was all oval and averaged 2.01 ± 0.113 × 0.73 ± 0.026 mm. No differences in pattern can be detected on the ventral wing surfaces.

The genitalia of the mosaic were dissected and compared to typical male genitalia from southern Ohio (Fig. 2). The right half appears to be typically male, but the left half has several abnormalities. The halves of the uncus are not fused medially, and the left half is largely unsclerotized and dorsally enlarged. The left valva is narrowed basally but is otherwise well developed. A partially sclerotized projection from the left vinculum

FIG. 1. Bilateral sexual mosaic of *Mitoura gryneus*.

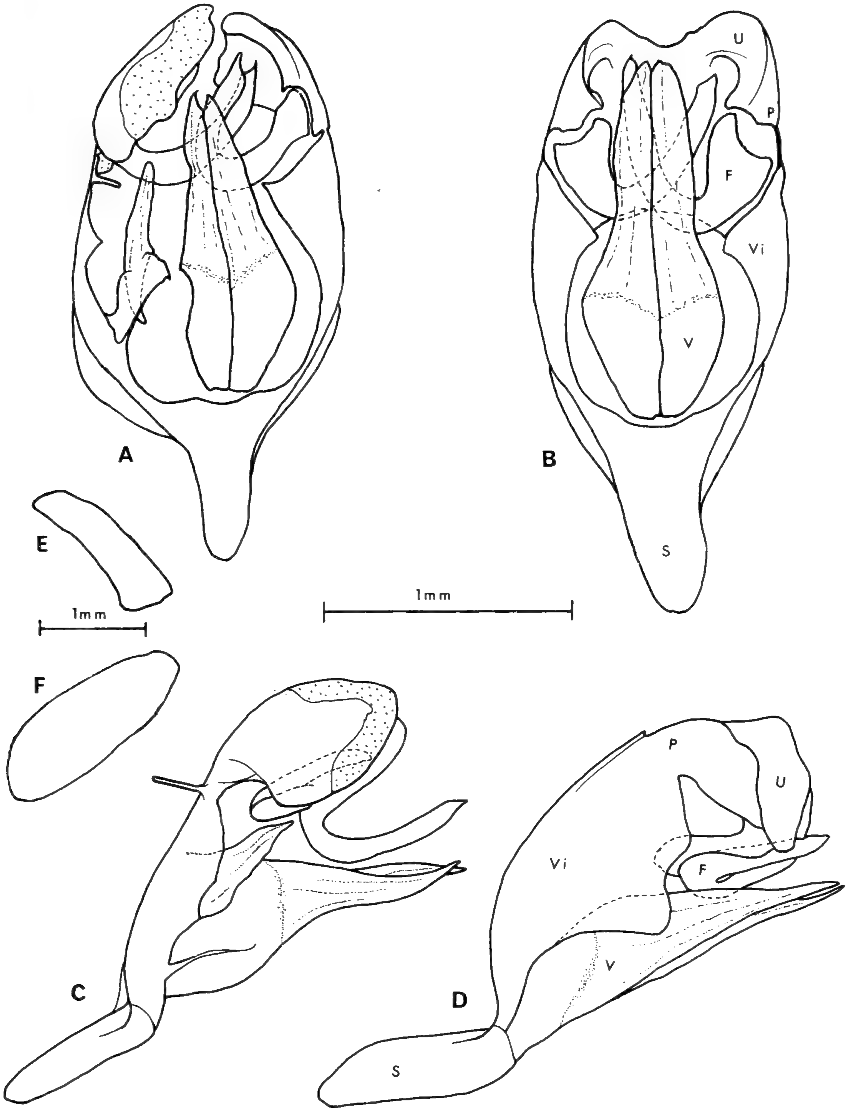

FIG. 2. Male genitalia and scent pads of *Mitoura gryneus*: **A,** sexual mosaic genitalia, posterior ventral view; **B,** typical genitalia, posterior ventral view; **C,** sexual mosaic genitalia, lateral view; **D,** typical genitalia, lateral view; **E,** left mosaic scent pad; **F,** right mosaic scent pad. F, falx; P, pedunculus; S, saccus; U, uncus; V, valva; Vi, vinculum.

is similar in structure and shape to the valvae and may represent the development of a second left valva. At this projection's point of attachment the vinculum is very broad and flattened. Near the juncture of the vinculum and pedunculus a heavily sclerotized rod projects anteriorly. The rod has no apparent counterpart in typical male or female genitalia. The aedeagus does not differ from that of typical males.

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BOOK REVIEWS

THE LIFE HISTORIES OF BUTTERFLIES OF JAPAN. VOLUME I. PAPILIONIDAE, PIERIDAE, DANAIDAE, by Haruo Fukuda, Eiichi Hama, Takeshi Kuzuya, Akira Takahashi, Mayumi Takahashi, Ban Tanaka, Hiroshi Tanaka, Mario Wakabayashi and Yasuyuki Watanabe. xxii + 277 pp., 64 col. pls., 1982. Hoikusha Publishing Co., Ltd., 17-3, 1-chome, Uemachi, Higashi-Ku, Osaka, 540, Japan. (Price not stated in review copy.)

This book treats the up-to-date knowledge of the early stages, adult behavior and distribution of all resident and vagrant species of the families mentioned. The area covered ranges from Hokkaido southwest to Iriomote-Jima. Thus, the entire chain, ranging from Arctic-Alpine to Subtropical conditions, is included. The main text is in Japanese and appears to be authoritative as extensive references are cited and topics such as changes in distribution and mortality curves are included.

For the majority of our membership there are 12 pages of capsule species accounts with cross reference to the color plates and 16 pages and distribution maps.

As we have come to expect from Japanese books, the color plates are of high quality with the colors appearing sharp and true. For each species the adults as found in nature, egg, larva, and pupa are portrayed. Often the habitat or host plant is also included. The adults are often shown in natural behavioral activities such as mating, oviposition, taking moisture or nectaring. The pictures are excellent but occasionally not clear.

For those interested in the many parallels in the life history traits between our species and those of Japan, this book is a must.

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Journal of the Lepidopterists' Society
38(2), 1984, 147–148

THE BUTTERFLIES OF THE YEMEN ARAB REPUBLIC, by Torben B. Larsen. Royal Danish Academy of Sciences and Letters, København. Biologiske Skrifter 23(3). 62 pp. 1982. 120 Danish kroner.

The Middle East is, sadly, best known around the world for its seemingly endless cycles of vengeance and violence. Between the wars, a few hardy souls have been able to do pioneering work on the lepidopteran faunistics of the region; foremost among them is Torben Larsen. Larsen's 1974 book *Butterflies of Lebanon* remains a model of how to do a regional fauna correctly. He continued his tradition of excellence with work in Oman, east Jordan, and Saudi Arabia, and now with this little monograph of the Yemeni fauna. Naive Americans who think the Persian Gulf region consists of bare dunes and date-palm oases—and little else—have a lot to learn from this work. Larsen provides fine discussions of climate, vegetation, butterfly distributions and seasonality. There are few North American faunistic papers that match this for the sophistication of the ecogeographic presentation.

The main body of the text—the species accounts—includes some geographical surprises. This is hardly surprising. Although there has been an unexpectedly long history of collecting in Yemen, the aggregate data are scanty. Larsen spent five weeks in the country in prime season and got 101 species. He missed only 5 species recorded by others for the country, and added 31 to the list. He was also able to find some new entities: the new taxa, for which excellent descriptions and figures are provided, are *Neptis serena* *annah*, *Cacyreus niebuhri*, *Lepidochrysops forsskali*, and the genus *Tuxentius*, removed from *Castalius*. There is also a description of a unique, unnamed female of a new *Lepidochrysops*. All the new taxa and others of particular interest are shown on two color plates, which include three surprisingly lush habitat photos.

There is an appendix by A. H. B. Rydon: "Taxonomic notes on some members of the *Charaxes viola* group, with descriptions of three new species from the Yemen Arab Republic and Ethiopia," with one color and two black-and-white plates.

When Larsen has completed his series of monographs for the region, biogeographers and ecologists will be able to look for general organizational rules for butterfly faunas in desert and seasonal-arid climates; already some hints of order are beginning to emerge. Now, if only the people of the region could be persuaded to put down their guns and go butterfly-hunting instead!

ARTHUR M. SHAPIRO, *Department of Zoology, University of California, Davis, California 95616.*

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Contributions to the *Journal* may deal with any aspect of the collection and study of Lepidoptera. Contributors should prepare manuscripts according to the following instructions.

Abstract: A brief abstract should precede the text of all articles.

Text: Manuscripts should be submitted in *triplicate*, and must be typewritten, *entirely double-spaced*, employing wide margins, on one side only of white, 8½ × 11 inch paper. Titles should be explicit and descriptive of the article's content, including the family name of the subject, but must be kept as short as possible. The first mention of a plant or animal in the text should include the *full scientific name*, with *authors* of zoological names. Insect measurements should be given in *metric units*; times should be given in terms of the *24-hour clock* (e.g. 0930, not 9:30 AM). Underline only where *italics* are intended. References to footnotes should be numbered consecutively, and the footnotes typed on a separate sheet.

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GENERAL NOTES

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Cover illustration: Head (antennae mostly missing) of *Paranthrene tabaniformis* (Rottemburg). This drawing was prepared by George Venable, Smithsonian artist, for inclusion in the Sesiidae fascicle for the Moths of America North of Mexico. The dusky clearwing, a Holarctic species, is a borer in the exposed roots, stems and branches of willows and poplars.

JOURNAL OF
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SOD WEBWORM MOTHS (PYRALIDAE: CRAMBINAE) IN SOUTH DAKOTA

B. MCDANIEL,[1] G. FAUSKE[1] AND R. D. GUSTIN[2]

ABSTRACT. Twenty-seven species of the subfamily Crambinae known as sod webworm moths were collected from South Dakota. A key to species has been included as well as their distribution patterns in South Dakota.

This study began after damage to rangeland in several South Dakota counties in the years 1974 and 1975. Damage was reported from Corson, Dewey, Harding, Haakon, Meade, Perkins, Stanley and Ziebach counties. An effort was made to determine the species of Crambinae present in South Dakota and their distribution. Included are a key for species identification and a list of species with their flight periods and collection sites.

MATERIALS AND METHODS

Black light traps using the General Electric Fluorescent F_{15} T8 Bl 15 watt bulb were set up in Brookings, Jackson, Lawrence, Minnehaha, Pennington and Spink counties. In Minnehaha County collecting was carried out with a General Electric 200 watt soft-glow bulb. Daytime collecting was used in several localities. Material in the South Dakota State University Collection was also utilized. For each species a map is included showing collection localities by county. On the maps the following symbols are used: ● = collected by sweepnet. ◒ = collected by light trap.

Key to South Dakota Crambinae

1a. R_5 stalked 2
1b. R_5 arising directly from discal cell 22

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[1] Plant Science (Entomology) Department, South Dakota State University, Brookings, South Dakota 57007.
[2] Northern Grain Insect Research Laboratory, Brookings, South Dakota 57006.

2a. Male antennae simple, serrate, lamellate 3
2b. Male antennae pectinate 19
3a. Forewing with discal area silvery white 4
3b. Discal area not silvery white 12
4a. Forewing silvery white, no stripe 5
4b. Forewing with silvery white stripe or stripes 6
5a. Dark scaling in median area, complete row of terminal black spots .... *Microcrambus elegans* Clemens
5b. Dark scaling absent, immaculate silvery white .... *Crambus perlellus innotatellus* (Walker)
6a. Forewing with single silvery stripe 7
6b. Forewing with one silvery stripe in the discal cell, one silvery stripe along costa 11
7a. A white patch beyond discal silvery stripe 8
7b. Without white patch 9
8a. Stripe extends beyond costal inception of subterminal line; forewing apex falcate .... *Crambus pascuellus floridus* Zeller
8b. Stripe not reaching costal inception of subterminal line; apex square .... *Crambus alboclavellus* Zeller
9a. Wing base with stripe and brown area above discal stripe nearly equal in width .... *Crambus praefectellus* Zincken
9b. Wing base with costal brown area reduced to a narrow line 10
10a. Gnathos narrow at base, broadening distally, appearing spoon shaped; subterminal area of wing as dark as median area, usually with four black dashes .... *Crambus ainslieellus* Klots
10b. Gnathos narrow throughout; subterminal area paler than median area, usually with five black dashes .... *Crambus leachellus* Zincken
11a. Terminal line preceded by black dots .... *Crambus agitatellus Clemens*
11b. Terminal line preceded by black dashes .... *Crambus laqueatellus* Clemens
12a. Fringe metallic gold 13
12b. Fringe not metallic gold 16
13a. Terminal line replaced on lower half of wing by dots .... *Chrysoteuchia topiaria* (Zeller)
13b. Terminal row of dots complete 14
14a. White scaling along cubitus .... *Crambus coloradellus* Fernald
14b. White scaling along cubitus absent 15
15a. Front conical .... *Agriphila vulgivagella* (Clemens)
15b. Front flattened .... *Agriphila ruricolella* (Zeller)
16a. Lower half of forewing along inner margin darker than discal area 17

16b. Lower half of inner margin of forewing not darker than discal area .... *Pediasia luteolella* (Clemens)

Three forms are recorded from South Dakota and are separated as follows:

Forewing light yellow-brown .... *P. l. luteolella* (Clemens)
Forewing dark brown .... *P. l. caliginosella* (Clemens)
Forewing gray .... *P. l. zeella* (Fernald)

17a. Fringe cut by white opposite veins .... *Pediasia trisecta* (Walker)
17b. Fringe ground color, not cut by white opposite veins 18
18a. Three terminal black dots; inner margin sprinkled with black scales .... *Pediasia dorsipunctella* (Kearfott)
18b. Seven terminal black dots .... *Pediasia mutabilis* (Clemens)
19a. Male antennae bipectinate .... *Thaumatopsis pexellus* (Zeller)
19b. Male antennae unipectinate 20
20a. A black stripe from base to apex of forewing .... *Thaumatopsis fernaldellus* Kearfott
20b. Black stripe absent 21
21a. Cubitus white scaled, wing brown .... *Thaumatopsis pectinifer* Zeller
21b. Cubitus not set off by white scaling; wing light brown to white .... *Thaumatopsis repandus* Grote
22a. Ocelli absent 23
22b. Ocelli present 24
23a. Palpi more than three times as long as head; hindwings white .... *Thopeutis forbesellus* (Fernald)
23b. Palpi less than twice as long as head; hindwings brownish gray .... *Occidentalia comptulatalis* (Hulst)
24a. Wings crossed by two yellow stripes .... *Euchromius californicalis* (Packard)
24b. Wings without two yellow stripes 25
25a. Forewings with vein 3A present; silvery white with brown lines .... *Platytes vobisne* Dyar
25b. Forewings with 3A absent 26
26a. Vein R_2 arising from discal cell; color silvery white .... *Argyria nivalis* (Drury)
26b. Vein R_2 stalked with R_{3+4}; color brown with light colored veins .... *Eoreuma crawfordi* Klots

Subfamily Crambinae

Crambus praefectellus praefectellus Zincken
(Figs. 1C-2, 4a & b)

Records. 99 specimens from Brookings, Lawrence, Minnehaha counties.

Flight period. Bivoltine with peaks in June and August, extreme dates 2 May to 18 September.

Remarks. Klots (pers. comm.) calls this subspecies an eastern and Rocky Mountain form. He stated that the Rocky Mt. race is larger and brighter. He called attention to the wide brown costal border from base of the forewing.

Crambus leachellus Zincken
(Figs. 1A-6, 4g & h)

Records. 56 specimens from Brookings, Minnehaha, Spink counties.

Flight period. Peaked late in September, extreme dates 31 August to October.

Remarks. Klots (pers. comm.) stated that this species is almost continent-wide; often very common to abundant. He states it is of some economic importance in lawns. More or less continually on wing over a long period of time. Klots considers the color and pattern usually indistinguishable from *C. ainslieellus* but genitalia very distinctive. We have found the gnathos to be a distinguishing character in separating *C. leachellus* from *C. ainslieellus* in South Dakota material.

Crambus ainslieellus Klots
(Figs. 2A, 4c & d)

Records. 135 specimens from Brookings, Custer, Dewey, Haakon, Harding, Jackson, Lawrence, Meade, Minnehaha, Spink, Ziebach counties.

Flight period. Most records in mid-September, extreme dates 30 August to 24 September.

Remarks. Klots (pers. comm.) considers *C. ainslieellus* like *C. leachellus* to be almost continent-wide in distribution. He states that *C. ainslieellus* is rare or uncommon. However, we have found it to be the more common species in the western section of South Dakota.

Crambus laqueatellus Clemens
(Figs. 1A-5, 4i & j)

Records. 3 specimens from Brookings, Minnehaha counties. Dates of capture were 31 June and 3 August.

Remarks. Klots (pers. comm.) regards *C. laqueatellus* as fundamentally an eastern species. He states that it is often the first *Crambus* to fly in late spring. *C. laqueatellus* was only found in the eastern portion of South Dakota and only 3 specimens were collected. It is normally associated with lawn grasses and wet meadows.

Crambus perlellus innotatellus Walker
(Figs. 2B, 7c)

Records. 20 specimens from Brookings, Jackson, Lawrence, Meade, Minnehaha, Pennington, Shannon counties.

Flight period. Most records in early August, extreme dates 19 July to 11 September.

Crambus agitatellus Clemens
(Figs. 1A-2, 5f)

Records. 2 specimens from Minnehaha County dated 16, 21 June.

Remarks. Klots (pers. comm.) said *C. agitatellus* is the conventional name now used in literature, but this will be corrected when he publishes his work dealing with the Crambinae.

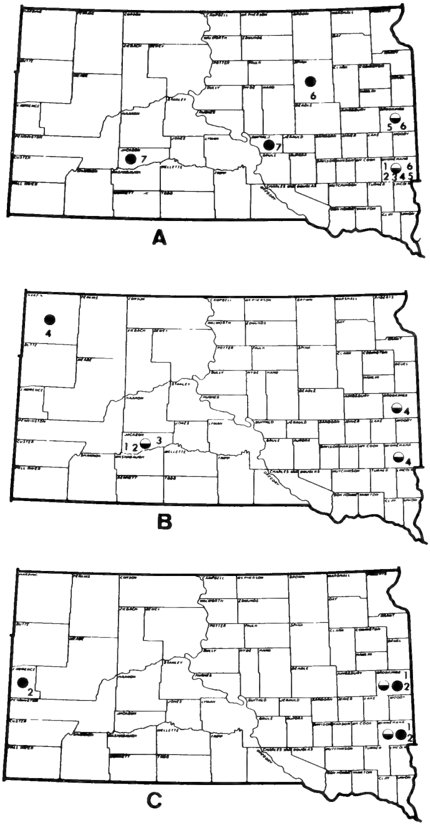

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FIG. 1. Distribution data for: **A**) 1—*Crambus alboclavellus*, 2—*Crambus agitatellus*, 3—*Crambus pascuellus floridus*, 4—*Microcrambus elegans*, 5—*Crambus laqueatellus*, 6—*Crambus leachellus*, 7—*Crambus coloradellus*. **B**) 1—*Thaumatopsis pectinifer*, 2—*Thaumatopsis repandus*, 3—*Occidentalia comptulatalis*, 4—*Thopeutis forbesellus*. **C**) 1—*Argyria nivalis*, 2—*Crambus praefectellus*.

Crambus alboclavellus Zeller
(Figs. 1A-1, 4e & f)

Records. A single specimen collected from Minnehaha County dated 15 July.

Remarks. Klots (pers. comm.) regards this species as often abundant in East, rarer westward. He said *C. alboclavellus* Zeller is the conventional name for this species; however, it is incorrect. He regards *C. alboclavellus* as difficult to distinguish from *C. agitatellus*, but genitalia are distinctive. We have only studied 3 specimens of *C. alboclavellus* and *C. agitatellus*; therefore our use of the presence or absence of a white patch beyond the single stripe on the forewing may not be a reliable character; genitalia were distinctive for the South Dakota material.

Crambus pascuellus floridus Zeller
(Figs. 1A-3, 5a)

Records. 4 specimens from Minnehaha County.

Flight period. Specimens collected on 2 July and 7 August.

Remarks. Klots (pers. comm.) said this species exists in the northern ⅔ of continent. He states that the nominate subspecies is Palaearctic and that *C. pascuellus floridus* is definetely a northern species, but found in the mountains of southern areas.

Microcrambus elegans (Clemens)
(Figs. 1A-4, 7g)

Records. 48 specimens from Minnehaha County.

Flight period. Most records in mid-July, extreme dates 28 June to 10 September.

Crambus coloradellus Fernald
(Fig. 1A-7)

Records. 2 specimens from Buffalo and Jackson counties dated 7 August.

Remarks. Klots (pers. comm.) stated that *coloradellus* is not congeneric with other members of the genus *Crambus* and that he is in the process of erecting a new combination for this species. However, for the purpose of this paper it will be treated as a member of the genus *Crambus*.

Chrysoteuchia topiaria (Zeller)
(Figs. 2C, 4k & l)

Records. 329 specimens were collected from Brookings, Jackson, Lawrence, Minnehaha, Pennington counties.

Flight period. Most records for South Dakota are in mid-July, extreme dates 2 May to 25 August.

Remarks. Klots (pers. comm.) states that this species has, until recently, been regarded as a North American race of the European "*Crambus*" *hortuellus* (Huebner) and is still so treated in the literature. It has been recorded as a pest on cranberry; however, it occurs widely where there is no cranberry, often it is abundant in grasslands. According to Klots there may be two "sibling" species, or "food plant" species. The species is northern but exists continent-wide.

Agriphila vulgivagella (Clemens)
(Figs. 2D, 5g & h)

Records. 121 specimens from Brookings, Dewey, Codington, Harding, Jackson, Lawrence, Meade, Minnehaha, Spink counties.

Flight period. Peak in early September, extreme dates 19 July to 18 September.

Remarks. In the literature this species is recorded as *Crambus vulgivagellus* the well known pest called "Vagabond Crambus." It is most often confused with *A. ruricorella* here in South Dakota.

Agriphila ruricorella (Zeller)
(Figs. 2E, 5e)

Records. 188 specimens from Clay, Dewey, Hamlin, Harding, Jackson, Lawrence, Meade, Minnehaha, Pennington, Shannon, Spink counties.

Flight periods. Most records in August, extreme dates 11 July to 23 September.

Remarks. *A ruricorella* is a smaller form than *A. vulgivagella* and often has some

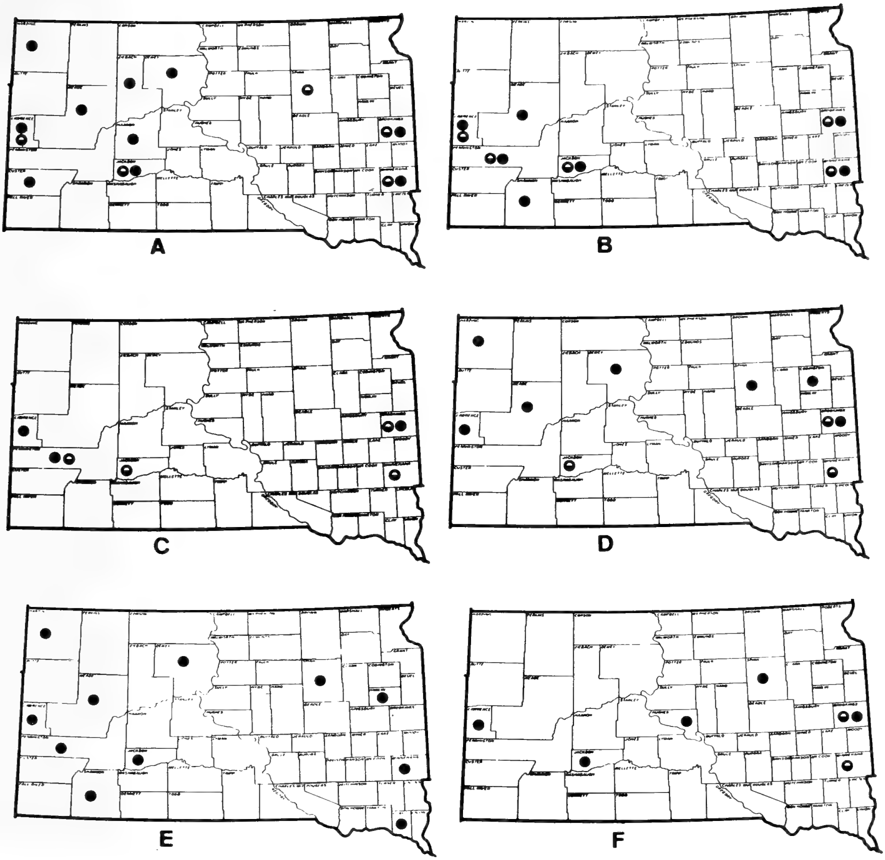

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FIG. 2. Distribution data for: **A**—*Crambus ainslieellus*, **B**—*Crambus perlellus innotatellus*, **C**—*Chrysoteuchia topiaria*, **D**—*Agriphila vulgivagella*, **E**—*Agriphila ruricorella*, **F**—*Pediasia luteolella*.

transverse markings on the forewings. The most distinguishing character of *A. ruricorella* is the flattened front. In *A. vulgivagella* the front is produced and conical.

Pediasia luteolella (Clemens)
(Figs. 2F, 5b, c, d, i)

Records. 47 specimens from Brookings, Hughes, Jackson, Lawrence, Minnehaha, Spink counties.

Flight period. Most records in July, extreme dates 11 June to 31 August.

Remarks. Klots (pers. comm.) states regarding two specimens sent to him "The specimens are not typical, but in this mess they are seldom so." He referred to the specimens as a continent-wide species complex, or superspecies, that includes *P. l. zeella* Fernald and *P. l. caliginosella* (Clemens). Color ranges from almost unmarked yellow to dark sooty brown, sometimes with contrasting marks, sometimes almost unmarked. Klots regards some of this group to be of economic importance. Some will damage sprouting corn. He expects to be putting this group in a new genus. In this paper we have treated *zeella* (Fig. 5c), and *caliginosella* (Fig. 5b), as subspecies and devised a key utilizing color to separate *P. l. luteolella, P. l. caliginosella* and *P. l. zeella*; this has worked well for our South Dakota material but may not hold up regarding other regions.

Pediasia trisecta (Walker)
(Figs. 3A, 7e & f)

Records. 3597 specimens from Brookings, Buffalo, Clay, Dewey, Codington, Fall River, Harding, Hyde, Jackson, Jones, Lawrence, Meade, Minnehaha, Pennington, Spink, Stanley, Todd counties.

Flight period. Bivoltine possibly trivoltine with peaks in July and September, extreme dates 7 May to 13 October.

Remarks. This species, until recently, has been known in the literature as *Crambus trisectus*. This is a very common webworm associated with lawns throughout South Dakota. It is very abundant during peak periods and can cause economic damage to grass lawns. According to Klots (pers. comm.) this species has white veins; often has reduced or short white streaks at the margin or in fringe area. A couple of very close species with sexual dimorphism exist. Also there is much variation between the 2–3 generations. This species is a continuous flyer. Klots warns that specimens with no traces of the white streaks should be carefully examined. They may be *Pediasia laciniella* (Grote).

Pediasia dorsipunctella (Kearfott)
(Figs. 3B, 6e & f)

Records. 191 specimens from Brookings, Jackson, Lawrence, Pennington, Spink counties.

Flight period. Most records in mid-August, extreme dates 19 July to 18 September.

Remarks. This species is smaller than *P. trisecta,* there are no white streaks in fringe of forewing. The male genitalia will separate *P. dorsipunctella* from *P. trisecta* in that the gnathos lack the terminal hook. To separate females the terminal fringe of forewing cut with white streaks is the important distinguishing character.

Pediasia mutabilis (Clemens)
(Figs. 3C, 6g & h)

Records. 58 specimens from Brookings, Brown, Duel, Lawrence, Minnehaha, Spink counties.

Flight period. Bivoltine with peaks by early July and early September, extreme dates 10 June to 18 September.

Remarks. This species is known as *Crambus mutabilis* Clemens in the literature. Klots (pers. comm.) intends to put this species in a different genus. This species belongs to the genus *Pediasia* and is so treated in this paper. Bleszynski (1959) cites this species as *Pediasia mutabilis*.

Thaumatopsis pexellus (Zeller)
(Figs. 3D, 6a & b)

Records. 1628 specimens from Brookings, Clay, Codington, Dewey, Harding, Jackson, Lawrence, Minnehaha, Spink counties.

Flight period. Most recorded in early to mid-September, extreme dates 16 July to 1 October.

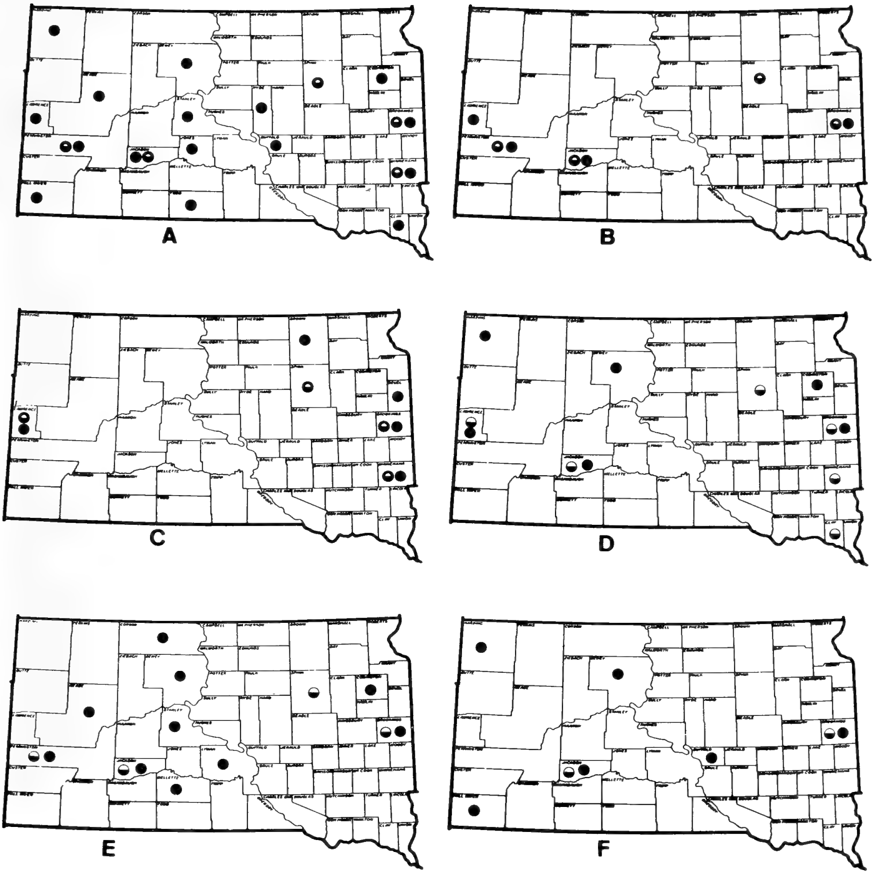

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FIG. 3. Distribution data for: **A**—*Pediasia trisecta,* **B**—*Pediasia dorsipunctella,* **C**—*Pediasia mutabilis,* **D**—*Thaumatopsis pexellus,* **E**—*Thaumatopsis fernaldellus,* **F**—*Euchromius californicalis.*

Remarks. Klots (pers. comm.) regards *T. pexellus* as very baffling in its local and individual variations. Males are needed for positive identification. The bipectinate antennae of the male separates it from all other South Dakota species. Females have filiform antennae and are indistinguishable from *T. fernaldellus* unless collected with males because of individual variations.

Thaumatopsis fernaldellus Kearfott
(Figs. 3E, 6c & d, 7h & i)

Records. 967 specimens from Brookings, Codington, Corson, Dewey, Jackson, Lyman, Meade, Mellette, Pennington, Spink, Stanley counties.

Flight period. Bivoltine with peaks in early June and early August, extreme dates 28 May to 20 September.

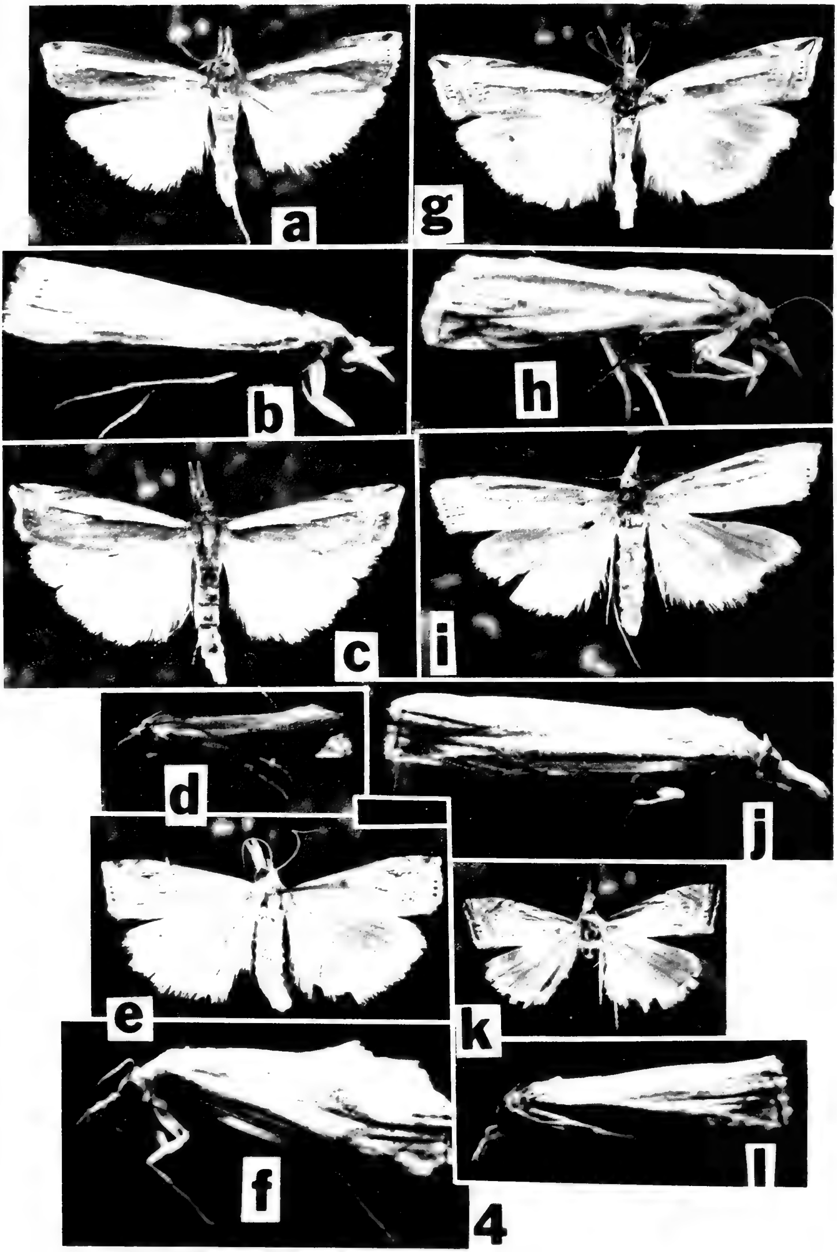

FIG. 4. **a & b**—*Crambus praefectellus*, **c & d**—*Crambus ainslieellus*, **e & f**—*Crambus alboclavellus*, **g & h**—*Crambus leachellus*, **i & j**—*Crambus laqueatellus*, **k & l**—*Chrysoteuchia topiaria.*

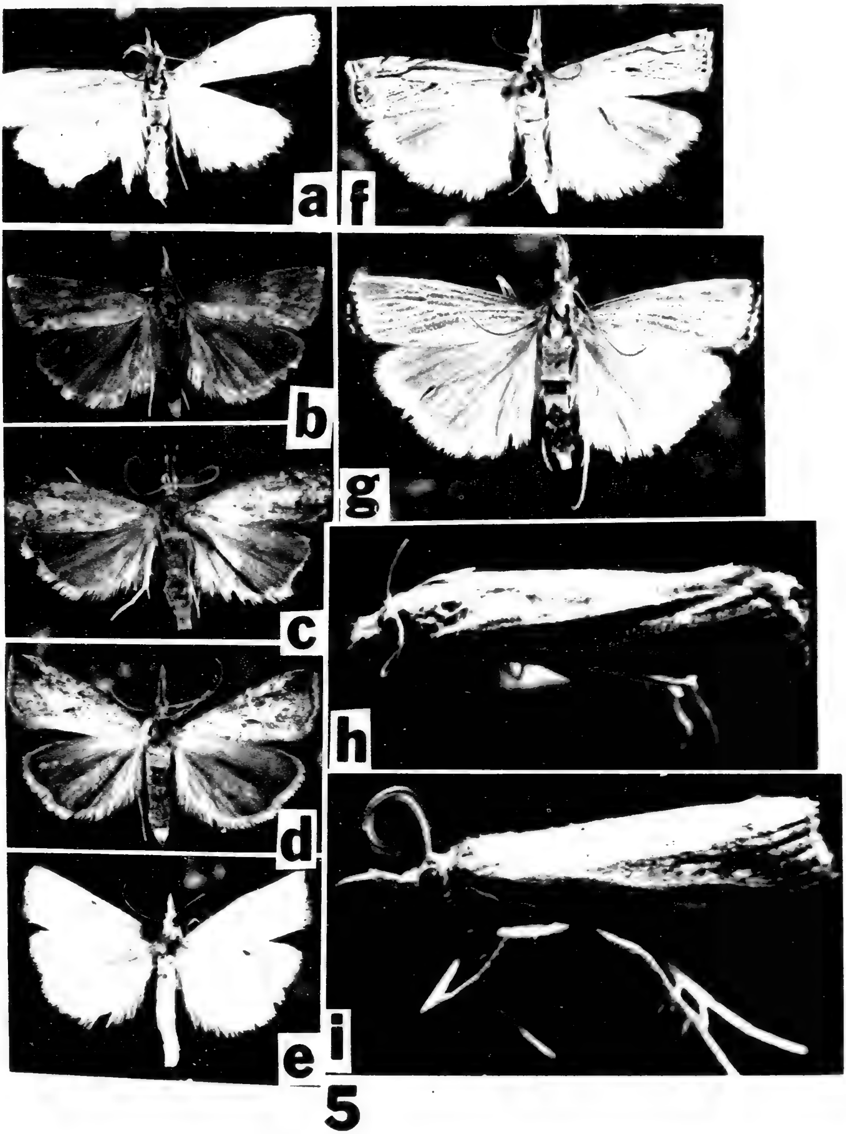

FIG. 5. **a**—*Crambus pascuellus floridus,* **b**—*Pediasia luteolella* form *caliginosella,* **c**—*P. l.* form *zeella,* **d**—*P. l. luteolella,* **e**—*Agriphila ruricolella,* **f**—*Crambus agitatellus,* **g & h**—*Agriphila vulgivagella,* **i**—*Pediasia luteolella.*

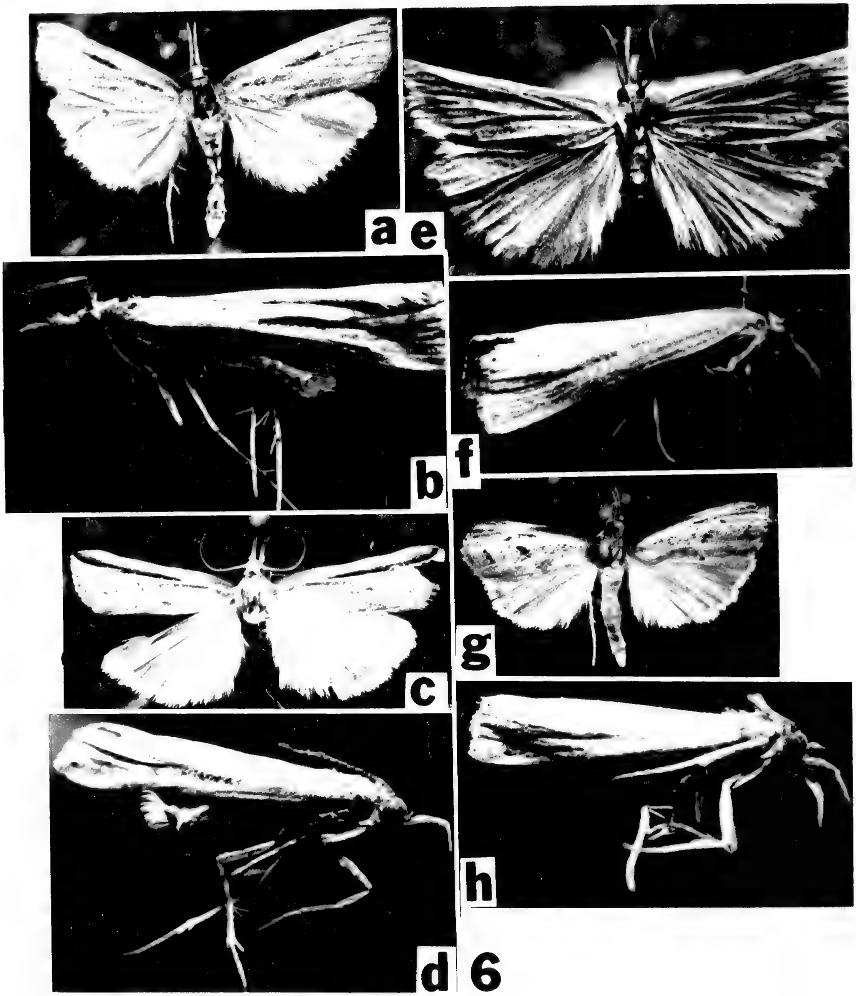

FIG. 6. **a & b**—*Thaumatopsis pexellus,* **c & d**—*Thaumatopsis fernaldellus,* **e & f**—*Pediasia dorsipunctella,* **g & h**—*Pediasia mutabilis.*

Remarks. The identification of all but 63 specimens recorded in this work could be questioned; however, all material was compared with the 63 specimens identified by Dr. Klots as *T. fernaldellus.* The character used in the key (dark stripe from base to apex of forewing) is often rubbed off or is hard to see on "worn" or light trap collected specimens. Work needs to be done on the genitalia within this genus.

Thaumatopsis pectinifer Zeller
(Fig. 1B-1)

Records. 2 specimens from Jackson County dated 25 August.

Remarks. The presence of the white scaled cubitus vein is the reason for these 2 specimens being identified as *T. pectinifer.*

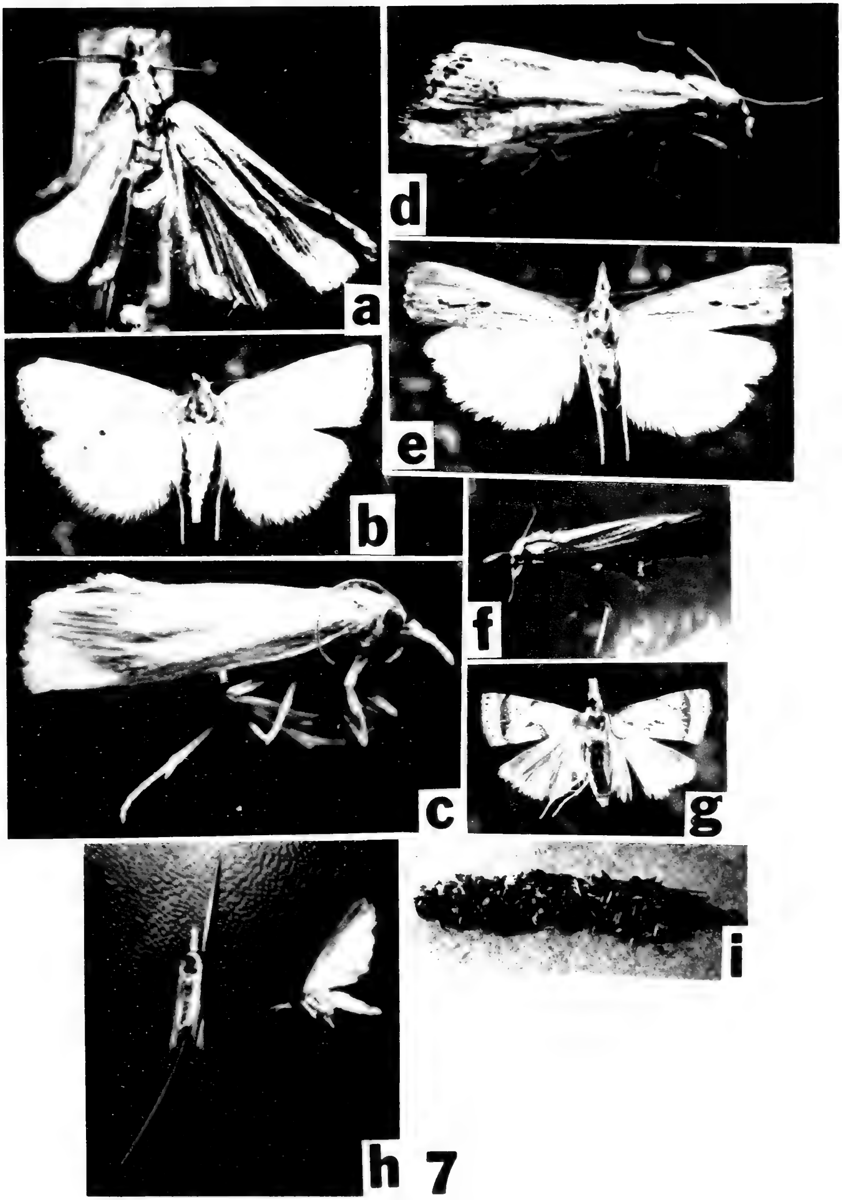

FIG. 7. **a**—*Thamatopsis repandus*, **b**—*Argyria nivalis*, **c**—*Crambus perlellus innotatellus*, **d**—*Euchromius californicalis*, **e & f**—*Pediasia trisecta*, **g**—*Microcrambus elegans*, **h & i**—*Thaumatopsis fernaldellus* male, female, larval case.

Thaumatopsis repandus Grote
(Figs. 1B-2, 7a)

Records. 7 specimens from Jackson County.

Flight period. Most recorded as being collected in late August, extreme dates 7 August to 8 September.

Remarks. Klots (pers. comm.) says the *T. repandus* material from South Dakota is a very good record. This western species represents an intrusive element in the population. This species is somewhat dimorphic in that the males have long or short pectinations of the antennae. Klots states the distribution for *T. repandus* as Rocky Mountain states westward.

Thopeutis forbesellus (Fernald)
(Fig. 1B-4)

Records. 6 specimens from Brookings, Harding, Minnehaha counties dated 12 July and 13 August.

Occidentalia comptulatalis (Hulst)
(Fig. 1B-3)

Records. 2 specimens from Jackson County dated 28 July.

Euchromius californicalis (Packard)
(Figs. 3F, 7d)

Records. 602 specimens from Brookings, Buffalo, Dewey, Fall River, Harding, Jackson counties.

Flight period. Peaks in mid-July, extreme dates 15 May to 2 October.

Remarks. This is the only species of this genus we have collected from South Dakota; however, the females of this species and *Euchromius ocelleus* are difficult to separate. All males studied belong to *E. californicalis*. The genitalia are the distinguishing structure between these two species. *E. ocelleus* has been recorded from North Dakota and can be found in South Dakota.

Platytes vobisne Dyar

Remarks. This species has been cited by Forbes in the literature as occurring in South Dakota.

Argyria nivalis (Drury)
(Figs. 1C-1, 7b)

Records. 41 specimens from Brookings, Minnehaha counties.

Flight period. Peaks in early July, extreme dates 18 June to 31 July.

Eoreuma crawfordi Klots

Remarks. Klots (pers. comm.) stated "One specimen, which I have returned, is very unusual and to be cherished. It is almost certainly *E. crawfordi* which I named in 1970 from Ames, Iowa, and Manitoba, Canada. But the abdomen is missing, so the determination is not certain (it must, then be a new species if not *crawfordi*)." No additional material of this species has been collected to date.

ACKNOWLEDGMENTS

We wish to thank Dr. Alexander B. Klots for aid in the determination of specimens and Dr. Edward U. Balsbaugh, Jr. for the loan of material from the North Dakota State University collection. This work is a cooperative effort of the South Dakota Agricultural Experiment Station, Brookings, South Dakota, and the Science and Education Administration, AR, USDA, as a result of coop agreement No. 12-14-3001-552. Approved for publication by the Director, Agricultural Experiment Station, South Dakota State University, Brookings, as Journal Series No. 1965.

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PAPILIO EURYMEDON LUCAS, 1852: A SYNONYM OF *PAPILIO ANTINOUS* DONOVAN, 1805 (PAPILIONIDAE)

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ABSTRACT. The holotype of *Papilio antinous* Donovan, 1805 has been recognised in the Macleay Museum, Sydney, Australia, and it is considered to be a senior synonym of *Papilio eurymedon* Lucas, 1852 of North America. The histories of these names and of the Donovan specimen are outlined and the nomenclatural problem discussed.

Donovan (1805) illustrated and described *Papilio antinous* (Fig. 1) with the comment "We have observed this undescribed species only in the cabinet of Mr. Francillon. It was obtained by this gentleman from Dr. White, who resided for some time in New South Wales." There was no mention of any type, and Donovan did not indicate how many specimens were before him. Although the provenance was not stated it was inferred from Donovan's comment to be New South Wales, Australia.

In 1818 Francillon's collection was sold at auction (Chalmers-Hunt, 1976). From an annotated copy of the sale catalogue in the Macleay Museum it is known that Alexander Macleay purchased a considerable proportion of it and he took it to Australia in 1825 with the rest of his vast collection.

Godart (1819) followed Donovan, providing a more detailed description of *P. antinous* and stating that the species came from New Holland. Boisduval (1832, 1836) also copied Donovan and referred to Godart.

In 1844 Doubleday listed, without comment, *Papilio antinous* as a junior synonym of *P. turnus* Linn., 1771 (now *P. glaucus* Linn., 1758), a North American species. This synonymy was accepted by Doubleday (1846).

On the death of Alexander Macleay in 1848 the Macleay collections were inherited by his son William Sharp Macleay, who continued to build and study them in collaboration with his cousin, William Macleay.

Early in 1852, both Lucas and Boisduval described *Papilio eurymedon* from California. Later that year Westwood (1852) added it to the list of diurnal Lepidoptera, and Gray (1853) listed it as being in the collections of the British Museum, London.

In June 1863 William Macleay (1864) addressed the Entomological Society of New South Wales saying "that he wished to take the earliest opportunity in his power of pointing out an error in Doubleday and

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FIG. 1. Donovan's original figure of *Papilio antinous*.

Westwood's Genera of Diurnal Lepidoptera, an error which seemed to have been adopted in all subsequent catalogues of *Papilionidae*. The *Papilio antinous* of Australia, which is figured in 'Donovan's Insects of New Holland', from the unique specimen in the cabinet of W. S. Macleay, Esq., of Elizabeth Bay, is placed by Doubleday and Westwood as a synonym of *Papilio turnus,* a well known American Butterfly. He had not noticed this circumstance until a few days ago, but he had then compared the *P. turnus* with the *P. antinous* in Mr. Macleay's collection, and found, as he had expected, that there was not even a resemblance between the species.

"The *P. antinous* clearly belonged to the *Podalirius* group of *Papiliones,* and would no doubt be found (as our acquaintance with the Northern parts of Australia increased) to be, as originally stated, a New Holland insect."

In this statement William Macleay clearly demonstrates that the nominal species-group taxon was based on a single specimen—"the unique specimen." It is therefore clear that that specimen is the holotype of *Papilio antinous* Donovan, 1805 under Article 73.(a)(ii) of the International Code of Zoological Nomenclature (1985).

William Sharp Macleay died in 1865 and the collections were inherited by William Macleay.

No doubt as a result of William Macleay's comments, Kirby (1871) listed *P. antinous* as being Australian. He also listed *P. eurymedon* from California. Later, in the first Australian catalogue to cover diurnal Lepidoptera, George Masters (1873), an associate of Macleay's, also claimed *antinous* as an Australian species, as did Semper (1878).

In 1887 William Macleay gave the Macleay collections to the University of Sydney where a new building, the Macleay Museum, had been built to receive them.

The second catalogue of Australian diurnal Lepidoptera to be published, Miskin (1891), placed *P. antinous* as "reputed to be Australian, but in support of which the evidence is not conclusive"; this appears to be the last occasion on which the name was used. Waterhouse (1903) made no mention of the name in his catalogue, nor did Bryk (1930), although he did refer to other species described by Donovan in 1805.

In 1969 the C.S.I.R.O. Division of Entomology, as custodian of the Australian National Insect Collection, was asked to locate and hold on permanent loan all the type and similarly important material from the Macleay Museum. Although many types have been recognised and transferred to the Australian National Insect Collection, the search for further types continues. During this search Mr. Ted Edwards drew my attention to a specimen in a drawer of mixed papilionids. This specimen (Fig. 2) bore the label "*Papilio antinous* Don. Australia" clearly written in George Masters' handwriting.

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FIG. 2. The holotype of *Papilio antinous* Donovan, 1805.

Masters was appointed curator of the Macleay collections by William Macleay in 1874 in order that these great collections could be reorganised and brought together. Unfortunately, during this work many specimens were neatly relabelled by Masters and the original labels discarded. This action has caused enormous problems in the recognition of type material; indeed, some types may no longer be recognisable.

There is no such problem with *Papilio antinous,* for it is clearly established (Macleay, 1864) that the unique specimen was in the Macleay collections, and in view of its true identity there is no likelihood of further specimens having been added.

It is therefore my opinion that the single specimen found in the Macleay Museum is the one referred to by William Macleay in 1863 (Macleay, 1864) and is therefore the holotype of *Papilio antinous* Donovan, 1805. Examination of this specimen clearly shows it to be conspecific with the North American *Papilio eurymedon* Lucas, 1852, which name must now be considered a junior synonym under Article 23 of the International Code of Zoological Nomenclature (1985).

However, since the name *Papilio antinous* has not been cited in the literature since 1891, there would appear to be a clear case, under Article 79 of the International Code, to make application to the International Commission of Zoological Nomenclature for its suppression as the established stability of the name *P. eurymedon* would otherwise be threatened. However, the purpose of this paper is to establish the correct identity of *Papilio antinous,* and any application to the Commission should be done by those specialists directly affected by the change of name.

Donovan's figure (Fig. 1) agrees well with the specimen of *P. antinous* (Fig. 2), and the few discrepancies are easily explained by his careless approach to his work, detailed by Westwood (1872) and Waterhouse (1938).

Synonymy

Papilio antinous Donovan, 1805: plate 16; Godart, 1819:54; Boisduval, 1832:43 & 1836: 331; Kirby, 1871:564; Masters, 1873:2; Semper, 1879:56; Miskin, 1891:83.
  Papilio turnus Doubleday (nec Linnaeus, 1771), 1844:16 & 1846:13.
  Papilio eurymedon Lucas, 1852:140; Boisduval, 1852:280; Westwood, 1852:529; Gray, 1853:24; Kirby, 1871:565.

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I wish to acknowledge the help of Ted Edwards (C.S.I.R.O. Division of Entomology, Canberra) in drawing my attention to the specimen, confirming the identification and for commenting on the manuscript. I also wish to thank Dr. D. S. Horning of the Macleay Museum for his advice and John Green and Alan Edward (C.S.I.R.O. Division of Entomology, Canberra) for the photography.

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HAMADRYAS IN THE UNITED STATES (NYMPHALIDAE)

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ABSTRACT. Seven species of *Hamadryas* have been collected in the United States. Species included in a recent checklist are: *H. amphinome mexicana* (Lucas), and *H. feronia farinulenta* (Fruhstorfer). *H. februa gudula* (Fruhstorfer) should be changed to *H. februa ferentina* (Godart). Additions to this list for the United States are: *H. amphichloe diasia* (Fruhstorfer), *H. guatemalena marmarice* (Fruhstorfer), *H. atlantis lelaps* (Godman & Salvin), and *H. iphthime joannae* Jenkins. Species unsubstantiated are: *H. fornax fornacalia* (Fruhstorfer) and *H. ferox* (Staudinger) (correct name is *H. amphichloe ferox* (Staudinger), and they should probably be deleted from the previous list. *H. guatemalena* (Godman and Salvin, 1883) (*nec.* Bates) is based on misidentifications of *H. feronia* in Texas.

The neotropical genus *Hamadryas* known for many years as *Ageronia* is a taxonomically confused genus of butterflies that has been in great need of revision. A critical revision of the genus has been completed (Jenkins, 1983) so that it is now possible to accurately identify the *Hamadryas* of the United States. This revision is based on examination of over 9000 specimens including 53 types in 30 major museums and collections, and on collecting and field studies by the author in 20 countries. Of the 100 taxa named, only 20 species and 21 subspecies are recognized. Keys to male and female adults, male genitalia, and descriptions and distributions are included in the above mentioned revision.

Hamadryas spp. have been difficult to determine because needed identification characters and keys have not been published previously, there is much confusion due to a plethora of synonyms created by Fruhstorfer, Bryk and others, and misidentifications of figures exist in many books. Numerous figures in Fruhstorfer in Seitz (1916) are erroneous. Klotz (1951, pl. 18) and Howe (1975, pl. 15) both identify figures of *H. februa ferentina* as *H. feronia*. In the recent book "Audubon Society Field Guide to North American Butterflies" by Pyle (1981) all *Hamadryas* pictures are misidentified. Picture 758, "white skirted calico," is identified as *Hamadryas feronia,* but it is actually *H. februa ferentina,* the most frequently collected species of *Hamadryas* in the United States. The common name designated for *H. feronia* is unfortunate since *H. feronia farinulenta* from Texas and Mexico has dark buff to light ochre ventral hind wings. Picture 759, "yellow-skirted calico," misidentified as *Hamadryas fornax* is actually *H. guatemalena marmarice* (taken in Mexico). I have found no valid

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or confirmed records of *H. fornax* in the United States. The common name "yellow-skirted calico" is not descriptive since the ventral hind wings of *H. fornax* are dark mustard to orange in color. *Hamadryas* are often known as "crackers" because of the crackling or clicking noise they make in flight. Some species are called "calicoes" because of the complex mosaic pattern on the wings that provides camouflage when they alight with wings outspread on tree trunks.

All available specimens of *Hamadryas* collected or purported to have been collected in the United States have been critically examined and determined.

A list of valid collection records for the United States is presented which includes seven species, four of which are new for the United States and not reported in Miller and Brown (1981), plus nomenclatorial changes. Three species previously reported by error for the United States have been based on misidentifications.

The following nomenclature follows Jenkins (1983).

A. Valid Records for the United States

1. *Hamadryas amphinome mexicana* (Lucas, 1853)

Specimens identified: (photograph) Texas, Hidalgo Co., Bentsen-Rio Grande Valley State Park. 1 ♂ (fresh), 3 Sept. 1972, Leg. W. W. McGuire (McGuire & Rickard, 1974). This specimen in the McGuire collection was photographed and published by Kendall (1974) showing dorsal and ventral views permitting identification of the subspecies as *mexicana*. It is the only positive collection record known to me in the United States and is almost certainly a chance migrant or stray. The nearest known record is at Tamazunchale, Mexico, over 500 km south. However, this subspecies became established in western Cuba and was commonly collected in 1934 and 1935.

In Miller and Brown (1981), Catalogue No. 685a.

2. *Hamadryas februa ferentina* (Godart, [1824])

Specimens identified: "Texas," 1 ♀ labelled "type" of *Ageronia februa gudula* (Fruhstorfer, 1916) in the British Museum (Natural History). I have examined and photographed this type, and it is a dark female of *H. februa ferentina*. The original description states that it comes from western Mexico. Texas, Hidalgo Co., Bentsen-Rio Grande Valley State Park, 2 ♀♀ 24 Aug. 1969, Leg. M. A. Rickard, in Amer. Mus. Nat. Hist. Coll.; Texas, Pharr, 1 ♀ Leg. H. A. Freeman, in O. Buckholz Coll., in Amer. Mus. Nat. Hist. Coll.; Texas, Hidalgo Co., Bentsen-Rio Grande Valley State Park, 1 ♀ (worn), 1 ♂ 24 Aug. 1969, Leg. Roy Kendall; 1 ♂ (fresh) 30 Aug. 1973, Leg. M. A. Rickard in Roy Kendall Coll.; Texas, Hidalgo Co., Loop 37, 6 mi. W of Mission (fresh), 19 Oct. 1973, Leg. W. William and N. McGuire, in Roy Kendall Coll.; "Texas" 1 ♂, 1 ♀ in Carnegie Museum Coll.; "Texas" 1 ♂ Coll. T. L. Mead in Holland Coll., No. 299, labelled "*Ageronia feronia* (Linn.)" in the Carnegie Museum Coll.

Other records: Reported from Texas by McGuire and Rickard (1974), Howe (1975), and others as *H. februa gudula* (Fruhstorfer) which is one of many synonyms of *H. februa ferentina*. This is the most commonly collected *Hamadryas* in the United States and is probably a resident or becomes established regularly in southern Texas. The larvae probably feed on the euphorbiaceous plant *Tragia* which occurs in southern Texas.

In Miller and Brown (1981) as *Hamadryas februa gudula* (Fruhstorfer) No. 683a.

3. *Hamadryas feronia farinulenta* (Fruhstorfer, 1916)

Specimens identified: Texas, Hidalgo Co., Loop 37, 6 mi. W of Mission, 1 ♂ (fresh)

15 Jul. 1975. In Roy Kendall Coll. "Texas" labelled "*A. formax*" [Sic.] 1 ♂ in Los Angeles Co. Mus. Nat. Hist.

Other records of "*feronia*": "This remarkable insect is said to be occasionally found in Texas" Holland (1898). Texas, Pharr. "Strays" in Oct. and Nov., Klots (1951). Texas, Brownsville, "Strays," Howe (1975). "Southern Texas." Many reports and quotes with no specific data starting with Scudder (1875) need verification. The two male records from Texas appear to be the only valid records of this species for the United States. No other United States specimens have been found in any of the museum collections studied. (This is frequently confused with *H. februa ferentina*. See misidentified record in Holland Coll. above.)

In Miller and Brown (1981), Catalogue No. 682a.

4. *Hamadryas amphichloe diasia* (Fruhstorfer, 1916)

Specimens identified: (Photograph). Florida, Monroe Co., Plantation Key, 5 Jul. 1978, Leg. Paul Tuskes. Florida, Monroe Co., Key Largo, Tavernier, 16 Jul. 1978 (sight record) Paul Tuskes. These specimens were reported as *Hamadyras februa diasia* in the 1978 Field Summary (1979). It is unknown whether they are migrants, temporary, or permanent residents. *Tragia saxicola* Small occurs in the Florida Keys as well as two other species of *Tragia* which could be host plants. *H. amphichloe diasia* occurs in Cuba, Jamaica, and Puerto Rico where it is relatively uncommon or rare and in Hispaniola where it is fairly common. *H. amphichloe diasia* has been called *H. ferox diasia*. As stated in Jenkins (1983) *Ageronia amphichloe* Boisduval, 1870 was *incertae sedis* for over 100 years due to the poor description. I examined the original Boisduval type in the British Museum and found that *Ageronia ferox tegyra* Fruhstorfer, 1916 is a synonym, and *H. ferox diasia* becomes *H. amphichloe diasia*. (For *H.* "*ferox*" records in Texas see list of unsubstantiated records below.)

Not listed in Miller and Brown (1981).

5. *Hamadryas guatemalena marmarice* (Fruhstorfer, 1916)

Specimens identified: Texas, Hidalgo Co., Bentsen-Rio Grande Valley State Park, 1 ♂ (fresh), 17 Aug. 1974, Leg. Frank Hedges, on loan to Roy Kendall Coll. (a specimen of this subspecies was photographed by Harry Darrow in Mexico, and published by Pyle [1981] as *H. fornax*). The Texas specimen appears to be the first and only valid United States record. This subspecies occurs from Tamaulipas in northeastern Mexico and Sonora, Mexico, to the Isthmus of Tehuantepec and Chiapas. Further details are being published by Kendall.

Other records of "*H. guatemalena*": Godman and Salvin (1883) confused and misidentified *H. feronia* as *H. guatemalena* and assumed that *H. feronia* reported for Texas by Strecker (1878) was *H. guatemalena*.

Not listed in Miller and Brown (1981).

6. *Hamadryas iphthime joannae* Jenkins, 1983

Specimens identified: Texas, Burnet Co. 1 ♂ (fresh) Aug., William C. Wood Coll., in the Amer. Mus. Nat. Hist. Coll. This is northwest of Austin, Texas, and is surely a stray migrant since the nearest records are at Tamazunchale and Tuxpan, Veracruz, Mexico, about 1000 km south. This is a new record for the United States. The specimen had been identified previously as *H. iphthime* (Bates) by F. M. Brown but was never published. *Ageronia iphthime* Bates was described from a syntype from Bogotá, Colombia, and partly from a syntype from Guatemala. I have designated the Bogotá type as lectotype of the Panamá and South American population and the Mexican and Central American population was described as *H. iphthime joannae*. See below for an erroneously labelled and misidentified specimen of *H. iphthime iphthime*.

Not listed in Miller and Brown (1981).

7. *Hamadryas atlantis lelaps* (Godman and Salvin, 1883)

Specimens identified: (Photograph). Arizona, Cochise Co., Douglas, San Bernadino Ranch, 1 ♂, 14 Aug. 1976, Leg. Peter Jump. The photograph was sent by Richard A. Bailowitz who also reports an additional sight record.

H. atlantis lelaps was recognized as a new subspecies by Jenkins (1983) after collecting specimens in Sinaloa, Mexico, and comparing with the ♀ type of *Ageronia lelaps* in the British Museum. Godman and Salvin in 1901 had synonymized *Ageronia lelaps* as the ♀ of *Ageronia atlantis*. Fruhstorfer in Seitz (1916) misidentified *lelaps* and applied the name to an undescribed *Hamadryas glauconome grisea* Jenkins (1983) which occurs in Sonora, Mexico, and which should be collected in Arizona and/or New Mexico.

This new record for the United States is a significant northward extension of range of *H. atlantis lelaps* which had previously been reported as far north as Álamos, Sonora, Mexico.

B. Unsubstantiated Records

1. *Hamadryas fornax* (Hübner, [1823])

H. fornax fornacalia (Fruhstorfer, 1907) is an uncommon and locally occurring subspecies that is definitely known as far north as near Tampico, Mexico, about 400 km south of Texas. *H. fornax* was reported from southern Texas by Scudder (1875) and quoted by many authors. Holland (1898) states "*A. fornax* is reported only from the hotter parts of Texas." I examined the Holland Collection in the Carnegie Museum which revealed a specimen labelled *Ageronia fornax* Hubn. in purple ink, probably in Holland's handwriting. It is labelled "Texas or N.M./Coll. T. L. Mead/Holland Coll." It is a misidentified male of *Hamadryas iphthime iphthime* which is found from Costa Rica to southern South America. Klots (1951) reported it from Pharr, Texas, in Oct., and Howe (1975) in the Brownsville area. Pyle (1981) misidentified and published a picture of *H. guatemalena marmarice* from Mexico as *H. fornax* for Texas. Despite all these publications I have not been able to confirm any valid specimens in over 30 major museums and private collections examined.

In Miller and Brown (1981), listed as *Hamadryas fornax fornacalia*, No. 681a.

2. *Hamadryas amphichloe ferox* (Staudinger, [1886])

H. amphichloe ferox is a rare species that has been reported from Texas. It occurs in Venezuela and Colombia and has been reported from Central America. I have studied and photographed the single holotype male of *H. ferox fictitia* (Fruhstorfer, 1916) from "Mexico" in the British Museum (Natural History). This is a synonym of *H. amphichloe ferox*. The locality record of Mexico is probably fictitious. I have examined two other old specimens of *H. amphichloe ferox* from Central America which are probably mislabelled: 1 ♂ from "Guatemala," U.S. National Museum Coll., and 1 ♂ from "Panama" in the Strecker Coll. at the Allyn Museum, neither with specific localities. Klots (1951) states "There is also a vague record of *H. ferox* Staudinger from southern Texas which I have been unable to verify." Hoffman (1940) also was dubious of *H. ferox fictitia* and knew of no locality in Mexico where it occurred.

In Miller and Brown (1981), listed as *Hamadryas ferox* (Staudinger), No. 684. An asterisk was used to indicate that it was of doubtful occurrence in the United States. This record should be deleted from the list.

3. *Hamadryas guatemalena* (Bates, 1864)

Godman and Salvin (1883) include the record of *H. feronia* from southwest Texas by Scudder (1875) and other authors as *H. guatemalena*. This was due to their confusion of these two species. They considered *H. feronia* as occurring from Panamá south and that *H. guatemalena* occurred in Central America and Mexico. This was based on misidentifications, and no known specimens were then available from Texas to confirm *H. guatemalena*.

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I would like to thank Roy O. Kendall for sending several Texas specimens of *Hamadryas* for determination and for comments on the manuscript, and to curators of numerous museums and private collections for permission to review their *Hamadryas*. I greatly appreciate the kind help and valuable comments of Dr. Lee D. Miller, Jacqueline

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A SEX PHEROMONE IN THE CALIFORNIA OAKWORM *PHRYGANIDIA CALIFORNICA* PACKARD (DIOPTIDAE)

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ABSTRACT. California oakworm (*Phryganidia californica*) virgin females confined to sticky traps attracted significantly more males than unbaited control traps. This demonstrates the presence of a sex attractant in this species.

The California oakworm (COW), *Phryganidia californica* Packard, the only species of the family Dioptidae in America north of Mexico, is a major defoliator of oaks in California (Essig, 1958; Brown & Eads, 1965). Previous studies (Harville, 1955; Sibray, 1947) have shown that COW populations erupt sporadically, but the causes of these eruptions are presently unknown. Attractive pheromones, should they exist, could provide a means of detecting sparse populations and incipient outbreaks and determining the distribution of this species (Daterman, 1978; Cardé, 1979).

Here we report results that indicate the presence of a female produced sex pheromone in this species.

MATERIALS AND METHODS

The study was carried out in October 1982 in a ca. ¼ hectare stand of California live oaks (*Quercus agrifolia* Neé) on the University of California campus, Berkeley. Adults used in these trials were field collected pupae which were confined individually to 90 × 23 mm shell vials plugged with cotton wool. The insects were reared under a natural photoperiod in the laboratory and allowed to emerge in these vials.

Pherocon 1C® (Zoecon Corp., Palo Alto, CA) sticky traps were used in all trials. Traps were baited by confining one virgin female to a cylindrical (6 × 12 mm) steel mesh cage suspended from the trap roof. A 5 ml water vial plugged with cotton was also included in cages. Control traps were each fitted with a cage containing a water vial but no female. Traps were placed in arbitrarily selected California live oaks, hung between 2 m and 4 m above ground, and at least 8 m apart.

In the first trial, 10 traps were baited with females which had emerged from pupae 0–24 hours prior to the experiment. Ten control traps were also deployed. In the second trial, eight traps were baited with females which had eclosed 12–24 hours prior to the experiment, 12 with females that eclosed 24–36 hours prior to trap placement and 10 unbaited traps served as controls. In each trial traps were examined 24 hours after they were deployed.

TABLE 1. Male moths caught by traps baited with virgin females and unbaited controls.

	Female age (hours)*	Number of traps	Mean catch	Standard deviation	Range
Trial I	Control a	10	0.1	0.3	0–1
	0–24 b	10	23.7	29.3	0–70
Trial II	Control a	10	0.1	0.3	0–1
	12–24 b	8	66.4	41.4	0–114
	24–36 b	12	55.4	46.5	0–126

* Within trials, treatments (female age at trap deployment) followed by the same letter are not significantly different ($\alpha = 0.05$).

RESULTS

The number of males caught in each trap for a particular trial was ranked and these data were analyzed by means of the Mann-Whitney test (Conover, 1971, p. 224). In each trial, traps baited with virgin females caught a significantly greater number of males than unbaited controls (Table 1). In the second trial, although the number of male moths caught in traps baited with the younger females caught more males than the older females, this difference was not significant. In both trials, some females failed to attract moths (Table 1).

Since baited traps caught a significant number of moths and all COW moths trapped were males, these results demonstrate the presence of a sex attractant in this species. Thus, attempts to extract, isolate, and identify the active secretions seem justified, not simply because of the economic importance of this species, but also because of its unique position among North American Lepidoptera.

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POPULATION BIOLOGY OF THE GREAT PURPLE HAIRSTREAK, *ATLIDES HALESUS*, IN TEXAS (LYCAENIDAE)

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ABSTRACT. The population biology of the great purple hairstreak, *Atlides halesus* Cramer, was studied at two sites in Texas. *A. halesus* feeds on mistletoe (*Phoradendron tomentosum* Engleman) and prefers the younger, non-woody parts of the plant. It is most common in late spring and prefers isolated host plants for oviposition at the southern site. Hymenopteran parasitoids are the major source of mortality, emerging from eggs, third instar larvae and pupae.

Atlides halesus Cramer is the largest widely distributed lycaenid butterfly in the United States. It ranges northward from Mexico to New York and Oregon, and is locally common in most of the southern states (Howe, 1975). Larvae feed on different species of mistletoe (*Phoradendron*, Loranthaceae). Haskin (1933) has described the life history of *A. halesus* in Florida. This article describes its population biology at two locales in Texas and includes information on time of development, phenology, response to host density, use of different plant parts and sources of mortality. American mistletoe (*Phoradendron tomentosum* Engl.) is the host of *A. halesus* in most parts of Texas. *P. tomentosum* is a widely distributed hemiparasitic shrub which infects a variety of deciduous trees. In central Texas, it is most common on ulmaceous hosts (*Ulmus crassifolia, Celtis* spp.), while further south it has apparently adapted to mesquite (*Prosopis glandulosa* Torrey, Leguminoseae).

METHODS

Two field sites were used, one for rearing caterpillars and the other for field observations. The Brackenridge Field Station of the University of Texas is located on the Colorado River, about two miles north of Town Lake in Austin, Texas. Elm (*Ulmus crassifolia*) and hackberry (*Celtis* spp.) are the major hosts of *P. tomentosum*. *A. halesus* is common in late spring, with adults sometimes found in groups of three or four on flowers. Adults are occasionally found flying in mid-winter in the Austin area. Three *A. halesus* larvae were collected at the Brackenridge Station and brought back to the lab for rearing, on 12 April 1979 (#1) and 16 April 1979 (#2, #3). The larvae were fed fresh *P. tomentosum* leaves and weighed daily on a CAHN Electrobalance until pupation.

The Chaparral Wildlife Management Area (CWMA) of the Texas

TABLE 1. Size classes of leaves and stems.

Size class	Stems (diameter) (mm)	Leaves (surface area/leaf) (mm^2)
1	Greater than 10	Greater than 500
2	5–10	300–500
3	2.5–5.0	100–300
4	0–2.5	0–100

Parks & Wildlife Department was used for field observations. The CWMA is about 60 miles north of the Mexican border at Laredo, with desert grassland vegetation dominated by mesquite (Whittaker et al., 1979). Mesquite is the only major host of *P. tomentosum.* Most of the mistletoe is on older trees found in disturbed areas. A total of 375 *P. tomentosum* at four sites were individually marked in 1980 and censused once a month between March 1981 and October 1981 (insect activity was low during the winter months so no data were collected). Each of the four sites had a windmill or water pump and a large tank for holding water. They were surrounded by fencing, and brush inside the fenced area had been periodically removed, leaving a few large trees, most of which were heavily infested with *P. tomentosum.* For each marked *P. tomentosum,* I recorded the diameter of the host (mesquite) tree, the distance of the tree from the nearest holding tank and the number of *P. tomentosum* on the tree. *P. tomentosum* plants were chosen to include a variety of host diameters, distances from water and densities of infestation (see Whittaker, 1982 for details). Plants were searched for *A. halesus* as thoroughly as possible. Because *A. halesus* larvae are very cryptic, some caterpillars were undoubtedly missed, especially on large, leafy mistletoe plants. For every *A. halesus* encountered, I recorded the stage of development (egg or larval instar number), the number of the host plant, and the part of the plant it was on (leaf, stem, or inflorescence). Leaves and stems were further divided into four size categories (Table 1). Data were analyzed to determine relative preference by *A. halesus* for *P. tomentosum* at different distances, densities and host diameters, and for different parts of the plant. More information on data collection and analysis is contained in Whittaker (1982).

RESULTS

Eggs are scattered over the host plant by the ovipositing female. As many as 22 were found on one plant, but they are not laid in clusters. Sometimes eggs are found on the branch of the mistletoe's host tree near the site of infection. Larval eclosion from the egg leaves an open-

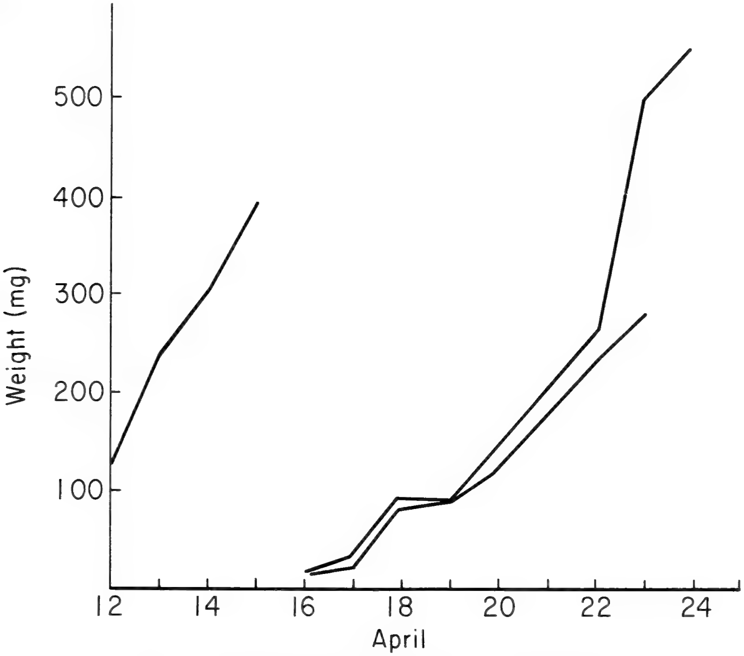

FIG. 1. Growth curves for three *A. halesus* larvae.

ing on the top of the egg and may be distinguished from parasitoid emergence, which leaves an opening on the side of the egg. The egg parasite is presumably a chalcidoid or proctotrupoid wasp but was not identified. The eggs have a hard outer surface and are easily noticeable. According to Haskins (1933), the duration of the egg stage is about seven days.

Larvae are green and darken with age. They are similar to a mistletoe leaf in color and texture, and extremely cryptic. Of the larvae collected at the Brackenridge site, one grew from 124 mg to 392 mg in four days before pupating, one grew from 11.7 mg to 281 mg in eight days and one increased from 15.7 mg to 553 mg in nine days (Fig. 1). Haskin's (1933) larvae spent about 20 days between hatching and pupation. Pupae are dark brown and are sometimes found at the base of trees on which mistletoe grows (Emmel & Emmel, 1973). The minimum duration of the pupal stage seems to be about 16 days (Haskin, 1933) (no records were kept of pupal eclosion by the three caterpillars from Brackenridge). Fig. 2 shows the phenology of *A. halesus* larvae at CWMA in 1981. Caterpillars are most common in late April but remained common through early June and were found during all censuses.

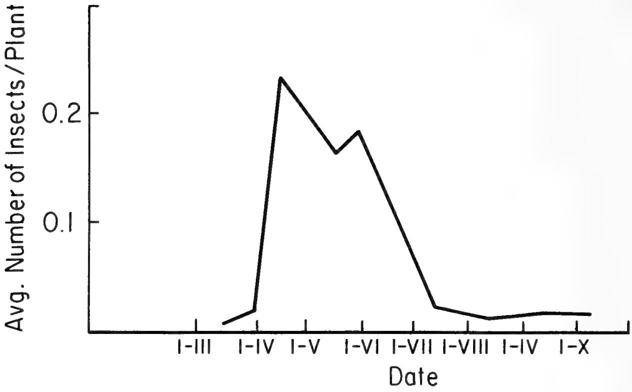

FIG. 2. Phenology of *A. halesus* at CWMA.

Fig. 3 shows the percent of observations of *A. halesus* larvae on different parts of the plant. Young (type 4) leaves were fed on most often, followed by fairly young (type 3) leaves, young (type 4) stems and fairly old (type 2) leaves. Early instar caterpillars fed on young leaves or rasped the surface of older leaves; late instars can chew through the older leaves. *A. halesus* larvae occasionally defoliated entire plants, leaving only woody (type 1 and type 2) stems remaining. Fig. 4 shows the observed number of larvae found on mistletoe plants growing at different densities divided by the expected number, based on a uniform distribution (Whittaker, 1982, p. 73). There were more *A. halesus* caterpillars than expected at low density infestations. The distribution of eggs showed a similar pattern; so, this distribution reflects preference by the ovipositing female and not differential mortality. *A. halesus* was also relatively more common on small diameter mesquite trees and far away from water tanks (Whittaker, 1982), both of which were correlated with low mistletoe density.

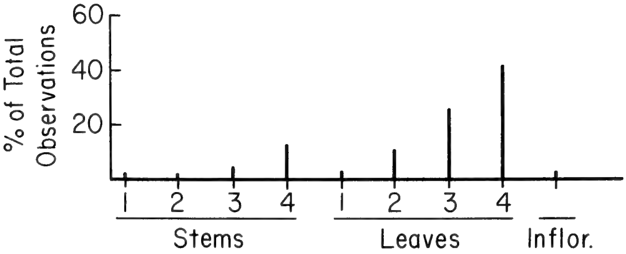

FIG. 3. Feeding preferences for different parts of the host plant.

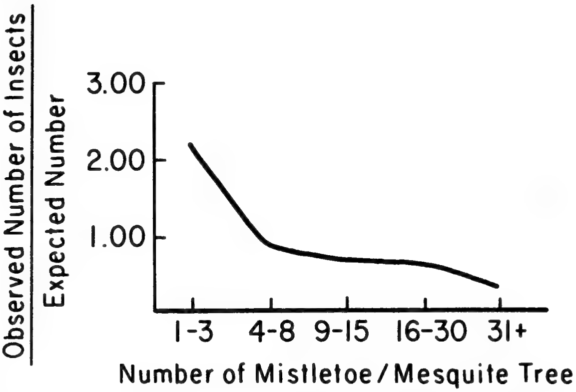

FIG. 4. Response of *A. halesus* to host plant density.

Fig. 5 shows the age structure of *A. halesus* found on censused plants. Eggs are probably over-represented, because they aren't cryptic like the larvae. Parasitism by an unidentified hymenopteran is a major source of egg mortality. First and second instar larvae weren't readily distinguishable, so they are grouped together. A braconid parasitoid (*Apanteles* sp.) emerged from many third instar larvae, leaving behind a cocoon underneath the dorsal integument of the caterpillar, and a large chalcidoid (*Metadontia amoena* Say) emerged from some pupae. Starvation following host plant defoliation was another source of mortality. Fig. 5 reflects the high incidence of mortality due to parasitism in the egg stage, third larval instar and pupae. Adults may be under-represented, because unlike the larvae, they don't spend all their time on the host plant and were only occasionally observed during oviposition.

DISCUSSION

Atsatt (1981) has hypothesized that selection for "enemy-free space" has been responsible for many of the radiations in host plant use within the Lycaenidae. Lycaenids have independently switched hosts to mistletoes (Loranthaceae, Viscaceae) several times. Many mistletoes are frequented by ants, which sometimes tend homopteran populations for nectar and protect lycaenid caterpillars from parasites and predators. *P. tomentosum* in Texas supports several species of host-restricted aphids and scale insects, all of which are tended by ants (Whittaker, 1982). No interactions between *A. halesus* larvae and any of the ant species were observed in the course of my study, and I suggest that the shift of *Atlides* onto mistletoe was a result of the nutritive qualities of the plant and not protection by ants. The remarkable cryptic col-

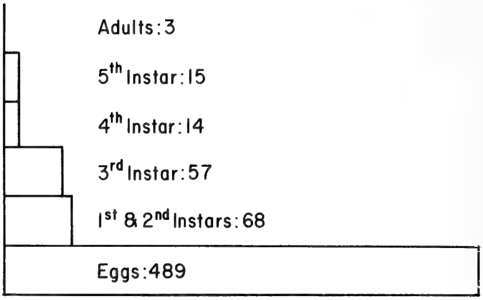

FIG. 5. Numbers of *A. halesus* of different ages.

oration of *A. halesus* larvae may offer protection against avian predators, but the high rates of parasitism indicate that it is not effective against hymenopterans. The noctuid moth *Emarginea* (*Cyathissa*) *percara* Morrison is preyed on heavily by hemipterans (*Largus cinctus* Herrich-Schaeffer, Largidae and *Podisus acutissimus* Stal, Pentatomidae) and attacked by at least one of the ant species which frequent *P. tomentosum*. *E. percara* feeds on the same parts of the mistletoe plant as *A. halesus* but is much more abundant in the Chaparral area and is more likely to be found on older, high density mistletoe infestations (Whittaker, 1982). *E. percara* defoliation is a major source of mortality for *P. tomentosum*. *A. halesus* also kills mistletoe plants and also threatens the resource base for the ants' homopteran herds, but its thick integument probably protects it from attack by both ants and hemipterans (Malicky, 1970). Many butterfly species have now been found to oviposit preferentially on isolated host plants (Courtney & Courtney, 1982). In the case of *A. halesus*, I believe it is a mechanism for reducing competition with the voracious and destructive *E. percara*, which is not a strong flier as an adult and probably has trouble reaching isolated mistletoe plants.

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FORAGING BEHAVIOR OF TAWNY EMPEROR CATERPILLARS (NYMPHALIDAE: *ASTEROCAMPA CLYTON*)

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ABSTRACT. Tawny emperor caterpillars moved up to 3 m to new feeding sites, passing by numerous leaves in the process. These cryptic larvae molted on the underside of leaves or between leaves they tied together before feeding at the new sites.

Cryptic and thus presumably palatable caterpillars may avoid their natural enemies by feeding on the underside of leaves, foraging at night, commuting to and from feeding sites, moving some distance between feeding bouts and cutting off leaf remains after feeding on leaves (Heinrich, 1979). This appears to be a consequence of birds learning to forage preferentially on plants with caterpillar-damaged leaves (Greenberg & Gradwohl, 1980; Heinrich & Collins, 1983). Parasitoids also use damaged leaves and frass to locate caterpillars (Sato, 1979).

Tawny emperor caterpillars (*Asterocampa clyton flora* (Edwards): Nymphalidae) are of particular interest here, because they aggregate in the early instars, in contrast to most cryptically-colored caterpillars. By aggregating, these caterpillars may cause considerable leaf damage at a feeding site and thus, draw attention to themselves in a way that early instars of solitary, cryptic larvae would not. The objective of this study was to examine the foraging behavior of early instar tawny emperor caterpillars.

METHODS

The caterpillars were observed on hackberry trees (*Celtis laevigata* Willdenow) at the University of Florida (Gainesville) in fall 1981. Egg clusters were located on the underside of leaves on the distal portion of major branches. Larval aggregations were followed by placing labeled bands on leaf petioles of occupied leaves. Each day caterpillars were censused by searching leaves of the main branch with the egg cluster. During the molting periods these censuses provided a reliable record of total surviving larvae. However, during feeding bouts caterpillars were often moving back and forth along the branches and thus difficult to census accurately. Consequently, only larvae on leaves were censused. Leaf tissue eaten by the caterpillars was estimated to

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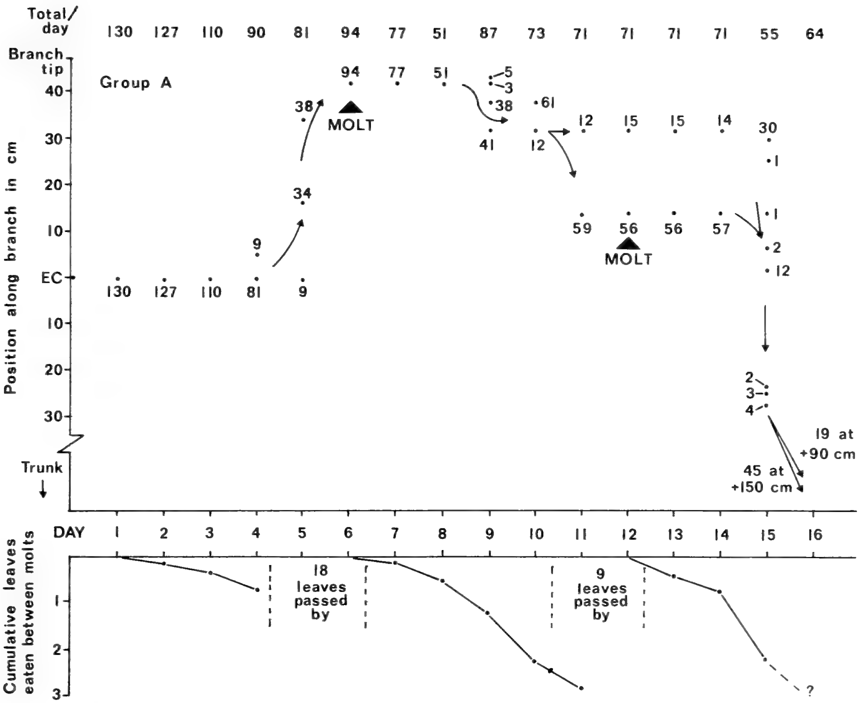

FIG. 1. Foraging behavior of tawny emperor caterpillars, from 24 September through 9 October 1981. EC indicates the position of the egg cluster on the branch. Larval numbers per leaf are shown. Arrows indicate periods of larval movement.

the nearest tenth and then averaged for number of leaves eaten per aggregation per observation.

RESULTS AND DISCUSSION

After hatching, the caterpillars fed on that same leaf and occasionally on adjacent leaves. For example, group A ate 35% of the leaf tissue of two of three adjacent leaves. Group B fed on four adjacent leaves, removing 60% of the leaf material. Five to six days later the larvae moved up to 1.2 m to a new site, passing by numerous leaves and presumably suitable food along the way (Figs. 1 & 2). Reaggregation at the next site took one to two days. Then larvae molted on the underside of a leaf or between adjacent leaves, often tying the edges of the leaf or leaves around them. After molting the larvae fed on those leaves and others on the twig, often leaving only the major leaf veins intact (Fig. 3). Group A fed on seven of eight adjacent leaves, removing 43% of the leaf tissue. Group B ate 34% of four adjacent leaves, subdivided and continued feeding on a few more leaves. Four to six days after the second feeding bout, the larvae moved up to 3.1 m. During

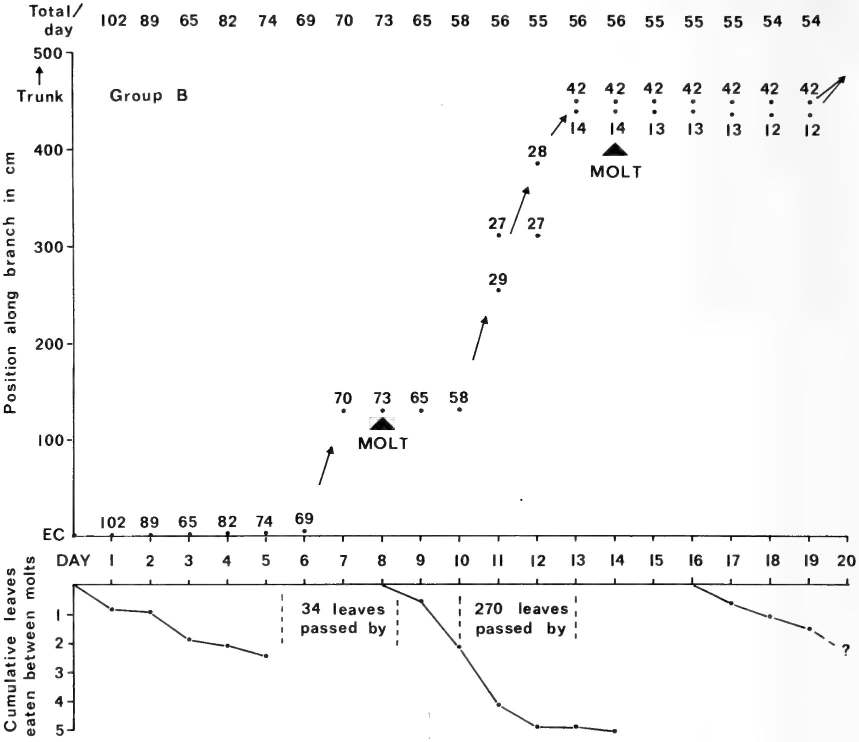

FIG. 2. Foraging behavior of tawny emperor caterpillars, from 24 September through 12 October 1981. EC indicates the position of the egg cluster on the branch. Larval numbers per leaf are shown. Arrows indicate periods of larval movement.

the second migration the larval groups often subdivided, as shown in Figs. 1 & 2. At the third set of sites they molted and then fed, staying there about five to six days.

At the first molting site, 72.3 and 71.5% of the original number of larvae (Figs. 1 & 2, respectively) were present. About half of the original number of larvae were reaggregated at the second molting site (54.6 and 53.9% of those hatching from egg clusters A and B, respectively). Four factors may account for this larval loss. First, the missing larvae may have moved more than 500 cm (length of the major branches) before the second molt; but this seems unlikely. These larvae use silk trails to follow others and remass at new sites. During their migration the caterpillars walk along the branches, with leadership continually changing as the caterpillars pass others momentarily stopped or those backtracking. Consequently, a multi-stranded silk path is deposited which the last caterpillars follow with less rambling than their

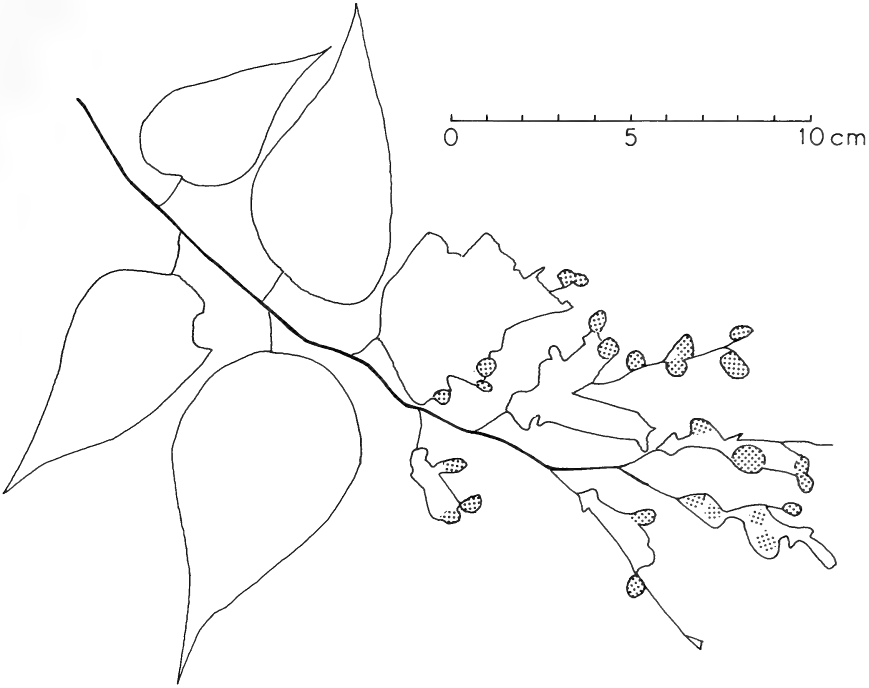

FIG. 3. Feeding site of second-instar tawny emperor caterpillars. Approximately 70% of the six distal leaves was eaten. Shaded areas indicate gall tissue that apparently was rejected by the caterpillars.

predecessors. A second factor contributing to larval disappearance may have been caterpillars dropping from the trees in response to disturbance. But as early instars, these caterpillars usually drop on silk threads and then climb the silk back to their feeding site. A third explanation for the decreasing larval numbers may have been that surveying leaves during group molting underestimated larval numbers. But the relatively constant larval numbers during the molting periods suggest that few if any larvae were wandering to and from the groups then (see "Total/day"for second molts, Figs. 1 & 2). Thus, the fourth factor, predation, is probably the major one contributing to larval disappearance. Only 10 dead larvae were found on the leaves, but predators may remove or entirely consume their prey. For instance, pentatomid bugs often carry off caterpillars and feed with their prey suspended from the beak and off the plant (Evans, 1983). Coccinellid beetle larvae may consume all but the head capsule of early instar caterpillars (Stamp, pers. observ.).

The effect of feeding caterpillars aggregating for several days at a site was to concentrate leaf damage. For example, at three feeding sites, all of which occurred at the end of branchlets, 79% of the leaf tissue of six adjacent leaves, 48% of 19 leaves and 73% of 30 leaves were eaten. Consequently, these larval aggregations by way of their leaf damage were easy to locate, and presumably predators and parasitoids find them apparent, also.

These tawny emperor caterpillars exhibited defensive behaviors, such as swinging their heads and attempting to bite with their mandibles when disturbed. The large, laterally-flattened head capsules with numerous protuberances on the edge are used in a shield-like manner when the caterpillars defend themsleves and may be effective against ants and other small predators. These caterpillars are attacked by chalcidoid and ichneumonoid wasps (T. Friedlander, unpubl. data). For instance, 68% of 41 larval sites had parasitized caterpillars, indicated by the presence of parasitic pupae on or around them (Stamp, unpubl. data). (The parasitized caterpillars were left behind when the post-molt individuals moved on.) Also, vespid wasps may remove tawny emperor caterpillars repeatedly, once they locate an aggregation (T. Friedlander, pers. comm.). Thus, it is not clear whether the defenses of these caterpillars would be enhanced by aggregation as the defenses are for other larvae (e.g., thrashing and regurgitating as with aposematic sawfly larvae, Tostowaryk, 1972).

The crypticity, movement away from feeding sites before molting, and tying leaves at molting sites suggest that tawny emperor caterpillars may be especially vulnerable to their enemies when molting. These caterpillars are less defensive then than during non-molting periods. Tawny emperor caterpillars may obtain some advantage from molting together, enclosed by leaves bound with silk, or from overwintering together (at mid-instar), having tied the deciduous leaves securely with multiple silk strands to the tree (Stamp, 1983). Perhaps these advantages outweigh the possible disadvantages that may arise from group feeding (i.e., concentrated leaf damage, which may attract natural enemies).

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HOST SHIFT OF *ECPANTHERIA DEFLORATA* (ARCTIIDAE) FROM AN ANGIOSPERM TO A LIVERWORT

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ABSTRACT. A population of *Ecpantheria deflorata* Fabricius (Lepidoptera: Arctiidae) was discovered in W. Indiana feeding on *Conocephalum conicum* (Marchantiales: Marchantiaceae), a liverwort. The normal hosts of *Ecpantheria* in the study area are two species of *Plantago*, and the shift to *Conocephalum* has occurred despite major differences in host plant chemistry.

Ecpantheria deflorata Fabricius is an arctid moth which has been reported to feed on a number of unrelated species in North America (Tietz, 1972). These include *Brassica oleracea* L. (Brassicaceae), *Helianthus decapetalus* L. (Asteraceae), *Robinia pseudocacacia* L. (Fabaceae), *Euphorbia heterophylla* L. and *Ricinus communis* L. (Euphorbiaceae), *Persea americana* Mill. (Lauraceae), *Phytolacca americana* L. (Phytolaccaceae), *Salix* sp. (Salicaceae), *Viola* sp. (Violaceae) and *Plantago rugellii* Dec. and *P. lanceolata* L. (Plantaginaceae).

In the Portland Arch Nature Preserve, Fountain Co., Indiana, we found that *Plantago rugellii* and *P. lanceolata* serve as the major host plants for *E. deflorata*.

We observed, however, that a number of larvae were grazing exclusively on *Conocephalum conicum* L. (Hepaticae), especially in the fall of the year. This liverwort forms large mats on sheer rockfaces and is very abundant at Portland Arch. Few other lepidopterans are known to feed on bryophytes (see Tuskes & Smith, 1984), and not many are known from other lower plants (e.g., *Euptychia* on a lycopsid—Singer et al., 1971). Several larvae of various instars were reared on *C. conicum* in the laboratory and pupated and emerged normally.

We consider this host shift to be of interest because of the great difference in secondary chemistry between *C. conicum* and the angiosperm hosts. The chemistry of *Conocephalum* has been reviewed (Markham & Porter, 1978; Spencer, 1979) and the plant has been found to contain a large array of mono- and sesquiterpenoids, including up to 0.6% dry weight (+) − bornyl acetate, a monoterpene existing in opposite chirality to that found in higher plants (Asakawa et al., 1976). Some liverwort terpenoids have been shown to inhibit feeding in Lepidoptera (Wada & Munakata, 1971). The major chemical constituents of *Plantago* are iridoid glycosides (Jensen et al., 1975).

We speculate that some larvae have shifted from *Plantago* to *Co-*

nocephalum primarily due to the close proximity of infested individuals of *Plantago* to *Conocephalum* covered rocks and to the similar texture of the two plants.

As we have observed a population of *Ecpantheria* to be present on *Conocephalum* consistently for over 10 years, and given the unique chemistry of hepatics which has probably kept lepidopteran herbivores in general from utilizing them as host plants, we feel that this host shift represents a major event in the population biology of *Ecpantheria*. This may prove to be a useful system for studying population differentiation across chemical barriers and may represent an incipient speciation event.

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ETHOLOGY OF DEFENSE IN THE APOSEMATIC CATERPILLAR *PAPILIO MACHAON SYRIACUS* (PAPILIONIDAE)

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ABSTRACT. In this investigation I was concerned with two aspects of the defensive ensemble of *P. machaon syriacus* larvae: behaviors which protected them from impending predatory attack and population dispersion. There was a comparatively high frequency of protective behaviors. The high frequency of response may be an adaptation against predators which can not recognize the warning signals or those which have a way of overcoming the larvae's defenses. I found that this aposematic insect was not commonly in large aggregations.

Aposematic animals are those which advertise their noxious qualities as an anti-predation technique. Clearly, the predators effectively selecting these aposematic traits will necessarily be able to detect the advertisement and gain some advantage in avoiding the noxious prey. The predator learns and remembers the undesirability of the prey (Evans & Waldbauer, 1982; but see Smith, 1977). An aposematic individual may have several different objectionable qualities in its armory, each of which may be effective against a different type of predator (Edmunds, 1974).

The larvae of *Papilio machaon syriacus* Verity (Lepidoptera: Papilionidae) are brightly colored and fairly obvious at close range. *P. machaon* larvae have been shown to be objectionable to birds (Järvi et al., 1981; Wiklund & Järvi, 1982) and ants (Eisner & Meinwald, 1965). This caterpillar seemed to be a good model for investigating certain aspects of the aposematic way of life.

I (1983) had shown that aposematic adult Lepidoptera were less likely to perform escape behaviors (elicited by predator-mimicking stimuli) than were cryptic, adult Lepidoptera. In this study I wanted to determine the frequency of apparently protective behaviors when aposematic caterpillars were subjected to various predator-like stimuli and the relative rate of habituation with these stimuli. I was also interested in finding a possible distributional correlate with aposematism. Cryptic species generally must maintain low population densities to reduce the possibility of search-image formation. Conversely, aposematic animals often form large and conspicuous aggregations (Wiklund & Järvi, 1982). Some aposematic larvae are held at low population densities by cannibalism (Williams & Gilbert, 1981). Eruptions of palatable insects are famous (e.g. locusts, armyworms), on the other hand.

METHODS

I worked in old fields and along roadsides near Jounieh, Lebanon from July through September. The last rains generally occur in late May. I performed all tests from 1000–1800 h local time when the ambient temperature ranged between 30–40°C. The caterpillars fed principally on various above ground portions of *Foeniculum vulgare* Mill. (Umbelliferae).

I tapped the substrate of resting *P. machaon syriacus* larvae in order to induce a vibration (Evans, 1978) and recorded the response. I performed this test first, since I found that I often jostled the bushes before the end of the tests. Hence, I was more sure that all caterpillars had similar treatment. I then applied one of four tactile stimuli: dorsal anterior touch (a single tap on the anterior) (group 1, $n = 50$), anterior squeeze (simultaneous bilateral pressure at the anterior) (group 2, $n = 39$), dorsal posterior touch (group 3, $n = 34$), and posterior squeeze (group 4, $n = 55$). I quickly released the bilateral pressure or the tap to avoid muting any response. The duration (± 0.1 s) and type of response (osmeterial extension, body flexion) were recorded. I then repeated the stimulus and recorded the response type. With dorsal anterior touch, possibly a minimal tactile stimulus, and with posterior squeeze, possibly a maximal tactile stimulus, I continued to administer the same stimulus every 10 s until the larva either dropped or ceased to respond thrice consecutively. This failure to respond three times in succession was interpreted as partial evidence of habituation.

Finally, I changed the second stimulus with a fifth and sixth group of larvae. I first administered a dorsal anterior touch and then an anterior squeeze to the fifth group ($n = 34$). With the sixth group ($n = 37$), I first applied a posterior dorsal touch then a posterior squeeze. The purpose of these last two test series was to compare the reactions to a different second stimulus.

No larva was used in more than one test series.

I analyzed the data using $r \times c$ contingency tables, Poisson analysis, and one-way analysis of variance (Snedecor & Cochran, 1980).

RESULTS

Initially, I was surprised at how frequently I discovered solitary *P. machaon syriacus* larvae (30.6% were alone). There was a significant divergence from the Poisson distribution ($P < 0.005$) with the majority of the high χ^2 value due to the solitaries. Later on, I observed adult females ovipositing single eggs ca. 1 m apart. Some large groups (ca. 60 plants) of *F. vulgare* had no larvae at all, but some isolated plants were heavily infested (≤ 9 larvae/plant). These multiple infestations were quite obvious. The smaller larvae (≤ 15 mm long) were usually feeding or resting on umbels where their color patterns were disruptive rather than aposematic. Larger caterpillars were rarely on umbels but usually on larger stems where they were effectively aposematic.

The caterpillars reacted to the stimuli by raising the anterior portion of the body (illustrated in Eisner & Meinwald, 1965), making a lateral thrust with the anterior portion of the body, and/or everting the osmeteria. The intensity of these activities varied: 1) In the minimal anterior raise, only the head and thoracic legs would rise away from the substrate; 2) In the maximum response, the anterior portion of the body would be so strongly flexed as to form a "U." The larva's lateral movement always included the head and thorax, but often the remainder of the anterior half of the body was also involved. The eversion of the osmeteria (usually moist) ranged from one-third to fully everted.

When the osmeteria were everted, I was able to smell nothing 44.7% of the time. When there was an odor, it was generally similar to butyric acid as noted by Eisner and Meinwald (1965). The surprise of the osmeterial extension and the odor might induce aversive behavior in a potential predator.

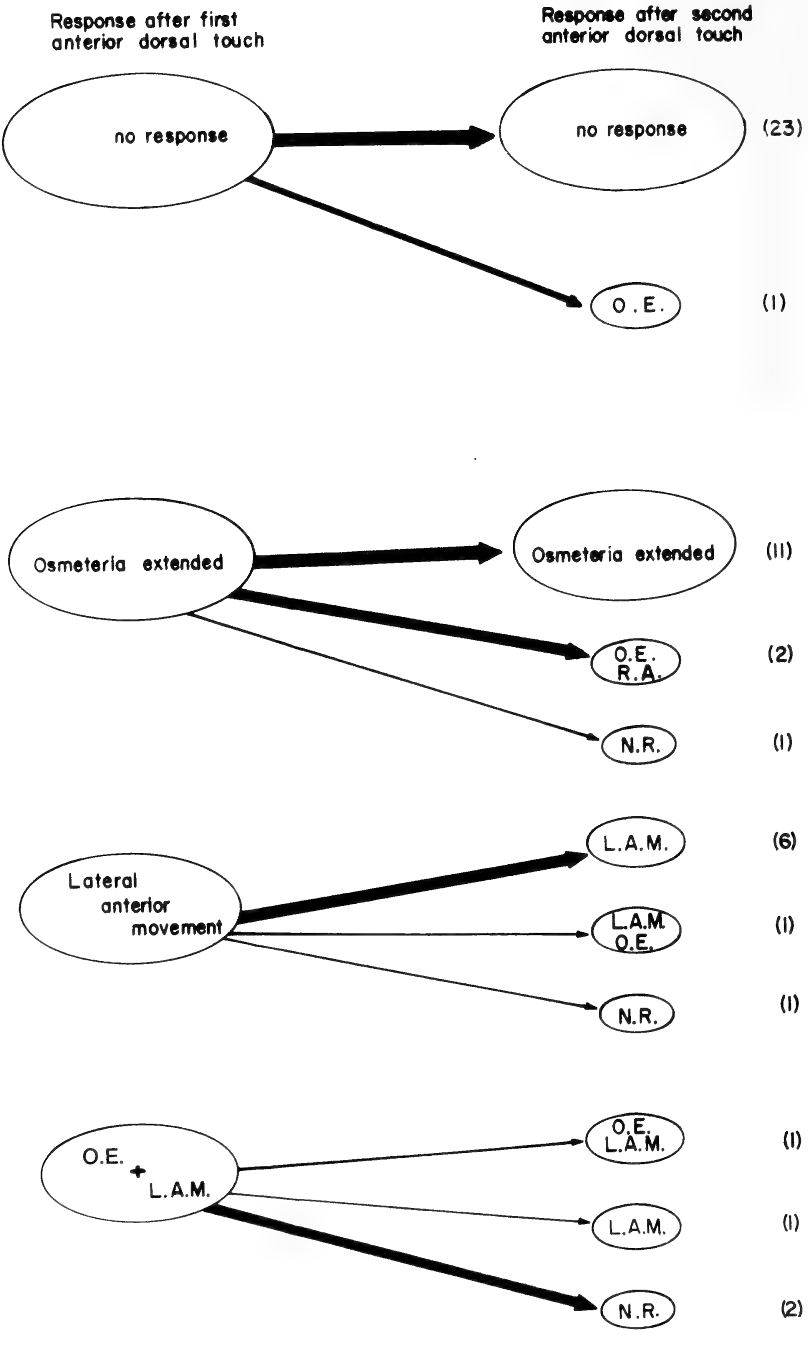
Table 1 illustrates the relative frequencies of behaviors elicited by the stimuli when administered initially. The caterpillars were significantly less likely to respond in any obvious way to substrate vibration than to the four tactile stimuli (χ^2, $P < 0.001$). The elicited responses from dorsal anterior touch were not significantly different from those with anterior squeeze (χ^2, $P > 0.10$). All other frequency comparisons were statistically significantly different (χ^2, $P \leq 0.01$). The posterior squeeze produced noticeable responses of possibly defensive value in 96% of the larvae, but substrate vibration elicited an obvious reaction in only 20%. Substrate vibration may merely indicate that a leaf gleaning bird or mammal is putting its weight on the stem (Evans, 1978). The results show that the posterior squeeze was more likely to stimulate a reaction than a dorsal posterior touch. The posterior squeeze approximates a grasp by a bird's beak and so is more similar to a real threat.

The mean durations of the various behaviors are also noted in Table 1. The means were not statistically significantly different (ANOVA, $P > 0.05$).

I wished to determine whether the larvae normally repeated the same behavior after receiving a seond similar stimulus. Fig. 1 illustrates the frequency of behaviors with the group 1 caterpillars as an example. Forty-one larvae exhibited similar behavior after the second anterior dorsal touch; only nine had different responses the second time. This

TABLE 1. Frequencies and durations of behaviors elicited by the first application of various stimuli to larvae of *Papilio machaon syriacus*. See text for a full description of behaviors and stimuli. All caterpillars were first stimulated by substrate vibration and then each was given one of the other four stimuli. Durations ±0.1 s.

	Responses						
Stimuli	No reaction	Lateral anterior movement	Lateral anterior movement + osmeterial extension	Anterior raised	Anterior raised + osmeterial extension	Osmeterial extension	Sample size
Substrate vibration	196	20	0	2	0	31	249
Dorsal anterior touch (includes group 5)	40	15	3	1	1	24	84
Anterior squeeze	14	3	6	0	0	16	39
Dorsal posterior touch (includes group 6)	24	1	2	16	27	1	71
Posterior squeeze	2	1	0	8	43	1	55
Durations ± S.D.		2.4 ± 3.83	7.8 ± 12.9	0.8 ± 0.40	6.7 ± 11.16	12.5 ± 6.54	


Response after first anterior dorsal touch
Response after second anterior dorsal touch
no response
no response
(23)
O.E.
(1)
Osmeteria extended
Osmeteria extended
(11)
O.E. R.A.
(2)
N.R.
(1)
Lateral anterior movement
L.A.M.
(6)
L.A.M. O.E.
(1)
N.R.
(1)
O.E. + L.A.M.
O.E. L.A.M.
(1)
L.A.M.
(1)
N.R.
(2)

general pattern of behavior occurred with the other three tactile stimuli when I repeated each of them. No set of second responses in any group was statistically significantly different from the set of first responses in that group (χ^2, $P \geq 0.10$).

In groups 5 and 6, I applied a different second tactile stimulus. The response frequency evoked by the anterior squeeze (as a second stimulus) was not significantly different from that appearing after the second anterior touch (χ^2, $P > 0.10$). However, the frequency was significantly different when the second stimulus was a posterior squeeze compared to when it was a repeated posterior touch (χ^2, $P < 0.05$).

In the habituation test, I found that the larvae continuing to receive the anterior dorsal touch exhibited some type of response slightly fewer times ($\bar{x} = 20.0 \pm 16.87$) than with the posterior squeeze ($\bar{x} = 20.5 \pm 13.75$). Three of the latter group eventually dropped but none of the former. The eventual failure to respond was probably not due to fatigue, since several of the non-responding larvae crawled away after I stopped applying the stimuli.

DISCUSSION

The highly localized groupings of larval *P. machaon syriacus* added to the overall impression of conspicuousness. Aposematic caterpillers often seem to feed in obvious locations (Heinrich, 1979). These larvae are distasteful to avian insectivores, and the caterpillars usually survive an attack from birds (Järvi et al., 1981; Wiklund & Järvi, 1982). The numerous aposematic larvae may act as a supernormal releaser in stimulating aversive behavior in the predator (Cott, 1940). Individual fitness may be increased in large groups of aposematic larvae since parasitoid-related mortality is reduced (Baker, 1970). Therefore, the high incidence of solitary individuals in this warningly colored species is surprising.

The degree of responsiveness to the tactile stimuli is also surprising in light of earlier work (Evans, 1983). The relatively high frequencies of responses and the reduced gregariousness could be rationalized if a large component of the mortality of the larvae were due to ants or

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FIG. 1. Frequency of reactions after a first dorsal anterior touch and then a second dorsal anterior touch. The width of the arrows is roughly proportional to the number of individuals performing the second act. **O.E.** = osmeteria extended; **R.A.** = raised anterior; **N.R.** = no observable response; **L.A.M.** = lateral anterior movement. Some activities are performed simultaneously. The parentheses at the right show the actual number performing the action. n = 50.

some other predator where learning plays a minor role in prey selection or where there would be little innate recognition of noxious prey. The most frequent responses (Table 1) included osmeterial extension as at least one component. The osmeterial secretions act primarily against ant predation (Eisner & Meinwald, 1965) but have little, if any, role in defense against bird predation (Järvi et al., 1981). Eisner and Meinwald (1965) note, however, that ants can exhaust the osmeterial secretions of these larvae by making repeated attacks. Whether or not such attacks occur in nature is unreported. The larva in such a situation might survive by throwing ants off with vigorous body thrusts.

The behavioral responses seem to be modal or fixed action patterns to the extent that they were stereotyped and appeared to have little learned component. The patterns of behavior were fixed since the same response was most often given to the same stimulus the second time. Most of the larvae eventually ceased to respond defensively. It appears that there was habituation.

CONCLUSIONS

The aposematic defensive ensemble implies a higher relative threshold for release of active protective behaviors (Evans, 1983). This principle is contingent upon a predator recognizing the aposematic signal and then avoiding contact with the noxious item. The results of this study suggest that some predators do not recognize the aposematic signal and are consistently warded off only by repeated active defenses.

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THE EGG OF *HOFMANNOPHILA PSEUDOSPRETELLA* (OECOPHORIDAE): FINE STRUCTURE OF THE CHORION[1]

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ABSTRACT. The egg of *Hofmannophila pseudospretella* (Stainton) was studied by scanning and transmission electron microscopy. The egg is usually obovoid but varies to ellipsoid or subcylindrical (0.58 × 0.41 mm). The basic pattern of sculpturing consists of low-lying longitudinal ridges joined by indistinct transverse ridges with the ridge intersections slightly elevated. This pattern is sometimes poorly developed, but the slight prominences formed by intersecting ridges are always evident. The surface of the chorion has a wrinkled or granular texture. There are 3 to 5 micropylar canals opening into an anterior pit which is surrounded by a rosette of rather short, petal-shaped primary cells. The primary cells are in turn partially or completely surrounded by series of secondary and tertiary cells. The aeropyles open on slight prominences near the anterior and posterior ends of the egg. Openings are quite abundant in these areas, but there are none elsewhere. Typically, the openings are funnel-shaped and may or may not be surrounded by collars. The chorion averages 4.23 μm thick, and in general structure is similar to that of other lepidopteran eggs.

The brown house moth, *Hofmannophila pseudospretella* (Stainton), is a cosmopolitan, household, mill, and storage pest. The larvae are omnivorous scavengers and attack a wide range of plant and animal products. In North America, *H. pseudospretella* is found from California north to British Columbia and east to Manitoba; there are isolated eastern records from Pennsylvania and southwest Greenland (Hodges, 1974). It has been recorded from cantaloupe seed, celery seed, fish meal, grain, mixed feed, lima beans, and milo in California (Strong & Okumura, 1958; Okumura & Strong, 1965). In Europe, *H. pseudospretella* is a common pest of stored products. Woodroffe (1951) reported that it is widely distributed in Britain, where it occurs in dwellings, stores, and mills as well as outdoors in bird nests. It occasionally becomes a major pest attacking bulk wheat, bagged flour, and other stored commodities. In the home, it is most often important as a clothes

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[1] Mention of a proprietary product in this paper does not constitute an endorsement of the product by the USDA.

moth. It is common and generally distributed in New Zealand where it is most often a pest of carpets (Somerfield, 1981).

Woodroffe (1951) gave an account of the life-history of *H. pseudospretella,* including a brief description of the egg. However, there have been no detailed studies of its chorionic structure. The study reported here was conducted as part of a project to characterize the eggs of stored-product insects and to facilitate their identification. The only other oecophorid egg that has been studied is that of the white-shouldered house moth, *Endrosis sarcitrella* (L.) (Arbogast et al., 1983).

MATERIALS AND METHODS

Laboratory cultures of *H. pseudospretella* were established with adults that emerged from food packets (Strong, 1970) placed in an old shed and an old barn near Castroville, California. Voucher specimens have been deposited in the U.S. National Museum of Natural History. The moths were reared in the laboratory at 25 ± 1°C on 950 ml quantities of cracked wheat in 3.79 l jars. Cultures were maintained in a room at 60 ± 5% RH, but additional moisture was provided by a watering device in each jar. This consisted of a plastic vial (6 cm deep × 4 cm inside diameter) filled with water and covered with a piece of 11 cm filter paper that served as a wick. The filter paper was held in place by the vial's snap-on cap, which had a hole 25 mm in diameter cut in its center. The vial was placed in an inverted position on the bottom of the jar, and wheat was poured on top of it.

Eggs were collected by confining moths in 0.95 l jars without food. Each jar was covered with screen secured by a screw-type lid, and each contained a piece of pleated black construction paper to provide a resting place. Jars containing moths were held in a desiccator over a saturated solution of KNO_3, which provided an RH of ca. 92%. The moths oviposited freely in this situation, and the eggs, which adhered very lightly or not at all to the surfaces on which they were deposited, were collected by shaking them onto a piece of paper. After they were collected, the eggs were washed by gentle agitation or sonication for ca. 5 min in a 1% solution of Triton X-100®, rinsed in distilled water and air dried.

For examination in the scanning electron microscope (SEM), the eggs were mounted with double-sided tape on SEM stubs and sputter-coated with gold. They were examined with an International Scientific Instruments, M-7® SEM at 15 kV. Approximately 250 eggs selected arbitrarily from groups laid by ca. 30 females were examined. Length and width were determined from a sample of 33 eggs. Measurements were made on the display screen of the microscope at a magnification of ×150. The diameter of 18 aeropylar openings was determined from micrographs at either ×15,000 or ×20,000. The openings measured were on 13 different eggs. Counts of primary cells were made on a sample of 20 eggs, either from the screen or from micrographs. All measurements and counts are given as mean ± standard deviation (S.D.). The terminology used in describing the structural features of the chorion is the same as used by Arbogast et al. (1980).

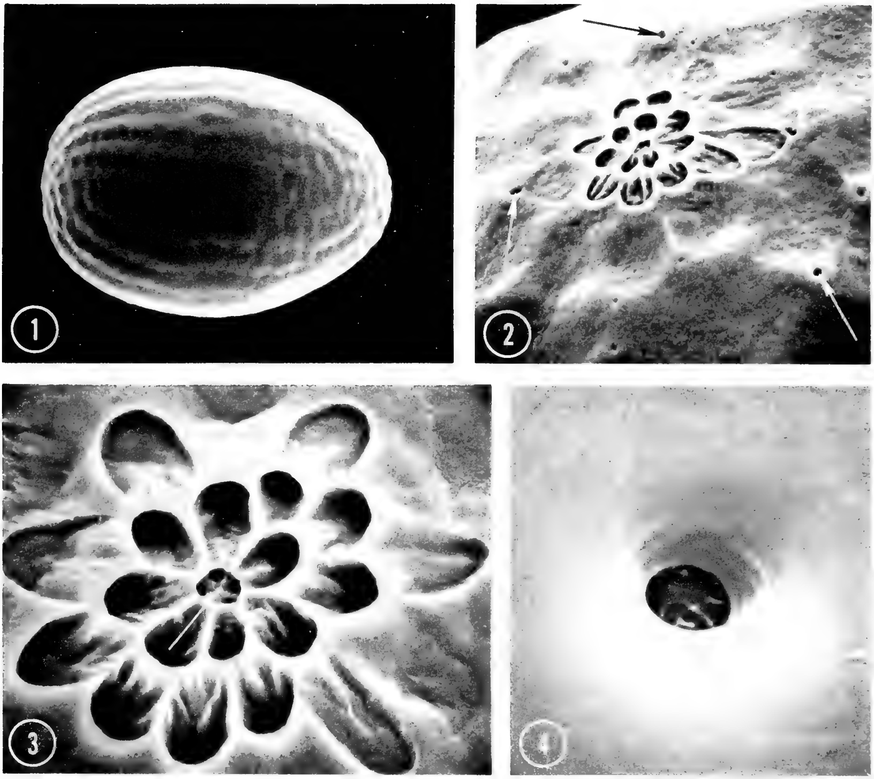
For examination by transmission electron microscope, the eggs were punctured with a minuten pin, fixed overnight in cold glutaraldehyde (5% in Millonig's buffer, pH 7.4), rinsed in Millonig's buffer, and post-fixed overnight in osmium tetroxide (1% in Millonig's buffer, pH 7.4). After fixation, the eggs were rinsed in Millonig's buffer and dehydrated in a graded series of water-ethanol solutions followed by ethanol and propylene oxide. Initial infiltration in a 1:1 mixture of propylene oxide and embedding resin (Araldite 6005®) overnight was followed by infiltration overnight in a 1:2 mixture of propylene oxide and resin and infiltration for three days in pure resin. After infiltration, the eggs were transferred to resin which was then cured at 48°C overnight. Sections were cut using a glass knife on a Porter Blum MT-2B® ultramicrotome and stained by flotation of grids on a 1% solution of uranyl acetate in water for 7.5 min followed by flotation on Reynold's lead citrate for 2.5 min. The sections were examined in a Phillips EM-200®. The thickness of the chorion and each chorionic layer is given as mean ± S.D. All means are based on measurements of 14 sections taken from a total of four eggs that were selected arbitrarily from a group laid by 36 females.

Eggs from adults collected in France, near Rennes, were also studied by the same methods.

RESULTS AND DISCUSSION

We found no differences between eggs of California *H. pseudospretella* and those collected in France. The eggs is usually obovoid but varies to ellipsoid or subcylindrical, 0.58 ± 0.04 mm long × 0.41 ± 0.02 mm in diameter at its broadest point (Fig. 1). Woodroffe (1951) described the egg as hard and shiny, oval and tapering toward one end. He noted that the eggs vary considerably in size and color and was able to distinguish two extreme types: (1) small and white, averaging 0.490 mm long and (2) large and yellow, averaging 0.595 mm long. Although Woodroffe stated that these differences persist throughout the incubation period, we were unable to distinguish such distinct types among the eggs we examined.

The egg is not boldly marked. Its basic pattern of sculpturing consists of low-lying longitudinal ridges joined by indistinct transverse ridges,



FIGS. 1–4. Egg of *Hofmannophila pseudospretella*. **1,** Lateral view of whole egg, anterior pole on left (×80). **2,** Anterior end showing micropylar area and aeropyles (arrows) (×570). **3,** Micropylar area showing central pit (arrow) with four micropylar canals opening on its periphery and rosette of cells surrounding the pit (×1140). **4,** Aeropyle near posterior end of egg (×8590); the inner layer of chorion, which forms the floor of the trabecular layer, is visible at the bottom of the opening.

the junctures being slightly elevated. This pattern is sometimes poorly developed and the ridges almost imperceptible, but the slight prominences formed by intersecting ridges are always evident, especially near the poles of the egg. The surface of the chorion has a wrinkled or granular texture (Figs. 2 & 3).

There are 3 to 5 micropylar canals opening into a central micropylar pit at the anterior pole of the egg (Figs. 2 & 3). The pit is surrounded by a rosette of 5–8 (6.9 ± 0.9) rather short, petal-shaped primary cells, which are in turn partially or completely surrounded by series of secondary and tertiary cells. The primary cells, and usually the secondary cells as well, are outlined by prominent carinae, and often carinal spurs extend into the cell discs. The tertiary cells, on the other hand, are

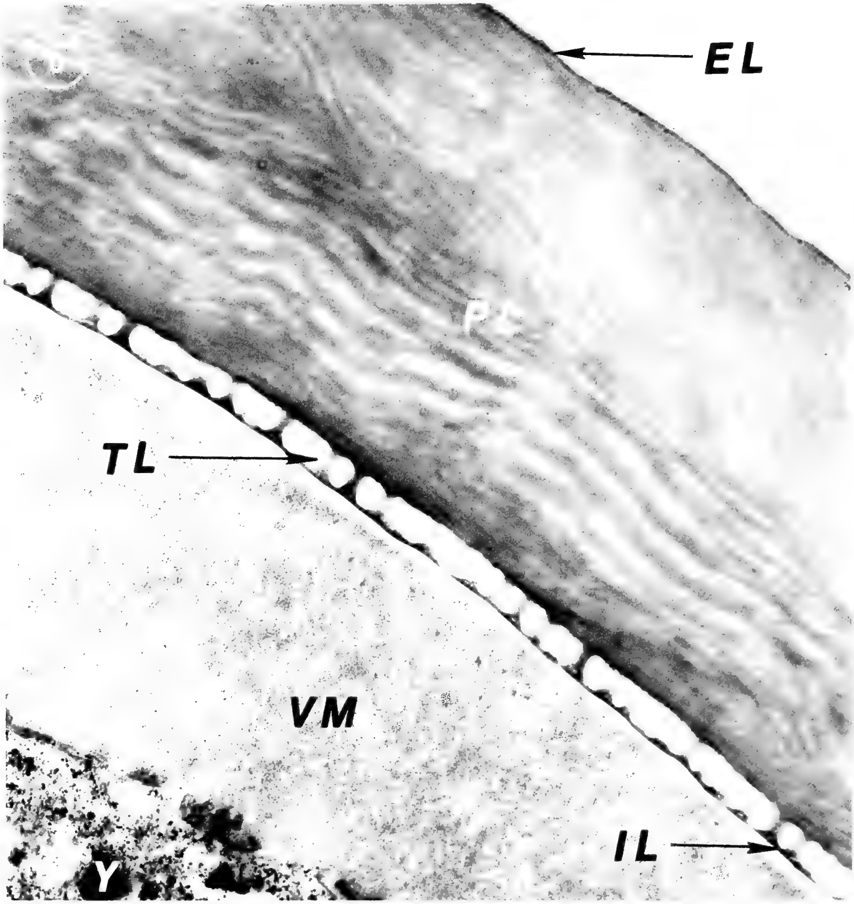


FIG. 5. Egg of *Hofmannophila pseudospretella*: thin section through the chorion and underlying membranes. **EL,** external layer of chorion; **IL,** internal layer of chorion; **PL,** principal layer of chorion; **TL,** trabecular layer of chorion; **VM,** vitelline membrane; **Y,** yolk material. (×13,340).

often outlined only by low-lying ridges and are thus poorly defined (Fig. 2).

The aeropyles open on slight prominences at the anterior and posterior ends of the egg (Fig. 2). Openings are relatively abundant in these areas but are absent elsewhere. Typically, the openings are funnel-shaped and may be surrounded by collars (Figs. 2 & 4). The diameter at the narrow end of the funnel ranges from less than 0.5 to more than 2.5 μm (1.0 ± 0.6 μm).

In sections (Fig. 5), the surface of the chorion appears quite smooth and devoid of mucilaginous colleterial secretions, which accounts for the failure of the eggs to adhere firmly to the substrate on which they are laid. There is no furrowing as in *E. sarcitrella* (Arbogast et al., 1983). The chorion averages 4.23 ± 0.76 μm in thickness, much thicker than the chorion of *E. sarcitrella*, which ranges from ca. 0.6 to 1.1 μm. The chorion of *H. pseudospretella* consists of four distinct layers (Fig. 5): an external layer (EL) (0.07 ± 0.03 μm), a lamellate principal layer (PL) (3.90 ± 0.72 μm), a trabecular layer (TL) (0.21 ± 0.05 μm) which consists of air held between vertical columns (trabeculae) and comprises the intrachorionic respiratory meshwork of the eggs, and an inner layer (IL) (0.06 ± 0.02 μm). Two layers can be distinguished within the principal layer by the orientation of the lamellae. These are parallel to the surface in the inner ⅖ of the principal layer but are usually oblique in the outer ⅗. This orientation as well as thickness may account for the resilience of the eggshell noted by Woodroffe (1951), who stated that "if an attempt is made to crush . . . [an egg] with a dissecting needle, . . . [it] will usually spring undamaged from beneath the needle." In the section figured, the vitelline membrane (VM) and yolk material (Y) are visible beneath the chorion. The egg from which this section was taken was newly laid; the vitelline membrane has not yet condensed, and the serosa and serosal cuticle have not developed.

The eggs of *H. pseudospretella* and *E. sarcitrella* resemble somewhat the eggs of Tineidae, but tineid eggs can be distinguished by the presence of microperforations in the surface of their chorion (Arbogast et al., 1980; Chauvin, 1977). The eggs of *H. pseudospretella* and *E. sarcitrella* have well-defined primary and secondary cells, and sometimes tertiary cells, in the micropylar area, but the remainder of the surface lacks cells, or has cells that are at best only faintly outlined and barely discernible. The eggs of all other stored-product moths that have been studied (except Tineidae) are marked by extensive reticulate patterns of well-defined cells and ridges; usually, these cover the entire surface of the egg (Arbogast et al., 1980; Arbogast & Byrd, 1981). Eggs of *E. sarcitrella* can easily be distinguished from those of *H. pseudospretella* by the maze-like pattern of closely spaced sinuous ridges that covers their entire surface and by the absence of aeropyles near their poles (Arbogast et al., 1983). In general structure, the chorion of *H. pseudospretella* is similar to most other lepidopteran eggs that have been studied (see, for example, Barbier & Chauvin, 1974; Chauvin & Barbier, 1976; Chauvin et al., 1974; Salkeld, 1973). The chorion is about the same thickness as that of *Galleria mellonella* (L.) (3.1 to 4.2

mm) (Barbier and Chauvin, 1974) but is thicker than that of *Tinea pellionella* L. (2.5 to 3.5 μm) or *Tineola bisselliella* (Hummel) (0.5 to 1.0 μm) (Chauvin, 1977).

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THE DYNAMICS OF ADULT *DANAUS PLEXIPPUS* L. (DANAIDAE) WITHIN PATCHES OF ITS FOOD PLANT, *ASCLEPIAS* SPP.

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ABSTRACT. Mark-recapture studies of adults of *Danaus plexippus* at four sites in southeast Queensland have been made over a ten month period. Despite unavoidable difficulties associated with non-compliance with the basic assumptions of standard mark-recapture techniques, population trends have been identified, abundance levels having late summer and late autumn peaks, declining to low levels in winter. Longevity of individuals, estimated as the "mean minimum life-span," was 12.4 days overall (13.5 for males, 10.0 for females). These estimates are regarded as conservative. Males predominated in all four sites but a seasonal pattern was evident with the proportion of males declining to below 50% at the end of summer. In the remainder of the sampling period the proportion of males varied from 50 to 75%. Separate estimates of population turnover in a single patch were obtained—within four days, an estimated 50% of the local population had been replaced by "new" individuals about half of which were newly emerged and half, presumably, immigrants.

The male-biased sex ratios are hypothesized to be due, at least in part, to aggressive male-female interactions with resident males, reducing within-patch residence times of females. The overall vagility of the species and the difficulty of studying events occurring between patches makes interpretation of the adult dynamics in this species difficult. Further work, investigating the role of intersexual behavior in determining within patch dynamics is in progress.

The distribution of host plants has been shown to influence the dispersion, abundance and survival of both larval and adult butterflies (Dethier, 1959; Ehrlich, 1965; Singer, 1971; Sharp & Parks, 1973; Zalucki, 1981a). Monarch butterflies (*Danaus plexippus* L.) in Australia lay eggs on introduced *Asclepias* spp. (milkweeds). These plants often grow in large dense patches (Zalucki et al., 1981). In this study we use mark-recapture techniques to investigate abundance, longevity and movement of adult monarchs at and between four milkweed patches in southeast Queensland. The monarch is native to North America and was first noted in Australia around 1871. In southeast Queensland the species breeds throughout the year (Smithers, 1977).

MATERIALS AND METHODS

The four study sites were located southwest of Brisbane (centering on 27°28′S; 153°1′E). The sites were widely spaced (5–16 km apart, Fig. 1) and there were numerous patches of milkweed in the intervening areas (see Zalucki et al., 1981 for a description of patch dispersion).

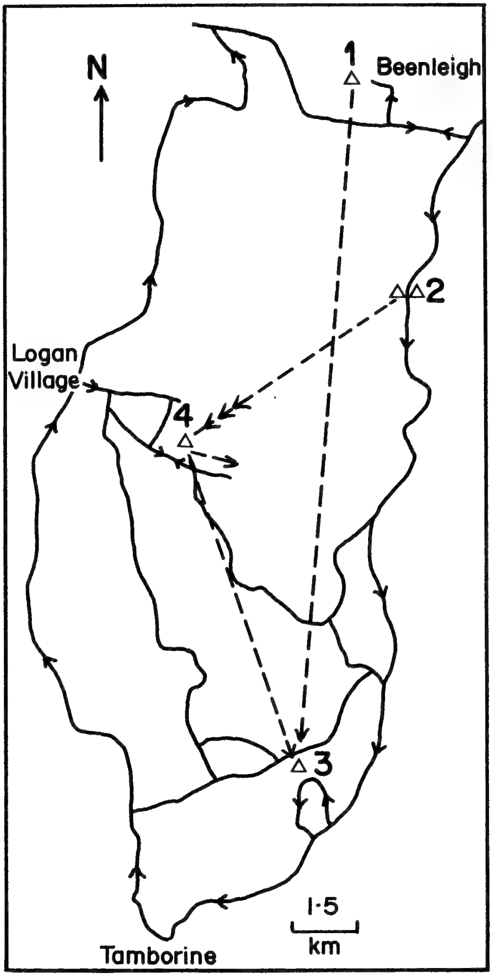


FIG. 1. Map showing location of study sites 1, 2, 3 and 4 (△), major roads (→) and urban centers. (--) indicates direction of movement and, the number of arrowheads, those butterflies marked at one site and recaptured at another.

Each site was sampled by 30–40 minutes netting once a week. Site 1 was sampled from 8 February to 5 July 1978 and site 3 from 2 February to 28 June 1978, whereas, sites 2 and 4 were sampled from 2 February to 22 November 1978 inclusive. Butterflies were tagged using the alar method outlined by Urquhart (1960), sexed and classified as either fresh (wings soft), old (wings chipped, color very faded) or middle aged (wings slightly chipped, little fading).

Population size, rates of recruitment and losses from a site were

TABLE 1. Summary of mark-recapture observations by site and sex.

	Males			Females			
Site	Marks	Recapt.	% recapt.	Marks	Recapt.	% recapt.	% males
1	228	18	7.9	142	6	4.2	0.62**
2	249	32	12.9	143	23	16.1	0.64**
3	237	22	9.3	132	8	6.2	0.64**
4	585	113	19.3	422	57	13.5	0.58**
	1299	185	14.2	839	94	11.2	0.61**

** Significantly different from 0.5, $P < 0.05$.

estimated from the recaptures using the Jolly-Seber method (Jolly, 1965; Southwood, 1966; Seber, 1973). Longevity of marked individuals was estimated as the "mean minimum life-span" (i.e. sum of days survived by all recaptures/total recaptured, see Ehrlich & Gilbert, 1973). The recapture at one site of individuals marked at another provided crude estimates of potential cross-country movements. The sex ratio of the catch was also recorded at each site on each sampling occasion.

In addition on one occasion, virtually all butterflies at site 4 were captured and marked on one day. The purpose of this exercise was threefold: (1) to determine whether the sample sex ratios were accurate; (2) to check population size estimates; and, (3) to check the rate at which a marked population is diluted by unmarked insects.

RESULTS

During the study period a total of 2138 butterflies were netted at the four sites, and of these, 279 (13%) were recaptured at least once; with the exception of site 2, a higher percentage of males was recaptured than females (Table 1).

The populations at the four sites were not isolated from each other. Five marked individuals were recaptured at a site other than the one at which they were marked (recapture distances 6.2, 6.2, 6.2, 7.8, 15.6 km) and one specimen was captured 0.7 km from site 4 (Fig. 1). From these interpatch recaptures we estimated that cross-country moves can proceed at a rate of ca. 1.5 km/day (range 0.7–2.48).

Population Estimates

Due to the low recapture rate at each site each week, male and female recaptures were combined to give weekly population estimates for each site (Fig. 2). The estimated population sizes, dilution and loss rates at each patch were characterized by their large variability. Field experience indicated that the population at each site did not fluctuate to the extent that the estimates suggested. The calculated fluctuations

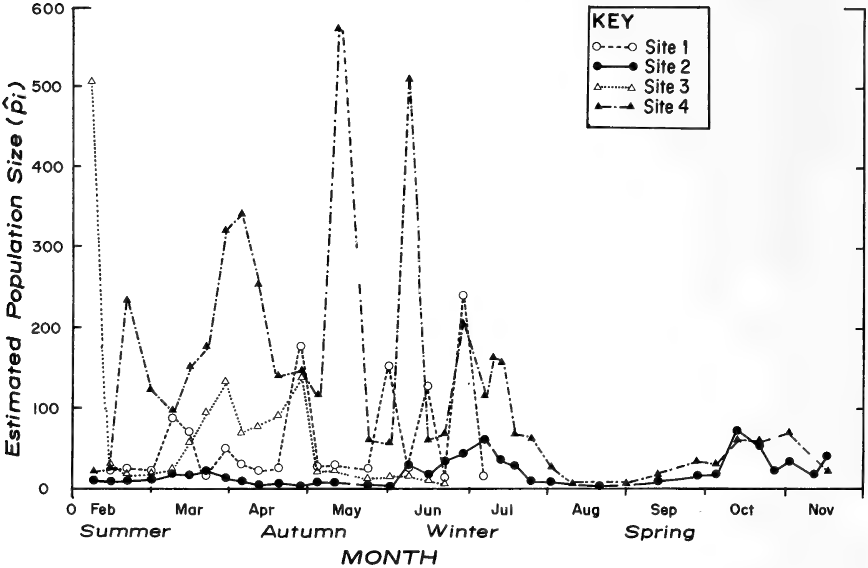


FIG. 2. Estimates of population sizes (P_i given by combining male and female recaptures) for each site.

were due to the failure of some of the assumptions of the method of estimation and the low rates of recapture.

One assumption is that recaptures be random. Marked females were recaptured randomly ($z = 0.3588$, $P > 0.5$); whereas, males were not ($z = 2.3294$, $P < 0.05$). The other assumption that is violated is that migration be permanent. Direct evidence for this occurred during the patch clearing exercise. Two tagged specimens where recaptured at site 4 before and after but *not* during the patch clearing exercise (see below).

Despite these problems, population trends over the sampling period are apparent (Fig. 2). Populations are high in late summer (100–200 butterflies per patch in February, Fig. 2), declining in early autumn (to around 50/patch in March), increasing again in late autumn to about 100/patch (April, May) and declining to low levels (10–50/patch) in winter. Populations increase in spring to achieve the high levels observed in summer.

Due to the variability of the various estimates obtained using the Jolly-Seber methods, the associated estimates of survivorship are unreliable. For these reasons we have analyzed longevity (survivorship) using a different method.

TABLE 2. Longevity[a] of marked *D. plexippus*.

	This study			North America[b]				Australia[e]	
Min. days survival	♂	♀	T	Min. days[c] survival	July–Aug 16[d] Summer	All months	T	Min. days survival	♂ + ♀
				0–5	4	33	37	3.5	720
7	93	67	160	5–10	5	20	25	10.5	360
				10–15	7	13	20	17.5	214
14	47	20	67	15–20	4	6	10	24.5	133
				20–25	4	5	9	31.5	76
21	23	5	28	25–30	2	4	6	38.5	57
				30–35		4	4	45.5	53
28	16	1	17	35–40		3	3	52.5	52
				40–45	1	3	4	59.5	22
35	4		4	45–50		1	1	66.5	20
				50–55		4	4	73.5	15
49		1	1	55–60				80.5	9
				60–65		2	2	87.5	17
56	1		1	65–70		1	1	94.5	7
				70–75				101.5	8
70	1		1	75–80				108.5	7
				>80		6	6	>115.5	85
Total	185	94	279	Total	27	105	132		1806
Mean min. life-span (days)	13.5	10	12.4		14.5	21.6	20.2		19.9

[a] Based on Ehrlich and Gilbert (1973). [(No. known age × days since capture)/Total recaptures] = Mean minimum life-span.

[b] Taken from Urquhart (1960, table II, p. 291).

[c] Calculations based on the midpoint of the interval. Those recaptured on the same day have been ignored.

[d] Marked and recaptured during summer months.

[e] Taken from Smithers (1973, table II).

Longevity

The "mean minimum life-span" for all individuals is about 12.4 days; 13.5 days for males and 10 days for females (Table 2). These values greatly underestimate longevity, reflecting as they do, the time spent in a patch (see below). This is determined by movements into and out of patches rather than by permanent removal due to death. Our estimates of life-span are similar to those calculated for the summer breeding population of *D. plexippus* in North America (Table 2). This presumably reflects a similar underlying population structure. The estimated life-spans are consequently less than the 40 days recorded for adults in captivity (Urquhart, 1960; Munger & Harriss, 1970; Zalucki, 1981b) and of adults marked and recaptured over the years in North America (Table 2). The estimated longevities based on Smithers (1973, table II) are also longer than our estimates. Smithers' recaptures are based mainly on butterflies from around Sydney, N.S.W., where

TABLE 3. Mean minimum life-span (in days) estimates[a] for sites 1–4 by sex and age.

Site	Males		Females	
	Fresh[b]	Other[c]	Fresh[b]	Other[c]
1	8.8	11.5	[d]	8.2
2	9.4	14.9	7.0	10.1
3	9.5	10.0	[d]	11.4
4	15.9	13.7	7.0	10.3
Pooled estimate	13.0	13.7	7.0	9.9

[a] Formula as in Table 4.
[b] Newly emerged, wings soft.
[c] Not newly emerged.
[d] None caught in this category.

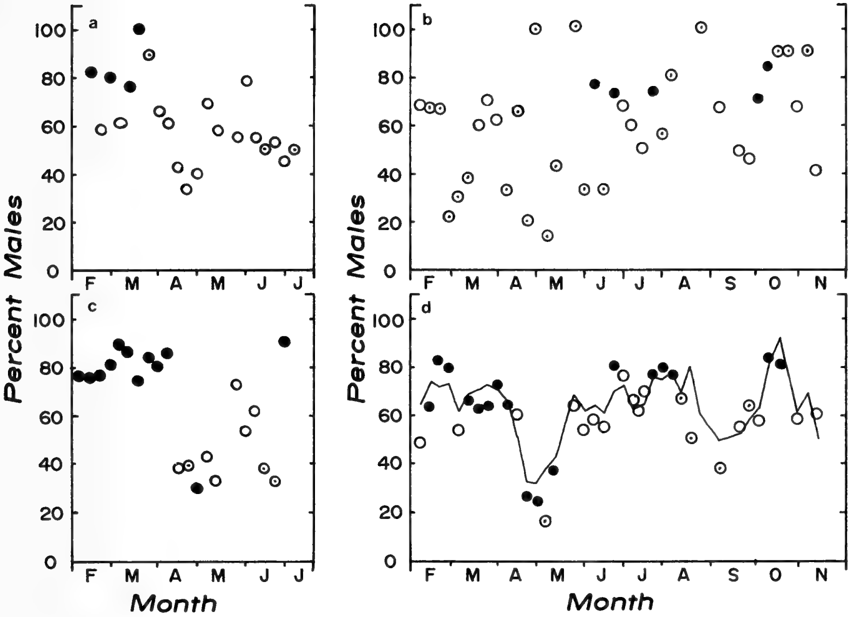
adults hibernate. That adults lived longer than indicated by recapture data is evidenced by the good condition of most adults (even the longest-lived) when they were last captured compared with their condition at the time of first capture.

The mean minimum life spans were calculated for each patch site with individuals categorized by age on the basis of wing wear (Table 3). These estimates are an indication of residence time in a patch. Females, both fresh and otherwise, have lower residence times than males (Table 3). We interpret this as being because females are more likely to leave a patch (i.e., have a shorter residence time) than males.

Sex Ratios

Males predominate at all patch sites (Table 1) and show similar changes in relative abundance over the study period across all four sites (Fig. 3; Spearman rank correlation coefficients: S1 × S3, 0.367, $0.01 < P < 0.05$; S1 × S4, 0.224, $P > 0.005$; S3 × S4, 0.728, $P < 0.001$; site 2 was ignored due to low sample sizes as were all samples with <10 individuals). All sites show a change from significantly more than 50% males, to significantly less than 50% males around early autumn (March, April). At other times of the year the sex ratio fluctuates from 75% to 50% males (Fig. 3). These changes may be due to sampling bias, changes in the sex ratio at birth, changes in male/female migration rates or male/female death rates.

To test if samples were biased we compared the estimates of sex ratio before and after the patch clearing exercise. This exercise gave the actual sex ratio in the patch on 8 July as 61% males. This does not differ from the sex ratio estimated by samples taken before (66%) and after this date (69%). On the strength of this result we feel that the sample estimates of the sex ratio probably indicate real fluctuations in the percentage of males. These fluctuations are not due to the produc-



FIGS. 3a–d. Percentages of males for each site plotted against time: site 1 (**a**), site 2 (**b**), site 3 (**c**) and site 4 (**d**). Solid symbols indicate significant deviation from 50% ($P < 0.01$). Open symbols denote non-significance. Double symbols indicate sample size small (<10). — average percent males across all sites shown in (d).

tion of all male broods—the sex ratio of newly emerged butterflies pooled over time for each site and the changes in the sex ratio at birth over time (pooled across sites) do not differ significantly from 50/50. This agrees with the sex ratio of laboratory reared adults (Zalucki, 1981c).

Population Turnover

Since, as far as we could tell, every adult was marked at site 4 on 8 July, a sample taken on the 12th should reveal what fraction had left, how many migrants had arrived and how many had emerged from around the patch (Table 4). Assuming that the population was about the same size on the 12th as on the 8th, then the sample taken on the 12th represents about half the population. On this basis multiplying the sample values on the 12th by two gives an estimate of the various marked and unmarked fractions in the population on that date.

On the basis of these calculations we suggest that about half the individuals marked on the 8th had left, and this was similar to the

TABLE 4. Mark-recapture history of adults netted on 8 and 12 July.

Date	Total netted	Marks	Unmarked	Fresh	Date of first capture for marked insects				
					8 Jul	5 Jul	28 Jun	21 Jun	14 Jun
8 July[a]	119	28	91	13		14	6	4	4
12 July[b]	52	37	15	6	23	6[e]	4[d,e]	2[e]	2[e]
12 July[c]	104	74	30	12					

[a] Patch completely cleared.
[b] Twice normal sampling effort (about 1 hour).
[c] 12 July values multiplied by 2.
[d] Includes 2 individuals *not* captured on the 8th.
[e] Also caught on the 8th.

situation with the marked individuals first captured on the 5th and then recaptured on the 8th. Individuals marked earlier (e.g., 28, 21 and 14 June) seem to be "resident"; that is, captured on both the 8th and 12th. Of the 30 "new" individuals, 12 (about 50%) were born within the patch (wings were in perfect condition, no scale loss or still soft) and 18 had immigrated into the patch, as had two individuals marked on 28 June. These were *not* present on the 8th but were caught again on the 12th.

Discussion

The present study of adult *D. plexippus* was conducted in a region where the insect breeds continuously throughout the year. The host plants of *D. plexippus*, milkweeds, represent a discontinuous, heterogeneous resource for adults and larvae. Milkweeds grow in dense, relatively well defined stands or patches. Patches vary greatly in area, plant density, age, condition and dispersion. The number of adults within any one patch varies through the year, the fluctuations representing changing birth, death and movement rates. Adult monarchs are highly vagile and have the potential to range widely during the course of their lifetime. The evidence for monarch movement is extensive and consists of: (1) the recapture of marked individuals at a patch other than the site of first capture—although the number of these in this study was small (due mainly perhaps to low sampling intensity), they indicate that monarchs can move between patches; (2) over half of the "new" individuals entering a patch population were not necessarily born there; (3) monarchs can be observed flying in all types of habitat and new milkweed patches are rapidly colonized (see Zalucki & Kitching, 1982a, b, c); and (4) various studies in North America in all seasons (e.g., Gibo & Pallett, 1979; Urquhart, 1960; Urquhart & Munger, 1970; Urquhart & Urquhart, 1976).

The monarch's vagility makes it difficult to study patch populations using techniques of mark-recapture. One difficulty is that in sampling a patch one is sampling a sub-population of a much larger population. Individuals in the sub-population move over a much wider area than is contained by a patch. For this reason marked individuals are not equally available for recapture in the sub- and parent populations. Movement into and out of the patch will cause fluctuations in the proportion of recaptures leading to large fluctuations in estimates of population size and large variances in associated vital rates (see also Brussard & Ehrlich, 1970).

Movement into and out of patches seems to depend partly on the interactions between males and females as evidenced by changing sex ratios. The changing sex ratios could also be due to differential male-female mortality. The mark-recapture method does not distinguish between losses due to death and those due to emigration. However, from laboratory studies, male and female survivorship curves are identical (fig. 6 in Zalucki, 1981b; $\chi^2_{21} = 0.908$). This leaves differential movement rates and consequent patch residence times (see Table 3) as the most likely explanation for changing sex ratios. Certainly, male-female interactions are dramatic. Males pursue any flying object within range. Females will attempt to evade males, and high speed chases usually ensue (see Pliske, 1974, for detailed description of courtship behavior). We suggest these sexual interactions between males and females could provide a mechanism whereby females are differentially dispersed from a local population, such as exists within a patch. Shapiro (1970) provides evidence for a similar dispersal mechanism in pierids.

The change in sex ratio towards females in early autumn (Fig. 3) is presumed to be due to the movement of females from around the countryside in towards large patches. It may even represent the return of individuals from inland areas, as the monarch's summer range contracts (Smithers, 1977). (Eanes & Koehn, 1978 note a similar change in sex ratios for migratory populations in North America.) However, this would imply that the inland population has a skewed sex ratio, for which there is no evidence.

Our observations indicate strongly that populations of monarchs around patches exhibit high rates of turnover. Our data on how far monarchs fly, given they leave a patch, are scant. Only five individuals were caught at sites other than the site of marking. These indicate the potential for cross-country movements but *not* what percentage of individuals undertake such movements. Of the butterflies netted, 87% are not recaptured (Table 1). Where do they go? Either monarchs "loiter" outside milkweed patches, moving in and out of local patches with some unknown percentage undertaking longer movements; or most monarchs range widely if only by diffusion among many clumps of patches. Further intensive studies, some of which are in progress, will be needed to distinguish among these and other hypotheses.

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BUTTERFLIES OF TWO NORTHWEST NEW MEXICO MOUNTAINS

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ABSTRACT. This article tabulates butterflies taken in the Chuska and Zuni Mts. of northwest New Mexico and extreme northeast Arizona. Emphasis is on the author's own experience during the period 1971–1978.

This paper is the third in a series which eventually will treat the butterfly fauna of all the major mountain ranges in New Mexico, except those which are unbroken extensions of the Colorado Rockies. The first, published by Holland (1974) dealt with six ranges in the central part of the state. The second, published by Ferris (1976) reported on the Grant-Catron County area, including the extensive Gila Mts. The present work is devoted to the Zuni and Chuska Mts. of northwestern New Mexico (see Figs. 1–3). Surveys of the butterflies of the Sacramento, Capitan, and Organ Mts. in southcentral New Mexico have also been completed, but publication of this work is being delayed until the Guadalupe Ridge has been investigated as well. Additionally, a survey of the Jemez Mts. in northcentral New Mexico is now completed and will be published soon. Besides the Guadalupe Ridge, studies of several ranges outlying the Gila are planned. These ranges include the Black, Animas and Datil Mts.

About four quite limited regional lists of the New Mexico fauna have also appeared; these lists are catalogued in the above-mentioned Holland and Ferris articles. Additionally, there is an unpublished dissertation by Toliver (1978) which tabulates every butterfly specimen taken in New Mexico prior to 1978.

The Chuska Mts. fall across the Arizona–New Mexico state line, but this survey considers equally the fauna on both sides of the line; natural rather than political boundaries delineate the study areas. The Carrizo Mts. (see Fig. 1), however, are not included in the present study, as they lie entirely in Arizona and are isolated from the main part of the Chuskas by a considerable expanse of very arid low desert.

The present article reports my studies for the years 1971–1978, during which I systematically surveyed the Zuni and Chuska Mts. While a third range, Mt. Taylor, also lies in this area (see Fig. 1), its fauna has already been reported by Holland (1974) and will not be redocumented here.

Endemism of butterfly species is rare in the New Mexico mountains. In this respect, the northwest part is typical of the state as a whole. Mt. Taylor and the Zuni Mts. support no endemics at any taxonomic

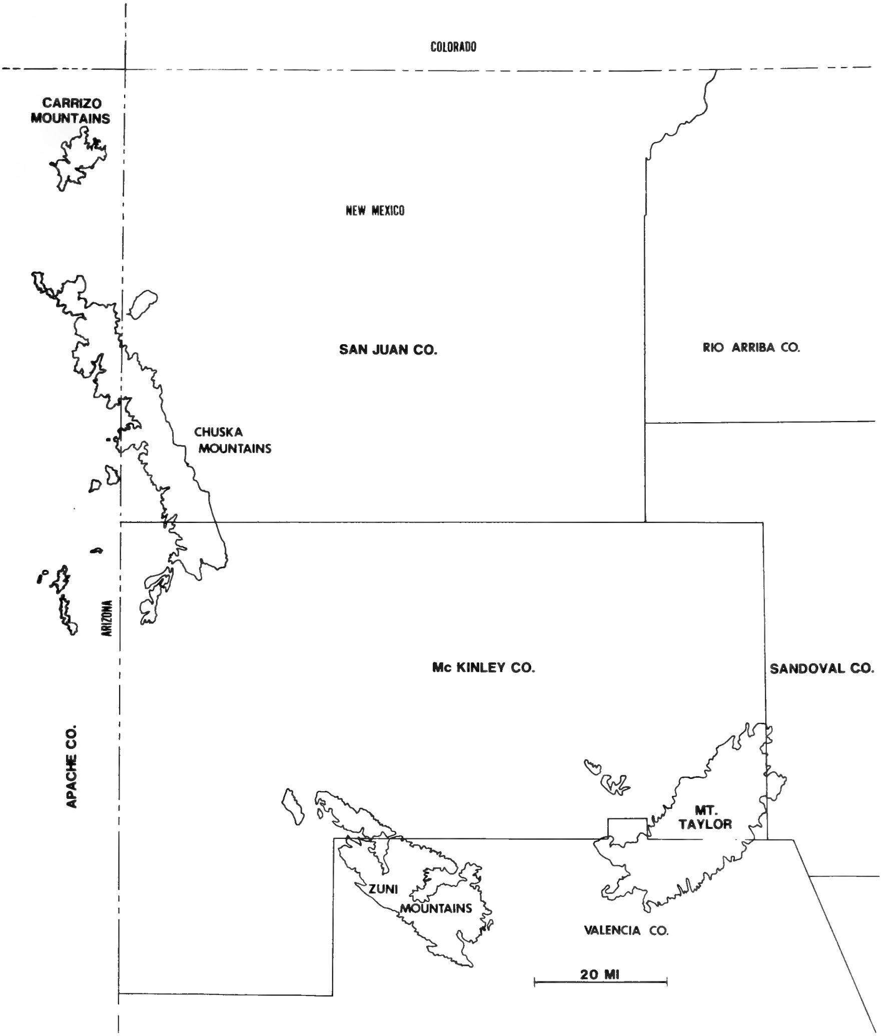

FIG. 1. Map of the mountains of northwestern New Mexico, showing the 8000′ elevation contours.

level. The Chuskas have a single subspecific endemic, *Occidryas anicia chuskae* Ferris & R. Holland. This near-total absence of endemism indicates that the desertification of the New Mexico lowlands is extremely recent, geologically speaking, in comparison with, for instance, the Mojave. I believe New Mexico mountains have been isolated for less than 4000 years. The one endemic taxon seems more likely to be a relict than something which actually evolved on the Chuskas.

The format of my earlier article was different from that of Ferris; Ferris gave more precise and detailed data which permitted cross-referencing to counties as well as mountain ranges. In this article, Ferris' format will be used.

Localities

The Chuska Mts. are sedimentary (red sandstone and limestone). The Chuska Mts. mainly consist of a vast plateau with sharp escarpments on all sides. Scenically, the red sandstone cliffs and canyons are very dramatic. The plateau has numerous subsidences where natural lakes have formed, some of which cover hundreds of acres. Much of the plateau top is forested with aspen (*Populus tremuloides* Michx.) and Douglas fir (*Pseudotsuga taxifolia* Mayr). There are also large open meadows. The southern end of the Chuska plateau is somewhat drier and lower, and ponderosa pine (*Pinus ponderosa* Laws.) is dominant. Collecting is generally not good on the plateau itself; the canyons running off the plateau tend to have a much richer fauna. Flora which significantly affects the butterfly diversity includes several willows (*Salix* spp.), Gamble oak (*Quercus gambelii* Nutt.), several species of juniper, several *Yucca* spp., *Ceanothis fendleri* Gray, *Rumex* sp. (possibly introduced), several columbines (*Aquilegea* spp.), several *Penstemon* spp. and paintbrushes (*Castilleja* sp.), cliffrose (*Cowania mexicana* D. Don.), and at least five species of *Eriogonum*. Lower elevations have considerable stands of saltbush (*Atriplex* sp.) and sage (*Artemisia* sp.). The fauna is undoubtedly affected by the absence of some plants as well. Missing flora include locust (*Robinia* sp.), hackberry (*Celtis* sp.), walnut (*Juglans* sp.), *Agave* sp., and mesquite (*Prosopis* sp.).

The Chuska Mts. lie entirely on the Navajo Indian Reservation. At present, the tribal authorities are not hostile to outsiders, and nearly the entire reservation is open to the general public without written or oral permission. This pleasant situation will probably change. On the negative side, sheep and goats have been allowed to devastate most of the Chuskas. It is unlikely that any Lepidoptera have actually been exterminated, but many species tend to be scarce and local because of the land abuse. Also, poorly regulated lumbering has been permitted over wide areas without even the minimal erosion-control and understory protection efforts one usually sees in national forests. Additionally, roads are terrible, and getting into the canyons where collecting is good tends to be very challenging. Regrettably, there is an element of suspicion that false Lepidoptera records have been claimed for the Chuskas, and to a lesser extent, the Zunis.

The Zuni Mts. are more rolling with few dramatic canyons or escarpments. In contrast to the Chuskas, the Zunis are principally volcanic. The flora is surprisingly similar to the Chuskas, considering the geological differences. The greatest disparity is that oak and ponderosa pine are more prevalent, with aspen and Douglas fir correspondingly restricted. Good collecting in the Zunis is less limited to the lower canyons. The Zuni Mts. have also been subjected to excessive land use, although most of the grazing is cattle rather than sheep and goats, so the destruction is less radical than in the Chuska Mts. The Zuni Mts. are mostly in the Cibola National Forest. Consequently, more conservative lumbering techniques have been practiced than in the Chuska Mts. Also, secondary roads are better maintained in the Zunis. Although the Zunis have been abused less than the Chuskas, it appears *Speyeria nokomis* (W. H. Edwards) has suffered extinction in the Zunis.

This land is subject to extreme temperatures, especially in winter. Summer temperatures reach 38°C; winter lows colder than −50°C have been recorded at the reservation town of Zuni. I have no idea how cold it gets in Roof Butte and Mt. Sedgwick. Precipitation occurs mainly in December–March and July–September. May is the driest month. Annual precipitation varies from 0.2 m in the rain shadow on the New Mexico side of the Chuskas, to around 0.8 m on Roof Butte.

Specific collecting sites and their alphanumeric codes are given below. The locality code symbols appear on maps in Figs. 2 and 3. As stated previously, this style of data presentation is copied from Ferris (1976).

ZUNI MTS., McKINLEY COUNTY, NEW MEXICO. Clo-Chen-Toh Ranch (**CCT**) 7100′; Cottonwood Gulch (**CG**) 7500′; Ft. Wingate (**FW**) 6800′; Gallup (**G**) 6700′; Grasshopper Canyon (**GC**) 7500′–7700′; Grasshopper Spring (**GS**) 7500′; McGaffey (**M**) 7500′; McGaffey Lake (**ML**) 7500′; Milk Ranch Canyon (**MRC**) 7600′; Nutria Diversion Reservoir (**NDR**) 7300′; NM Rt. 53 at Jct. to NM Rt. 32 (**NMJ**) 6600′; NM Rt. 53 at Jct. to Nutria (**NJ**) 7000′; Prewitt Tank (**PT**) 7800′; Ramah (**R**) 7000′; Ramah Lake (**RL**) 7000′; Stinking Spring (**SS**) 7500′; Wingate Tank (**WT**) 7600′; NM Rt. 400 at Jct. to Interstate 40 (**400**) 6900′; NM Rt. 412 at Jct. to Interstate 40 (**412**) 7200′.

ZUNI MTS., VALENCIA COUNTY, NEW MEXICO (now in CIBOLA COUNTY by action of the New Mexico legislature after this study was completed). Lower Bluewater Canyon (**lBC**) 7000′–7300′ (below Bluewater Dam); upper Bluewater Canyon (**uBC**) 7300′–7500′ (above Bluewater Dam); Bluewater Dam (**BD**) 7300′; Bluewater Village (**BV**) 6500′; Cebolla Canyon (**CC**) 7000′; Diener Canyon (**DC**) 8000′–9000′; El Morro National Monument (**EMNM**) 7000′; Kettner Canyon (**KC**) 8000′; Log Cabin Canyon (**LCC**) 7500′–8000′; Manga Canyon (**MC**) 7000′; Mt. Sedgwick (**MS**) 9300′; Ojo Redondo (**OjR**) 8000′; Oso Ridge (**OsR**) 8900′; Pink Rose Canyon (**PRC**) 7000′; Pole Canyon (**PoC**) 8000′–8500′; Prop Canyon (**PrC**) 8000′; Sawyer (**S**) 8000′; San Rafael (**SR**) 6700′; Tusas Mesa (**TM**) 8000′; lower Zuni Canyon (**lZC**) 7000′–7500′; upper Zuni Canyon (**uZC**) 8000′–8200′.

CHUSKA MTS., McKINLEY COUNTY, NEW MEXICO. Chuska Peak (**CP**) 8700′; Navajo (**N**) 6800′; Tohatchi (**Toh**) 6000′–7500′; Tohatchi Lookout (**TL**) 8300′; Whiskey Lake (**WsL**) 8000′.

CHUSKA MTS., SAN JUAN COUNTY, NEW MEXICO. Big Gap Reservoir (**BGR**) 5000′; Beautiful Mountain (**BM**) 8000′; Cox Canyon (**CC**) 6200′; *Occidryas anicia chuskae* Type Locality (**OacTL**) 7700′; FAA Installation (**FAA**) 9000′; Owl Springs (**OS**) 7500′;

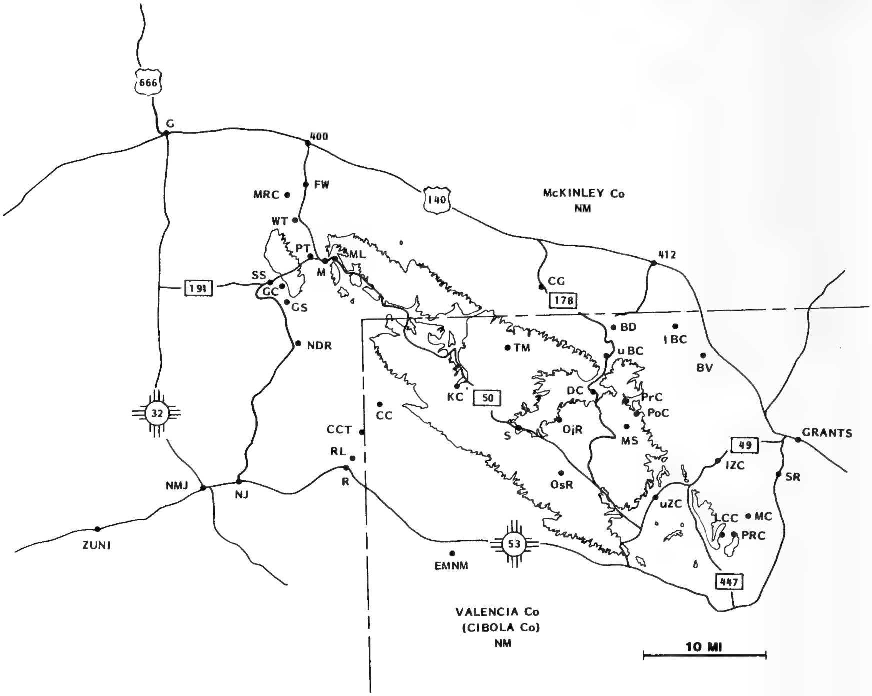

FIG. 2. Detail of the Chuska Mts., showing the 8000′ elevation contours and collecting localities.

Sanostee (**Sn**) 5500′; Shiprock Mt. (**SM**) 5500′; Toadlena (**Toa**) 6500′; Wheatfields Creek (**WfC**) 7400′–8200′; Whiskey Creek (**WhC**) 7700′; Washington Pass (**WP**) 8000′.

CHUSKA MTS., APACHE COUNTY, ARIZONA. Buffalo Gap (**BG**) 7800′; Chinle (**Ch**) 5500′; Cove (**Co**) 7000′–8000′; Ganado (**G**) 6500′; Hunters Point (**HP**) 7000′; Lukachukai (**L**) 7000′; Luka Peak (**LP**) 9200′; Roof Butte (**RB**) 8500′–9600′; Red Lake (**RL**) 6000′; Red Rock (**ReR**) 6000′–7000′; Round Rock (**RoR**) 5500′; Sawmill (**Sw**) 7800′; Spider Rock (**SR**) 7500′; Tsale Creek (**TC**) 7500′–8500′; Wheatfields Lake (**WfL**) 7000′; Wagon Wheel Campground (**WWC**) (Lukachukai Creek) 7500′; AZ Rt. 264 at Jct. to Sawmill, AZ (**264**) 7800′; 8 mi. north of Wheatfields Lake on Tsale Cr. (**8MNWfL**) 7500′.

Checklist

In the following checklist, mountain range and localities are noted as well as the flight period. (A "+" before a date indicates a common species which flies considerably later than the date indicated but for which late-season specimens were merely observed, not collected.) Nomenclature and species number is that of Miller and Brown (1981) except in a few cases where my opinion is strongly different.

Collectors, besides myself, who have supplied records are Richard Bailowitz (RB), Robert Langston (RL), James Scott (JS), Michael Fisher

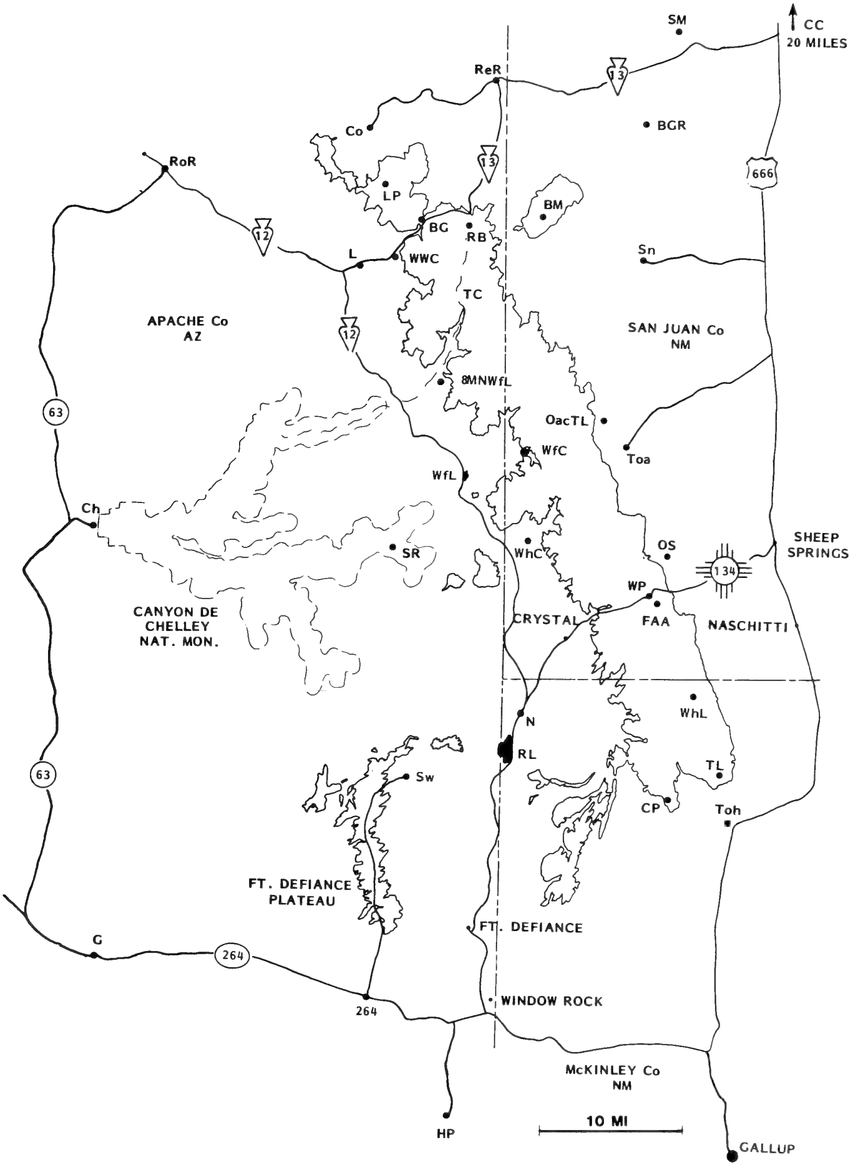

FIG. 3. Detail of the Zuni Mts., showing the 8000′ elevation contours and collecting localities.

(MF), Clifford D. Ferris (CDF), Michael Toliver (MT), Kilian Roever (KR), John Justice (JJ), Carl Cushing (CC), Oakley Shields (OS), Bruce Griffin (BG), and Ray E. Stanford (RES). Records from the Toliver manuscript are denoted (TM). Most of these records are very old and due to John Woodgate's collecting at Ft. Wingate; hence, if known, the year of capture is included with (TM) records. Where a date is replaced by a "?" in (TM) records, the record probably is of the period 1906–1911. The Woodgate material from Ft. Wingate is now part of the American Museum of Natural History collection except for lycaenids which apparently are mostly in the Carnegie Museum.

John Woodgate was a fence-rider who carried a butterfly net until his eyesight failed. We have records of his at Ft. Wingate, NM, from 1906 until 1911, and at Jemez Springs, NM, from 1912–1913 (Williams, 1914); after this he apparently vanished. From the diversity of his records, it is obvious that he had become a much more sophisticated collector by 1913 than when he started in 1906. As recently as 1970, some of his material was under glass in a bar in Jemez Springs.

Conditions at Ft. Wingate are very different than they were in Woodgate's day, and some species have probably disappeared from the immediate vicinity. In fact, the town itself has been moved nine miles east! The pre-1912 Ft. Wingate records presumably refer to the old site.

HESPERIIDAE-PYRGINAE

7. *Epargyreus clarus* (Cramer). **Chuska Mts.:** ? no specific data (KR). To my knowledge, the foodplant *Robinia* is absent from Chuska and Zuni Mts.

20. *Zestusa dorus* (W. H. Edwards). **Chuska Mts.:** ? no specific data (KR).

48. *Thorybes pylades* (Scudder). Found almost everywhere in study area above 7000′. May 4–July 8.

50c. *Thorybes mexicana dobra* Evans. **Chuska Mts.:** WP, FAA, vic. WfL, 10 mi. E WfL on WfC. May 19–July 8.

83. *Erynnis icelus* (Scudder & Burgess). **Chuska Mts.:** WWC, RB, 8 mi. N WfL on TC, 12 mi. N WfL on TC, 10 mi. E WfL on WfC. June 19–July 8.

84a. *Erynnis brizo burgessi* (Skinner). **Chuska Mts.:** RB, 2 mi. SW Cove, 2 mi. SE Cove, 8 mi. N WfL on TC, 12 mi. N WfL on TC, BG, WWC, 2 mi. NW Toh, CP, WP, BM. **Zuni Mts.:** NDR, SS, MS, lZC, FW (TM, 1908 & 1909). April 23–July 4.

86. *Erynnis telemachus* Burns. **Chuska Mts.:** 2 mi. NW Toh, Toa, WWC, WP, 4 mi. W WP, BG, 12 mi. S Toa, 12 mi. N WfL on TC, RB, 2 mi. SE Co, 10 mi. S SR. **Zuni Mts.:** 1BC, 4 mi. S FW, GS, lZC, RL, NMJ, FW (TM, 1908 & 1909). April 19–+June 11.

90. *Erynnis horatius* (Scudder & Burgess). **Chuska Mts.:** ? no specific data (KR).

93a. *Erynnis pacuvius pacuvius* (Lintner). **Chuska Mts.:** RB, 4 mi. S Co, TL, 2 mi. NW Toh, TL. **Zuni Mts.:** MS, TM, GS, PoC, DC, lZC, PrC, FW (TM, 1908 & 1909), OsR (CC). May 2–July 4.

95. *Erynnis funeralis* (Scudder & Burgess). **Chuska Mts.:** Toa, WfL. **Zuni Mts.:** WT (KR & RH). May.

98. *Erynnis afranius* (Lintner) & *persius* (Scudder). **Chuska Mts.:** BM, WhC, WWC, RB, WP, RL, BG, LP, 6 mi. SW Sn, 2 mi. SE Co, 2 mi. SW Co, 12 mi. S Toa,

12 mi. N WfL on TC, TL. **Zuni Mts.:** PoC, MS, PrC, uBC, DC, KC, uZC, GC, lZC, GS, PRC, OsR, FW (TM, 1909). April 24–August 18.

102. *Pyrgus xanthus* W. H. Edwards. **Chuska Mts.:** ? no specific data (KR). **Zuni Mts.:** 2 mi. W M, DC, 8 mi. N OjR, OjR, BD, PoC, PrC, lZC. April 25–May 30. Univoltine.

103. *Pyrgus scriptura* (Boisduval). **Chuska Mts.:** ReR. **Zuni Mts.:** PoC, SS, NJ. May 6–August 19. At least bivoltine.

104. *Pyrgus communis* (Grote) & *albescens* Plotz. Most material from the study area is probably referable to *communis*. However, a somewhat mosaic distribution exists, with certain pockets of *albescens* being existent, especially around BD (Toliver, 1978). I am not convinced two species are involved here. I do not think the concept of a single genetically dimorphic species should be ruled out in cases such as this and *Celotes* in the absence of corroborating fertility studies. In general, specimens are found nearly everywhere in the study area except above 8000′. At least April–September.

107. *Pyrgus philetas* W. H. Edwards. **Chuska Mts.:** L (CDF & RH). June 26. This is definitely not a resident species.

109. *Heliopetes ericetorum* (Boisduval). **Chuska Mts.:** HP, Toa. **Zuni Mts.:** NJ (KR & RH), FW (TM, 1910). June 10–July 3. Probably migratory and not present every year.

115. *Pholisora catullus* (Fabricius). **Zuni Mts.:** lZC, lBC, FW (TM, 1906). June 27–July 30.

118a. *Pholisora alpheus alpheus* (W. H. Edwards). **Chuska Mts.:** 2 mi. E WP, BGR. **Zuni Mts.:** NDR, FW, NJ, 400, 6 mi. E R. May 5–July 3.

121. *Piruna pirus* (W. H. Edwards). **Chuska Mts.:** WWC, RB, BG, W of Sn at 8000′, 8 mi. W Toa, 10 mi. E WfL on WfC. June 22–July 21.

HESPERIIDAE-HESPERIINAE

145. *Oarisma garita* (Reakirt). **Zuni Mts.:** lZC, uBC, MS, ML, LCC, PoC. June 24–August 6.

146. *Oarisma edwardsii* (Barnes). **Zuni Mts.:** NDR, PoC, GS, LCC, MRC, PRC, NJ, FW (TM, 1908), EMNM (RL). July 2–August 6.

152. *Yvretta rhesus* (W. H. Edwards). **Zuni Mts.:** PoC, BD, 4 mi. E R, NDR, 3 mi. W M, LCC, PT, FW (TM, 1907 & 1908). May 21–June 15. Univoltine.

155. *Stinga morrisoni* (W. H. Edwards). **Chuska Mts.:** RB, TL, CP, 3 mi. S WhL, WP, 264. **Zuni Mts.:** PoC, MS, uZC, lZC. May 1–June 18.

156a. *Hesperia uncas uncas* W. H. Edwards. **Chuska Mts.:** WfL, Toa, 3 mi. W Toa, 2 mi. NW Toh, BM, HP. **Zuni Mts.:** NDR, NMJ, PoC, lZC, uBC, 412, 400, NJ, FW, GC, 12 mi. S G, PT. June 8–August 22. Bivoltine.

157. *Hesperia juba* (Scudder). **Chuska Mts.:** L (JJ & RH). May 18.

158n. *Hesperia comma susanae* L. Miller. **Chuska Mts.:** ? WP (KR). **Zuni Mts.:** SS, 4 mi. SW FW. August 26–September 5.

159. *Hesperia woodgatei* (R. C. Williams). **Chuska Mts.:** 2–4 mi. NW Toh. **Zuni Mts.:** 2 mi. S FW. September 10–+September 24. Woodgate also recorded this species at FW in 1907 and 1908, several years before the type series was taken (1913) at Jemez Springs, NM.

163a. *Hesperia pahaska pahaska* (Leussler). **Chuska Mts.:** 2 mi. NW Toh, RL, TL, CP, 3 mi. S WhL, WP, BM, HP. **Zuni Mts.:** 2 mi. S FW, GS, PoC, SS, DC, WT, lBC, LCC, PT. May 17–+July 4.

166. *Hesperia viridis* (W. H. Edwards). **Chuska Mts.:** Toa, BG, 2 mi. E CP. **Zuni Mts.:** LCC, MC, lZC, PRC, PoC. May 29–July 28.

175a. *Polites sabuleti sabuleti* (Boisduval). **Chuska Mts.:** Toa. May 26. A curious situation exists here from two viewpoints. Inspection of a particular arroyo perhaps 15 times over eight years yielded nothing. However, on 26 May 1978, *sabuleti* was present in numbers. Subspecies *chusca* (W. H. Edwards) apparently was not described from the Chuska Mts., but from Mohave Co., Arizona (Brown &

Miller, 1980). "Chuska" is a Navajo word meaning "white fir." "White fir" (*Abies concolor* (Gordon & Glendinning)) occurs in many Arizona mountain ranges including the Hualapais of Mohave Co., but not in the Chuskas (Kearney & Peebles, 1964; Pearce, 1975).

177. *Polites draco* (W. H. Edwards). **Chuska Mts.:** ? no specific data (KR).
179. *Polites themistocles* (Latreille). **Chuska Mts.:** WfL, WWC, Toa, 8 mi. N WfL on TC, OacTL, WhC, 4 mi. E WfL, 2 mi. NW Toh. **Zuni Mts.:** KC, PT. June 8–August 5.
187a. *Atalopedes campestris campestris* (Boisduval). **Chuska Mts.:** WhC. August 5.
194. *Ochlodes snowi* (W. H. Edwards). **Chuska Mts.:** ? no specific data (KR). **Zuni Mts.:** PrC, 4 mi. S FW, GS, lZC, PoC. July 29–August 15.
199. *Poanes taxiles* (W. H. Edwards). **Chuska Mts.:** Toa, 2 mi. E CP. **Zuni Mts.:** 4 mi. N NMJ, GS, PoC, LCC, MC, lZC, NDR, FW (TM, ?). June 8–July 28.
217a. *Euphyes ruricola ruricola* (Boisduval). **Chuska Mts.:** 1 mi. W Toa, WWC, 8 mi. N WfL on TC, Toa, 12 mi. N WfL on TC, 8 mi. E WfL on WfC. June 8–August 5.
222. *Atrytonopsis vierecki* (Skinner). **Chuska Mts.:** Toa, Sn. **Zuni Mts.:** lZC, NJ, LCC, SR, MC, FW (TM, 1907). May 19–June 8.
225. *Atrytonopsis python* (W. H. Edwards). **Zuni Mts.:** LCC, MC, PoC, NJ, SR, MRC, BD (MT), FW (TM, 1907). May 29–July 2.
230. *Amblyscirtes cassus* W. H. Edwards. **Zuni Mts.:** POC, LCC, PRC, GS, lZC, FW (TM, ?). June 25–July 28.
231. *Amblyscirtes aenus aenus* W. H. Edwards. **Chuska Mts.:** ? no specific data (KR). **Zuni Mts.:** lZC, GS, LCC, NDR, PRC, GC, PoC, FW (TM, 1907). June 1–August 8. An undescribed subspecies of *aenus* with very whitish dorsal forewing spots occurs in southern New Mexico. The present populations are typical.
233. *Amblyscirtes oslari* (Skinner). **Zuni Mts.:** GS. June 19.
236. *Amblyscirtes texanae* Bell. **Zuni Mts.:** OsR. August 18. One very worn specimen taken. Undoubtedly a stray from at least 100 miles to the south or west.
249. *Amblyscirtes phylace* (W. H. Edwards). **Zuni Mts.:** POC, GS, lZC, PoC, DC, BC, MRC. May 30–July 29.

MEGATHYMIDAE

286c. *Megathymus coloradensis navajo* Skinner. **Chuska Mts.:** 2 mi. N BG, 2 mi. NW Toh, WWC, 2 mi. SE Co, L, 12 mi. S Toa. **Zuni Mts.:** PoC, GS, 3 mi. NE M, lZC, FW. April 29–June 9. Woodgate took the type series of *navajo* at FW in 1910 or 1911 (Skinner, 1911).
289. *Megathymus streckeri* (Skinner). **Chuska Mts.:** 6 mi. SW of Jct. of Nav. Rt. 34B & main rd. to Sn, BM. **Zuni Mts.:** FW (TM, ?). May 20–July 4. Curiously, all wild-caught specimens of *coloradensis* have been males and all *streckeri* have been females.

PAPILIONIDAE

297a. *Battus philenor philenor* (Linnaeus). **Chuska Mts.:** 2 mi. SE of Co (visual record by RH and CDF). 25 June 1978.
303a. *Papilio polyxenes asterius* Stoll. **Chuska Mts.:** 3 mi. NW LP, TL, Toa. **Zuni Mts.:** PT, NJ, BD (OS). May 21–July 23.
308. *Papilio bairdii* W. H. Edwards. **Chuska Mts.:** 8 mi. SW Sn, BG, CP, LP. **Zuni Mts.:** NDR, 4 mi. S FW, GS, MS, WT, PoC, ML, BD (TM, 1969, leg. Funk). May 2–September 14.
311a. *Papilio zelicaon zelicaon* Lucas. **Chuska Mts.:** TL, FAA, WP, RB, WWC, WfL, 4 mi. S Co. **Zuni Mts.:** MS, GS, PoC, NDR, DC. April 29–June 14. Univoltine population.
312b. *Papilio indra minori* Cross. **Zuni Mts.:** FW (collector unknown, specimen is in LACM). 27 May 1917.

231a. *Pterourus rutulus rutulus* (Lucas). **Chuska Mts.:** WWC. **Zuni Mts.:** PoC, NDR. May 21–June 14. Unaccountably rare in Chuskas and Zunis.

322. *Pterourus multicaudata* (W. F. Kirby). **Chuska Mts.:** RL, 3 mi. NW Co. **Zuni Mts.:** 15 mi. S Grants on NM 53, PoC, EMNM (RL, sight record). June 24–July 23. This species is also unaccountably rare in the Chuskas and Zunis.

PIERIDAE

329. *Neophasia menapia* (C. & R. Felder). **Chuska Mts.:** 2 mi. W Toa, 1 mi. E WP, 8 mi. N WfL on TC, Toa, OacTL. **Zuni Mts.:** GS, PoC. July 16–August 7.

332. *Pontia beckerii* (W. H. Edwards). **Chuska Mts.:** BGR, 2 mi. S SM, L, 6 mi. S Sn, Toa, SM, 2 mi. E RoR. May 5–July 24. At least bivoltine.

333c. *Pontia sisymbrii elivata* (Barnes & Benjamin). **Chuska Mts.:** 2 mi. E of Toh, 2 mi. SE Co, WWC, WP, 10 mi. SW Toa, FAA, RB, 7 mi. SW Toa, WfL, TL, Toa, SR. **Zuni Mts.:** MS, BD, lZC, NDR, OsR (CC). April 22–June 14.

334. *Pontia protodice* (Boisduval & LeConte). Found everywhere, especially below 7500′, in the study area. Some phenotypes from the study area fall into the outdated concept (Brown, 1957) of *occidentalis* (Reakirt), but not the present concept (Chang, 1963). At least from April to September.

338. *Artogeia rapae* (Linnaeus). **Chuska Mts.:** Ch, Toa (MF & RES), LP. **Zuni Mts.:** BV, SR. May 11–+June 26.

343c. *Euchloe hyantis lotta* Beutenmuller. **Chuska Mts.:** FAA, 7 mi. SW Toa, 2 mi. SW Co, TL. April 23–June 4.

348b. *Anthocharis sara inghami* Gunder. **Chuska Mts.:** 2 mi. SE Co, Toa, 7 mi. SW Toa. Chuska populations grade towards *julia* W. H. Edwards. **Zuni Mts.:** MS, uBC, 4 mi. S FW, GC, PrC, PoC, 3 mi. NE M, lZC, NDR. April 21–May 14.

351c. *Colias philodice eriphyle* W. H. Edwards. **Chuska Mts.:** WfL, Toa, 5 mi. S RB, BG, 6 mi. W Sn, 8 mi. N WfL on TC, 16 mi. N WfL on TC. **Zuni Mts.:** BV. May 15–September 2.

352. *Colias eurytheme* Boisduval. Found almost everywhere in NM. Records from Zunis and Chuskas are restricted to April–September due to collecting season. Sandia Mts. (Albuquerque, NM) records exist for every month.

355. *Colias alexandra* W. H. Edwards. **Chuska Mts.:** ? BG (KR).

368a. *Zerene cesonia* (Stoll). **Chuska Mts.:** RL, L, 8 mi. N WFL on TC. **Zuni Mts.:** GS. May 12–July 30.

371b. *Phoebis sennae eubule* (Linnaeus). **Zuni Mts.:** R, GS, NMJ. August 6–August 19. This species had strong northward migrations in 1976 and 1977. It is not a permanent resident of the study area.

380. *Eurema mexicana* (Boisduval). **Chuska Mts.:** several sight records; no actual specimens of this migratory species. **Zuni Mts.:** WT, POC. At least May–July.

388. *Eurema nicippe* (Cramer). **Chuska Mts.:** 16 mi. N WfL on TC, 8 mi. N WfL on TC, 10 mi. S SR. **Zuni Mts.:** WT, POC, RL, BD (MT). May 11 to at least July.

389. *Nathalis iole* Boisduval. **Chuska Mts.:** Sn, Toa, WfL. **Zuni Mts.:** PoC, NMJ, GS, BD (MT). April 22–late summer.

LYCAENIDAE

392d. *Tharsalea arota schellbachi* Tilden. **Chuska Mts.:** ? no specific data (KR). **Zuni Mts.:** FW (TM, ?. Specimen is in Carnegie Museum. It may not be a Woodgate specimen.). No date.

404. *Epidemia helloides* (Boisduval). **Chuska Mts.:** WfL, 3 mi. W Toa. May 17–June 22. Number of broods uncertain, but probably more than one. WfL (just below dam) is the site of the only known *helloides* population in Arizona. The *Rumex* at this site may be introduced.

408a. *Hypaurotis crysalus crysalus* (W. H. Edwards). **Chuska Mts.:** 2 mi. SE Co, 2 mi. NW Co, Toa. **Zuni Mts.:** GS, FW (TM, 1907). July 3–August 13. Possibly bivoltine in some areas. Curiously, bivoltinism is suspected in more boreal parts of northcentral NM, and in the Sierra Madre of Chihuahua. Chuska and Zuni populations appear to be univoltine.

412a. *Atlides halesus halesus* (Cramer). **Chuska Mts.:** Toh, 2 mi. SE Co, Toa, 6 mi. SW S, CP. **Zuni Mts.:** GS, POC, FW (TM, 1906 & 1907). May 2–August 5.

418b. *Satyrium behrii crossi* (Field). **Chuska Mts.:** BG, 3 mi. SE Co, 3 mi. NW Co, 10 mi. SW Sn, LP, 2 mi. SW Co. **Zuni Mts.:** GC, FW (TM, ?). June 25–July 13.

422c. *Satyrium sylvinus itys* (W. H. Edwards). **Zuni Mts.:** FW (TM, ?. Specimen is in Carnegie Museum. It may not be a Woodgate specimen.). No date.

433. *Ministrymon leda* (W. H. Edwards). **Chuska Mts.:** L. **Zuni Mts.:** 5 mi. W M, LCC. May 21–June 19. These specimens are obviously migrants as the foodplant *Prosopis* does not grow in or near the Zunis or Chuskas.

446a. *Callophrys apama apama* (W. H. Edwards). **Chuska Mts.:** TL, WWC, 8 mi. WfL on WfC, 2 mi. NW of Toh. **Zuni Mts.:** PrC, GS, PoC, FW (TM, 1909 & 1910), OjR (RB). April 29–August 15. Bivoltine, peaks in May and early July.

449b. *Callophrys sheridanii neoperplexa* Barnes & Benjamin. **Chuska Mts.:** no actual records, but RES believes it may be present as it is found farther south in Apache Co., AZ (White Mts.). *sheridanii* has erroneously been reported as occurring in northeastern NM. The only known NM population is in the Sacramento Mts. in the southern part of the state, although a single specimen turned up in 1983 in the San Juan Mts. just south of the Colorado state line (JS & RES). Thus, its distribution is strongly disjunct.

452. *Mitoura spinetorum* (Hewiston). **Chuska Mts.:** 2 mi. SE Co, RB, WP, TL, FAA, 2 mi. NW Toh. **Zuni Mts.:** SS, PoC, DC, FW, lZC, NDR, GS, BD (MT). April 23–August 14. Out-of-state collectors often express surprise that *spinetorum* is a common butterfly in New Mexico, as it apparently is much less abundant in other parts of its range. There is a record of 400 specimens being taken in a day near Magdalena, NM (JJ).

458a. *Mitoura siva siva* (W. H. Edwards). **Chuska Mts.:** WWC, Toa, 2 mi. NW Co, Co, L, Toh, 6 mi. SW Sn, 2 mi. E CP, 4.5 mi. S HP, 11 mi. SE RoR, LP. **Zuni Mts.:** PoC, CC, lBC, lZC, 4 mi. S FW,[1] NDR, RL, GS, SR, 6 mi. E R. April 22–August 6.

463. *Sandia mcfarlandi* P. Ehrlich & Clench. **Zuni Mts.:** lZC. 2 May 1976 (2 specimens). Not seen in other years. In 1974, Holland stated that the foodplant *Nolina texana* does not occur on Mt. Taylor. Since then, I discovered a colony visible only by railroad about 10 miles east of Grants. Intensive searching has failed to turn up *mcfarlandi* at this site. The lZC population is extremely small, and may be on the verge of natural extinction (human impact on the area is minimal). A similar very weak population occurs near Acoma, about 30 miles east of Grants. No adults have ever been taken at Acoma, but a single larva was found there in 1971 and reared out.

464d. *Incisalia augustus iroides* (Boisduval). **Chuska Mts.:** taken at CC (MF & RES), 29 April 1974; no records from actual slopes of Chuskas.

465b. *Incisalia fotis fotis* (Strecker). **Chuska Mts.:** 1 mi. NW Toh, Toa, L. **Zuni Mts.:** PrC, PoC, GS, FW (TM, ?). April 21–June 8.

471a. *Incisalia eryphon eryphon* (Boisduval). **Chuska Mts.:** WWC, WP, 2 mi. NW Toh, BG, FAA, RB, 4 mi. W WP, 7 mi. SW Toa, WfL, 8 mi. N WfL on TC, 10 mi. S SR. **Zuni Mts.:** PrC, PoC, DC, 3 mi. W M, GS. April 24–June 14.

478c. *Strymon melinus franki* Field **Chuska Mts.:** 3 mi. W Sn, 8 mi. N WfL on TC, 2 mi. SE Co, 11 mi. E RoR, 4 mi. N OS, WWC, BGR, L, 8 mi. SW Sn, 2 mi. NW

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[1] Miller and Brown indicate the type locality of *siva* is "Probably near Fort Wingate, Arizona [sic]." Actually, Fort Wingate is in New Mexico, and always has been as Arizona was once part of New Mexico. For a general discussion of the indiscriminate use of the locality designation "Arizona" on material collected by the Wheeler Expedition, see Brown (1983). Refer to Brown and Opler (1970) for a discussion of the confusion caused by this indiscrimination with respect to fixing the *siva* type locality.

Toh, 4.5 mi. S HP, 264, BM. **Zuni Mts.:** GS, ML, lZC, 5 mi. W M, NDR, MRC, 6 mi. E R, FW (TM, 1907). May 11–+August 7.

495. *Brephidium exilis* (Boisduval). **Chuska Mts.:** 264, RoR. **Zuni Mts.:** PoC, FW, 400, NMJ, G, RL. May 11–August 31.

498. *Leptotes marina* (Reakirt). **Chuska Mts.:** WWC, Toa, 5 mi. E G, Ch, 10 mi. S SR, 264. **Zuni Mts.:** NDR, 5 mi. W M, PoC, 1 mi. N FW, PT. May 11–August 6.

502a. *Hemiargus isola alce* (W. H. Edwards). Common and universally distributed in NM at elevations up to 7500′. At least May–September in Zunis and Chuskas.

504d. *Everes amyntula herrii* F. Grinnell. **Chuska Mts.:** 2 mi. SE Co, Toa, WWC, 4 mi. S Co. **Zuni Mts.:** uZC, PoC, PrC, GS, lZC. May 1–August 15.

505h. *Celastrina argiolus cinerea* (W. H. Edwards). **Chuska Mts.:** BG, WWC, WP, FAA, 4 mi. W WP, HP, WhC, 2 mi. SE Co, Toa, 4 mi. S Co, 2 mi. NW Toh. **Zuni Mts.:** PoC, 5 mi. W M, DC, PoC, NDR, FW (TM, 1906 & 1910). Form "marginata" occurs commonly in the Chuskas but never in the Zunis. April 30–August 9.

508a. *Euphilotes battoides centralis* (Barnes & McDunnough). **Zuni Mts.:** PoC, PrC, lZC, GC, 400, 5 mi. W M, 3 mi. NE M, OsR, PrC, MC, EMNM (RL). July 10–August 22.

508b. *Euphilotes battoides ellisii* (Shields). **Chuska Mts.:** 2–3 mi. NW RoR, 20 mi. S Ch on AZ 63. August 31–September 10.

511c. *Euphilotes rita spaldingi* (Barnes & McDunnough). **Zuni Mts.:** PoC, GS, 12 mi. S G, 4 mi. S FW (JS), M (JS), FW (TM, 1907). July 29–August 22.

511d. *Euphilotes rita emmeli* (Shields). **Chuska Mts.:** "E of Shiprock on dunes " (JS in TM). August and September.

513d. *Glaucopsyche piasus daunia* (W. H. Edwards). **Chuska Mts.:** WP, WWC, RB, 3 mi. NW Co, 8 mi. E WfL, RL, 12 mi. N WfL on TC, 2 mi. S WP. **Zuni Mts.:** 2–3 mi. W M, PoC, GS, PT, FW (TM, 1910). May 16–June 30.

514f. *Glaucopsyche lygdamus oro* (Scudder). **Chuska Mts.:** WP, 2 mi. NW Toh, 1 mi. E WP, WWC, 2 mi. SE Co, 12 mi. N WfL on TC, 2 mi. S WP. **Zuni Mts.:** GS, PoC, PT, FW (TM, ?. Specimen is in Carnegie Museum. It may not be a Woodgate specimen.). April 29–June 22.

517b. *Lycaeides melissa pseudosamuelis* Nabokov. **Chuska Mts.:** 2 mi. NW Toh, Toa, 2 mi. SE Co, RL, WfL, WWC, BGR, L, 6 mi. SW Sn. **Zuni Mts.:** uBC, PoC, NDR, PrC, GS, CCT, FW (TM, 1907 & 1908). May 18–August 20.

518b. *Plebejus saepiolus whitmeri* F. M. Brown. **Chuska Mts.:** 2 mi. S WP, ? TC (KR). June 17.

520b. *Icaricia icarioides lycea* (W. H. Edwards). **Chuska Mts.:** 3 mi. NW Toh, 2 mi. SE Co, 2 mi. W Toa, 1 mi. E WP, WfL, BG, 8 mi. N WfL on TC, OacTL, WhC, LP, 5 mi. NW Toa, 4 mi. N OS, 4 mi. S Co, BM. **Zuni Mts.:** GS, PT, lZC, PoC, 5 mi. W M, DC, 3 mi. NE M, WT, GC, FW (TM, 1909 & 1910). May 23–August 9. Bivoltine.

522b. *Plebejus acmon texana* Goodpasture. **Chuska Mts.:** 10 mi. N WP, 8 mi. SW Sn, RL, 16 mi. N WfL on TC, WfL, 2 mi. S WP, LP. **Zuni Mts.:** PoC, lZC, NMJ, FW (TM, 1910), BD (MT). May 1–+August 19.

526e. *Agriades rustica rustica* (W. H. Edwards). **Chuska Mts.:** WP, RB, WWC, BG, 8–16 mi. N WfL on TC, 2 mi. NW Toh, 2 mi. S WP, LP. **Zuni Mts.:** PoC, DC. May 29–July 10.

544a. *Apodemia mormo mormo* (C. & R. Felder). **Chuska Mts.:** 6–8 mi. SW of Sn, 2 mi. NW of Toh. **Zuni Mts.:** 3 mi. NW of NDR, FW (TM, 1907 & 1910). July 24–September 18. At least bivoltine. Populations from the Rio Grande Valley, from Albuquerque south, are *m. cythera* (W. H. Edwards), *m. mejicanus* (Behr) or *m. duryi* (W. H. Edwards). Jemez Mts. populations I have personally seen are all *m. mormo*. Due to the great distances between known colonies in western New Mexico, we do not know where the dark DHW form (typical *mormo*) begins to replace the reddish form (*cythera*). Mixed or intermediate populations have not been found in the northern half of New Mexico.

550. *Apodemia nais* (W. H. Edwards). **Zuni Mts.:** PoC, PrC, GS, FW (TM, 1910). June

24–August 15. Bivoltine. In New Mexico, *nais* feeds on *Ceanothis* and usually occurs in association with *C. apama* and *E. pacuvius*.

LIBYTHEIDAE

552b. *Libytheana bachmanii larvata* (Strecker). **Chuska Mts.:** 11 mi. E RoR. **Zuni Mts.:** DC, NMJ. May 27–August 19.

NYMPHALIDAE

562. *Euptoieta claudia* (Cramer). Records from vitually everywhere in NM. At least April–October.

568. *Speyeria nokomis nigrocaerulea* (W. & T. Cockerell). I personally am convinced *nigrocaerulea* is a valid subspecies. **Chuska Mts.:** colonies in Apache Co., AZ, and San Juan Co., NM; numerous other dubious records; one authentic specimen from WWC (BG). Ova obtained from confined females from Apache Co. have been reared through on potted *Viola* without attempt by the larvae to enter the usual, troublesome *Speyeria* larval diapause. This procedure yields adults around 1 Dec. (JJ). **Zuni Mts.:** BD (MT, sight record, 29 August 1967). At present, sheep and goats have rendered this locality incapable of supporting a *nokomis* colony. The WWC record in the Chuskas may represent a stray from an as yet unlocated colony. I fear the Zuni Mts. population is now extinct. July 20–August 10. *This should be proposed as an endangered species.*

574f. *Speyeria atlantis dorothea* Moeck. Populations in Chuskas and on Mt. Taylor are definitely *dorothea*, not *nikias* (Ehrmann). **Chuska Mts.:** FAA, BG, RB, 1 mi. E WP, 8 mi. N WfL on TC, OacTL, 4 mi. SE Co, 8 mi. S ReR, 10 mi. WSW Sn. **Zuni Mts.:** ? no specific data (KR). June 22–July 27.

592. *Poladryas arachne* (W. H. Edwards). **Chuska Mts.:** 8 mi. N WfL on TC, 2 mi. NW Toh, WWC, BG, Toa, 3 mi. NW Co, OacTL, RL, TL, BM, HP. **Zuni Mts.:** PoC, lZC, PrC, GC, NDR, LCC, FW (TM, 1907), BD (MT). May 14–August 31. Bivoltine.

597d. *Thessalia leanira alma* (Strecker). **Chuska Mts.:** 2 mi. NW Toh, WfL, L, RL, WhC, HP. **Zuni Mts.:** PoC, lZc, NMJ, CC, NDR, 6 mi. E R, FW (TM, 1907), BD (MT). May 17–August 9.

599a. *Chlosyne lacinia crocale* (W. H. Edwards). **Zuni Mts.:** CG. August 15.

609. *Charidryas acastus* (W. H. Edwards). **Chuska Mts.:** 2 mi. SE Co, WWC, Co, L, 4.5 mi. S HP. **Zuni Mts.:** PoC, NMJ. May 13–June 15.

623. *Phyciodes tharos* (Drury) ssp. **Chuska Mts.:** 3 mi. SE Co, 2 mi. NW Co, RB, 8 mi. W Toa. June 15–July 23. Unlike eastern populations and some which have become established around cultivated areas in southern NM, this large phenotype is univoltine. See Ferris and Brown (1981) for interesting remarks on the Chuska Mts. *tharos*. It seems possible that we are dealing with two species in New Mexico; one native, large, bright, mostly univoltine and found in undisturbed places; and another introduced from the East which is small, dark, multi-voltine and generally restricted to built-up areas.

625c. *Phyciodes pratensis camillus* W. H. Edwards. **Chuska Mts.:** Toa, WWC, 2 mi. SE Co, L, WfL, RL, HP, 8 mi. N WfL on TC, 2 mi. NW Toh, WhC, 12 mi. N WfL on TC. **Zuni Mts.:** 4 mi N NMJ, 2 mi. W M, PrC, SS, 5 mi. W R, BD, NDR, BV, PoC, GS, B, NMJ, lBC, FW (TM, ?). May 1–August 6.

626b. *Phyciodes picta canace* W. H. Edwards. **Chuska Mts.:** BGR, 3 mi. W Sn, 6 mi. E Sn, WhC. May 12–+August 10. At least four broods.

629b. *Phyciodes mylitta* nr. *callina* (Boisduval). **Chuska Mts.:** 1 mi. E WP, WP, 2 mi. NW Toh, RB, WWC, 8 mi. W Toa, 8 mi. E WfL, RL, 12 mi. N WfL on TC, 5 mi. NW Toa. **Zuni Mts.:** BD, PoC, GS, PrC, lZC, uBC, FW. April 29–+July 3. *callina* (TL Sonora, Mexico) is not a very satisfying name for these populations. However, the name *arizonensis* Bauer is so vaguely described as to make one unsure as to what it is applied.

631a. *Occidryas anicia alena* (Barnes & Benjamin). **Chuska Mts.:** 2 mi. SE Co, N slope BG, Co, L, 1 mi. NW Toh, WfL, 2 mi. SW Co, 12 mi. S Toa, 4.5 mi. S HP, 5 mi. E G. **Zuni Mts.:** GS, NDR, NMJ. April 30–June 15.

631g. *Occidryas anicia chuskae* Ferris and R. Holland. **Chuska Mts.:** RB, 8 mi. N WfL on TC, 8 mi. W Toa, OacTL (CDF & RH), 10 mi. E of WfL on WfC, 6 mi. NW Toa. June 22–+July 8. Separated from *alena* temporally (latest *alena* June 15, peak in May) and altitudinally (*alena* 5500′ to 7000′ in Chuskas, *chuskae* 7300′ to 9000′).

638a. *Polygonia satyrus satyrus* (W. H. Edwards). **Chuska Mts.:** Toa, 8 mi. W Toh. **Zuni Mts.:** NDR. April 21–+July 11.

642. *Polygonia zephyrus* (W. H. Edwards). **Chuska Mts.:** BG, RB, FAA, 3 mi. NW Toh, WWC, WP, 2 mi. S WP. **Zuni Mts.:** DC, 4 mi. S FW. April 23–+August 10.

647a. *Nymphalis californica californica* (Boisduval). **Chuska Mts.:** 2 mi. SE Co, 4 mi. SE Co, BG, Toa. **Zuni Mts.:** PoC, DC. April 21–July 21.

648a. *Nymphalis antiopa antiopa* (Linnaeus). Common everywhere in NM at intermediate elevations (Upper Sonoran and Canadian zones) at least April through October.

649b. *Aglais milberti furcillata* (Say). **Chuska Mts.:** ? no specific data (KR). This species is found on other mountains in northwestern NM.

650. *Vanessa virginiensis* (Drury). **Chuska Mts.:** Toa, 8 mi. W Toa, 264. **Zuni Mts.:** 3 mi. W M, WT, DC, NJ. May 11–+July 22.

651. *Vanessa cardui* (Linnaeus). Abundant everywhere and every year in NM from April to November. Migrations are much heavier in some years than others. In years of heavy migration, a few specimens always may be taken several weeks before the main migration arrives. Occasionally during migrations, the population is so dense as to interfere with nighttime light trapping of moths.

652. *Vanessa annabella* (Field). **Chuska Mts.:** WP, 2 mi. SE Cove, RB, Toh, WfL, TL. **Zuni Mts.:** lBC, NDR. May 19–+June 21.

653a. *Vanessa atalanta rubria* (Fruhstorfer). **Chuska Mts.:** WfL, 2 mi. SE Co, Toa, 11 mi. E RoR, 8 mi. N WfL on TC, 264. **Zuni Mts.:** NDR, DC, NMJ, OjR (RB). May 11–+July 11. Population may have a migratory component, as it is much more common in years of strong *cardui* migrations.

656. *Junonia coenia* Hubner. **Chuska Mts.:** RL, WhC, Toa, 12 mi. E RoR. July 1–August 6. All Chuska Mts. records from 1978, when a migration occurred. Not frequently encountered in the northwestern quarter of NM, although taken in numbers in the Jemez Mts. in 1983 and 1984.

665e. *Basilarchia weidemeyerii angustifascia* Barnes and Benjamin. **Chuska Mts.:** 2 mi. SE Co, WWC, BG, 4 mi. E WfL, 2 mi. E CP, BM, 2 mi. SW Co, LP. **Zuni Mts.:** 4 mi. N NMJ, NDR, GS, PoC, PrC, MRC, FW (TM, 1909). May 30–+July 21.

668a. *Adelpha bredowii eulalia* (Doubleday & Hewiston). **Chuska Mts.:** 8 mi. N WfL on TC, WfL, 6 mi. W Sn, WWC. **Zuni Mts.:** GS, PoC. May 28–September 2.

SATYRIDAE

717a. *Cyllopsis pertepida dorothea* (Nabobov). **Chuska Mts.:** 2 mi. SE Co, Toa, 2 mi. NW Toh, HP. **Zuni Mts.:** PoC, lZC, GS, NDR, LCC, PRC, MC, FW (TM, ?), BD (MT). June 18–August 13.

729. *Coenonympha ochracea* W. H. Edwards. **Chuska Mts.:** ? BG (KR).

733a. *Cercyonis meadii meadii* (W. H. Edwards). **Chuska Mts.:** 6 mi. W Sn, Toa, 2 mi. SE Co, 8 mi. SW Sn. July 14–September 2. *C. meadii* and *sthenele masoni* intergrade in the Chuskas.

734a. *Cercyonis sthenele masoni* Cross. **Chuska Mts.:** 1 mi. SE Co, 6 mi. W Sn, Toa, 8 mi. SW Sn, 8 mi. NW Sn. July 13–September 2.

735a. *Cercyonis oetus charon* (W. H. Edwards). **Chuska Mts.:** RB, 5 mi. S RB, 8 mi. W Toa, 8 mi. N WfL on TC, 3 mi. W Toa, 12 mi. N WfL on TC, 6 mi. W Sn, OacTL, 4 mi. E WfL, 10 mi. E WfL on WfC, BM. June 22–August 5.

748a. *Neominois ridingsii*. **Zuni Mts.:** lZC, uBC, 1 mi. N FW. May 31–June 27.

DANAIDAE

760. *Danaus plexippus* (Linnaeus). **Chuska Mts.:** 1 mi. W Toa, 8 mi. N WfL on TC, LP, HP. **Zuni Mts.:** NDR, FW. May–September.

761b. *Danaus gilippus strigosus* (Bates). **Chuska Mts.:** Toa, 11 mi. E RoR. **Zuni Mts.:** NDR, MRC. May 27–July 22.

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The author is indebted to R. E. Stanford, C. D. Ferris and L. D. Miller for reviewing this article. The Toliver manuscript is an indispensable reference for faunal studies of New Mexico. It is most regrettable it was never published.

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GENERAL NOTES

THE LARCH CASEBEARER, *COLEOPHORA LARICELLA* (HÜBNER) (COLEOPHORIDAE), IN WESTERN WASHINGTON

The larch casebearer, *Coleophora laricella* (Hübner), is a Palearctic moth which was first reported from the Pacific Northwest in 1957 by Denton (1958, U.S. For. Serv. Res. Note 51:1–6). Denton and Tunnock (1971, U.S.D.A. For. Pest Leaflet 96: fig. 1) mapped the species' range in the northwestern United States and adjacent parts of Canada. Since 1971, field parties from the University of Washington, Seattle, have observed larvae on western larch, *Larix occidentalis* Nuttall, from two localities on the east slope of the Washington Cascades Range: Chelan Co., 12.5 km SW Leavenworth, Bridge Creek Campground; and Kittitas Co., 8.8 km SE Cle Elum, Elk Heights. In March 1981, I found third instar larvae feeding on the new foliage of a European larch, *L. decidua* Miller in King Co., Seattle, Univ. Washington campus. Individuals were subsequently reared and voucher specimens deposited in the collection of the University of Washington College of Forest Resources. In the spring of 1981 and 1982, infestations of this moth were found on European larch at Green Lake, about four kilometers northwest of the campus.

Mr. Richard Johnsey, State Forest Entomologist, Washington Department of Natural Resources, who maintains western Washington records of pest insects, informed me that *C. laricella* had not been previously reported west of the Cascades in this state. How the moth crossed the Cascades (the lowest pass is 922 m) is conjectural. Prevalent winds are normally from west to east or north to south. The species may have been transported with nursery stock, or its spread westward may be natural.

I thank Dr. Robert Gara, University of Washington, and Dr. Frederick H. Rindge, American Museum of Natural History, for their encouragement and critical commentary on the manuscript.

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THE GESNERIACEAE AND BIGNONIACEAE AS FOOD-PLANTS OF THE LEPIDOPTERA

Robert K. Robbins and Annette Aiello in their paper, *Foodplant and Oviposition Records for Panamanian Lycaenidae and Riodinidae* (1982, J. Lepid. Soc., 36(2):65–75), with their single record of a gesneriad as a lepidopterous food-plant and their quotation from Ehrlich and Raven's 1964 paper, *Butterflies and plants, a study in coevolution*, that plants belonging to the Gesneriaceae, Bignoniaceae and Begoniaceae are not used or are under-utilized as lepidopterous food-plants, reminded me of a recent experience.

We have in East Africa a number of indigenous Gesneriaceae, including the wild ancestor of the very popular African Violet, or *Saintpaulia*, as well as numerous introduced species grown as pot plants in greenhouses and open verandahs, but I have only recently obtained a record of a gesneriad being eaten by a lepidopterous larva. On two separate occasions larvae of the polyphagous sphingid, *Coelonia mauritii* Btlr., have been found feeding on *Aeschynanthus marmoratus*, an introduced cultivar from Thailand, growing in a hanging basket suspended from the roof of an open-sided orchid house in Mombasa.

The following food-plants have previously been recorded for *C. mauritii*: *Acanthus* (Acanthaceae), *Cissus* (Ampelidaceae), *Bignonia, Fernandoa magnifica, Markhamia platycalyx, Millingtonia hortensis, Newbouldia imperialis, Spathodea, Tecoma, Tecomaria* (Bignoniaceae), *Cordia* (Boraginaceae), *Dahlia* (Compositae), *Convolvulus, Ipomaea* (Convolvulaceae), *Coleus, Pycnostachys, Salvia* (Labiatae), *Buddleia, Lachnopylis* (Loganiaceae), *Jasminum* (Oleaceae), *Lycopersicum, Nicotiana, Solanum* (Solanaceae), *Hebe speciosa* (Scrophulariaceae), *Clerodendron, Duranta, Lantana, Stachytarpheta indica* (Verbenaceae).

Contrary to Ehrlich and Raven's comment, the Bignoniaceae do provide food-plants for a considerable number of Lepidoptera, mostly Heterocera it is true, in East Africa, but I have far fewer records for India. Below is a complete list of my records:

Bignonia—Spilosoma investigatorum Karsch (Arctiidae), *Acherontia atropos* L., *Coelonia mauritii* Btlr. (Sphingidae); *Fernandoa—Cymothoe coranus* Gr. Sm. (Nymphalidae), *Epiphora mythimnia* Westw. (Saturniidae), *C. mauritii* (Sphingidae), *Mazuca strigicincta* Wlk. (Noctuidae), *Hyblaea euryzona* Prout (Pyralidae); *Jacaranda—Pachypasa sericeofasciata* Auriv. (Lasiocampidae); *Kigelia—C. coranus, Asterope boisduvali* Wllgrn. (Nymphalidae), *Mussidia nigrivenella* Rag., *M. fiorii* T. & deJ., *Zebronia phenice* Cr., *Udea ablactalis* Wlk. (Pyralidae); *Podranea—A. atropos* (Sphingidae); *Markhamia—Euproctis molundiana* Auriv. (Lymantriidae), *Pachypasa subfascia* Wlk., *Pseudometa castanea* Hamps. (Lasiocampidae), *Phiala atomaria* Holl. (Eupterotidae), *C. mauritii, Macropoliana natalensis* Btlr., *Andriasa contraria* Wlk. (Sphingidae), *Peratodonta olivaceae* Gaede (Notodontidae), *Latoia chapmani* Kirby, *L. hexamitobalia* Tams, *L. vivida* Wlk., *L. urda* Druce, *L. viridicosta* Hamps. (Limacodidae), *Salagena atridisca* Hamps. (Metarbelidae), *Lycophotia ablactalis* Wlk., *M. strigicincta* (Noctuidae), *Comibaena leucospilata* Wlk. (Geometridae), *Hyblaea puera* Cr., *H. euryzona, Polygrammodes junctilinealis* Hamps., *Z. phenice, Pyrausta fulvilinealis* Hamps. (Pyralidae); *Millingtonia—Hypolycaena philippus* F. (Lycaenidae), *A. atropos, C. mauritii, Pemba favillacea* Wlk. (Sphingidae); *Newbouldia—Argyrostagma niobe* Weym. (Lymantriidae), *Agrius convolvuli* L., *C. mauritii, A. contraria* (Sphingidae); *Spathodea—Holocera smilax* Ang. (Saturniidae), *A. atropos, C. mauritii, M. natalensis, Poliana witgensis* Strd., *A. contraria, Cephonodes hylas* L., *Hippotion osiris* Dalm. (Sphingidae), *Z. phenice* (Pyralidae); *Stereospermum—P. subfascia* (Lasiocampidae), *Z. phenice* (Pyralidae); *Tecoma—A. atropos, C. mauritii* (Sphingidae), *U. ablactalis* (Pyralidae); *Tecomaria—Spilosoma lutescens* Wlk. (Arctiidae), *A. atropos, C. mauritii* (Sphingidae). My Indian records are the sphingids *Acherontia styx* Westw., *A. lachesis* F., and *Psilogramma menephron* Cr. on species of *Tecoma, Stereospermum, Bignonia* and *Spathodea*; presumably *Hyblaea puera* also feeds on Bignoniaceae in India, but I have no records.

The Begoniaceae is another story, the only East African record I have is *Bracharoa quadripunctata* Wllgrn. (Lymantriidae) on *Begonia* sp., and for India the sphingids *Theretra clotho* Drury, *T. latreillei* Macleay and *Rhyncholaba acteus* Cr., also on *Begonia* spp.

I cannot help feeling that Ehrlich and Raven would have come to some very different conclusions if they had included the Heterocera in their survey.

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NOTES ON THE NATURAL HISTORY OF *PAPILIO VICTORINUS* DOUBL. (PAPILIONIDAE) IN NORTHEASTERN COSTA RICA

Papilio victorinus Doubl. (Papilionidae) is a member of the "*homerus* group" of "fluted" swallowtail butterflies inhabiting Central America and Mexico (Seitz, 1924, Macrolepidoptera of the World, Vol. 5, Kernan, Stuttgart). The caterpillar (instar not mentioned) and pupa were described by Schaus (1884, Reise Novara, Lepid., Papilio 4:101) from Mexico. All early stages and a larval food plant were reported for *P. victorinus* from El Salvador by Muyshondt et al. (1976, Rev. Soc. Mex. Lepid. 2:77–90). One specimen of this species in the pinned collection of the Costa Rican National Museum bears a label stating "reared 26 May 1979 on *Persea americana.*" Muyshondt et al. (op. cit.) also report *Persea* (Lauraceae) as the larval food plant of this butterfly. Butterflies of the "*homerus* group" are known to feed as caterpillars on several plant families, most notably Lauraceae, Hernandiaceae, Rubiaceae, Malvaceae, and Convolvulaceae (Scriber, unpubl. manuscript, Latitudinal gradients in larval feeding specialization of the world Papilionidae (Lepidoptera)—A supplementary table of data, for Psyche 80:355–373). Herein, I report for the first time the purported feeding association of *P. victorinus* with Hernandiaceae in northeastern Costa Rica, a discovery not unexpected given the known larval food plant associations of the "*homerus* group" species (Scriber, op. cit.). I also provide further documentation of the early stages to supplement those of Muyshondt et al. (op. cit.) for El Salvadoran populations.

At 1145 h on 2 February 1977, I observed a large black swallowtail butterfly place a total of four eggs on a leafy tree sapling (about 1.5 m tall) in a partly shaded clearing within mixed primary and secondary "premontane tropical wet forest" at "Finca La Tigra," near La Virgen (10°23'N, 84°07'W; 220 m elev.), Sarapiqui District, Heredia Province. This butterfly had large diffuse areas of bluish green on the upper surfaces of the hind wings. Although I could not readily determine the species, judging from my experience with observing other swallowtail butterflies in Costa Rica over the past sixteen years, I ruled out familiar species such as *Battus belus varus* Kollar, *B. polydamas* Linnaeus, *B. crassus lepidus* Cramer, *Eurytides pausanias prasinus* Roth. & Jordan, and *Papilio cleotas archytas* Hoppfer. In an earlier draft of this paper, I erroneously identified the butterfly in question as *P. birchalli* Hew. But after reading the reviewer's comments and rechecking descriptions of this species and consulting further the Muyshondt et al. (op. cit.) reference on *P. victorinus* early stages, I am assuming my species to be *P. victorinus*. One source of confusion was examining a wild-caught female specimen in the Costa Rican National Museum labeled as both *P. victorinus* and *P. birchalli*. The occurrence of *P. birchalli* in Costa Rica is questionable (e.g., Seitz, op. cit.). Because I was unable to rear the four eggs through to adulthood, I can only state that the species in question is purportedly *P. victorinus*. Further indirect evidence against it being *P. birchalli*, for example, is the systematic placement of this species within another "fluted" swallowtail group, the "*scamander* group," whose species with known life cycles are not associated with Hernandiaceae (Scriber, op. cit.). Given these considerations, I am assuming the species to be *P. victorinus*. Owing to the fact that it is often very difficult to obtain oviposition records for *Papilio* species in the wild (J. M. Scriber, pers. comm.), incomplete rearing data such as mine in this particular instance do provide an initial observation on which to build further studies, even though it may take many more years before myself or another researcher witnesses a large black *Papilio* placing eggs on Hernandiaceae in northeastern Costa Rica.

During oviposition, the butterfly in question made several swooping low passes over the small tree, each time placing an egg on the shaded forest plant (Fig. 1). The first honey-colored spherical egg (2 mm dia.) was placed on the **ventral** surface of a mature leaf. A second egg was placed, seconds later, on the **upper** surface of the **same** leaf. Prior

FIG. 1. Egg-placement forest habitat (**above**) and larval food plant (**below**, broadleaf plant immediately to the left of the insect net) of *Papilio birchalli* Hew. (Papilionidae) at "Finca La Tigra" in northeastern Costa Rica.

to ovipositing a third egg, the butterfly flew swiftly into the upper reaches of the forest, and then returned to place another egg on the **ventral** surface of a meristem leaf. A fourth egg was quickly placed on the **ventral** surface of the same leaf. Within approximately four minutes, the insect placed four eggs on two different leaves of the tree, apparently exhibiting a lack of "preference" for meristem versus mature leaf surfaces as oviposition cues. I left one egg on the plant and collected the other three for rearing.

Before leaving the site when collecting the eggs, I marked the tree with a small yellow tag (plastic) secured with copper wire. I marked the tree in order to make subsequent observations for additional eggs and caterpillars of this *Papilio* over the next several years. In doing so I also ensured accurate food plant voucher specimens for confirming identification of the plant. At the time the oviposition was observed, the tree had no flowers or fruits, rendering it difficult to make positive determination of the plant. A voucher of fresh leaves was collected at this time for determination, and over the following seven years, three additional vouchers were taken for determinations.

Based upon the examination of fresh fragmentary material collected from the tree for the first three times, three different well-known botanists familar with the Costa Rican flora independently determined the plant to be in the Araliaceae. Based upon a review of the manuscript when previously submitted to this journal and in which the food plant determination was challenged, I collected the fourth and final voucher from the tree (2 August 1984) and arranged for one of the botanists, Luis Diego Gomez, to re-examine the material. In conferring with another botanist, Luis Fournier, it was determined that the plant in question was Hernandiaceae, either *Hernandia sonora* or *H. guianensis* (L. D. Gomez, letter to A. M. Young, 3 August 1984). Mr. Gomez indicated to me that several features of the material lead one to believe that the plant is Araliaceae. Thus he writes: "The different lengths of the petioles, lustrous leathery leaves and the methylated aroma of crushed leaves, suggested an aralia." The methylated compounds underlying aroma of the crushed leaves are flavonoids also found in the Araliaceae and Umbelliferae (L. D. Gomez, pers. comm.). This distinctive aromatic property is also encountered in the Lauraceae, the other known larval food plant of *P. victorinus* and the "*homerus* group" (e.g., Muyshondt et al., op. cit.). In Costa Rica, the *Hernandia* in question (Fig. 1) is locally called "aguacatillo" (small avocado, little avocado), as Gomez conveyed to me, "not only because the twigs faintly resemble those of Lauraceae but because of the aromatic bark and leaves."

The eggs were kept in a large, clear, plastic bag maintained tightly shut and containing fresh cuttings from the food plant. The honey-colored egg (Fig. 2) darkened noticeably a day before hatching, and hatching occurred in eight days. The first instar larva (Fig. 2) immediately devoured the entire empty egg shell and readily everted a reddish orange osmeterium at the slightest provocation. The first instar larva is 6 mm long at the time of hatching, bears a glossy, smooth dark-brown head capsule, a dorsal pair of long, orange tubercles on the first thoracic segment; a second pair of short, dark brown tubercles are borne laterally on this segment. The second thoracic segment has one pair of short, dark brown tubercles and a lateral long pair (also brownish). Tubercles with short brown or black setae. The same pattern of two pairs of tubercles occurs on the third thoracic segment. The first three abdominal segments also have two pairs each of much shorter brownish tubercles; those of the fourth are white. Segments 5–8 with tubercles as segments 1–3 of the abdomen. Segments 9–10 with only dorsal, long, white tubercles. The elongate tubercles of both the first thoracic segment and the final abdominal segments give the body an illusory "bi-forked" appearance. The anal plate is dark brown; the remainder of the body is a patchwork of brown and white blotches.

Second instar larva similar in appearance to the first. Third instar (Fig. 3) without the prominent tubercles of the previous instars and now with the anterior third of the body greatly "swollen" in appearance. Resembles a typical *P. cresphontes* (Cramer) third instar.

Larvae perch on individual silken mats on **dorsal** surfaces of leaves, both in the laboratory and as observed for the one caterpillar left to hatch in the wild; quickly rears up first ⅔ of body when disturbed, and holds this position for a few minutes. The "wild" caterpillar disappeared as a third instar on 15 February 1977, fifteen days after the egg was placed there. By this time the caterpillar had moved off the original leaf where the egg had been placed.

Fourth instar larva very similar to third instar, but with row of roundish blue spots laterally on the abdominal region. Mimics of fresh bird dropping, as seen in the cater-

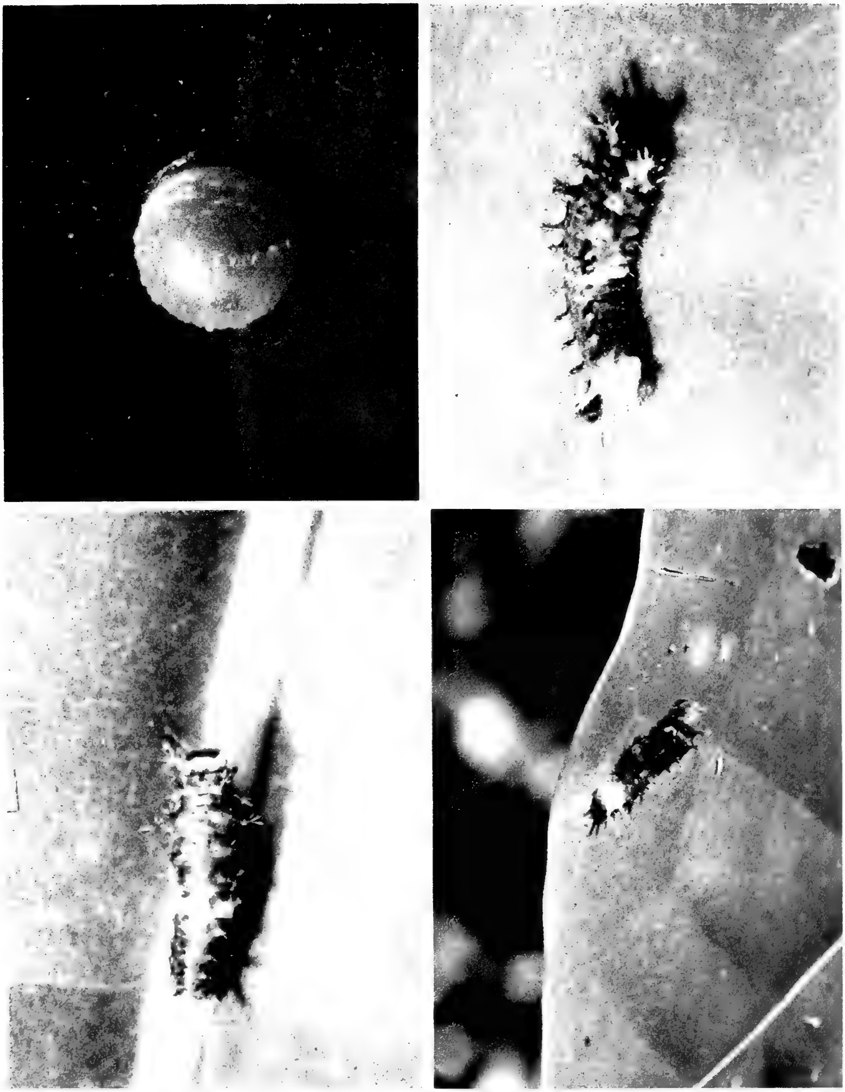

FIG. 2. Egg (**upper left**), a first instar (**upper right** and **lower left**), and early second instar (**lower right**) larva of *P. birchalli*. The photograph of the second instar was taken directly in the wild, on the food plant (Araliaceae, prob. *Dendropanax* sp.); note the silken mat the larva rests upon, in sunlight on upper side of a leaf.

pillars of many *Papilio* species. The fifth instar larva (Fig. 3) is very differently colored than the previous instars, becoming patterned in shades of green and brown and attaining a body length of about 55 mm (n = 3) in about 10 days. The appearance of the fifth instar in my study is virtually identical to that of Muyshondt et al. (op. cit.) for this

FIG. 3. Third instar larvae (**above**, in laboratory culture), and fifth instar larva (**below, left**) of *P. birchalli*. Also shown is the larval food plant individual with apical section removed for determination studies.

species in El Salvador. The "cross-like" dorsal trunk pattern (Fig. 3) may be typical for species in the "*homerus* group." Owing to an absence of additional food plant material, all three caterpillars died prior to pupation but were probably very close to pupation. For the time of study, the larval period was 45 days at about 25–29°C.

Although apical sections of the food plant individual were removed for identification purposes later in the study (Fig. 3), the plant grew to a height of about 3.0 m by December 1982, and average leaf size at this time was about half of that at the time oviposition was observed. No other eggs or caterpillars of *P. victorinus* were found on the tree over the following seven years (with about a total of 26 days per year at three different times per year for examining the tree).

Papilio species within the "*scamander*" and "*homerus*" groups appear to be typified as Magnoliales- and Laurales-feeders (Scriber, op. cit.), and as exemplified by the association of *P. victorinus* with *Persea* in both El Salvador (Muyshondt et al., op. cit.) and Costa Rica (Costa Rican National Museum specimen label data) as well as with *Hernandia* (this report). Both the Lauraceae and Hernandiaceae fall within the Laurales (Cronquist, 1981, An Integrated System of Classification of Flowering Plants, Columbia Univ. Press, New York). The similarity of aromatic properties of freshly crushed leaves in both groups, namely flavonoids (L. D. Gomez, pers. comm.), suggests a common ovipositional cue for *P. victorinus*. Yet, since these methylated compounds are also found in the Araliaceae and Umbelliferae, other known *Papilio* larval food plant groups (Scriber, op. cit.), *P. victorinus* must cue into still other factors in the food plant selection process, rendering the insect an excellent phytochemist.

I sincerely thank Luis Diego Gomez, Luis Jorge Poveda, and Gary S. Hartshorn for making initial determinations of the larval food plant, and to an anonymous reviewer who most admirably took the time to check carefully these determinations based upon the plates submitted with an earlier version of the manuscript. A special thanks to Luis Diego Gomez for taking the time in August 1984 to confer further with me on the plant identification, and to Dr. Luis Fournier for his assistance as well. And to whoever placed the "*P. birchalli*" name label on the female *P. victorinus* specimen (one of two specimens in the collection as of 17 August 1984) at the Costa Rican National Museum, please check it since it is a source of confusion with identification of the species. I thank Dr. J. Mark Scriber for reading the earlier draft and for helpful discussions which ensued from the editorial process. In the latter context, I also thank Dr. Thomas D. Eichlin, Journal Editor.

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"EDGE EFFECT" IN OVIPOSITION BEHAVIOR: A NATURAL EXPERIMENT WITH *EUCHLOE AUSONIDES* (PIERIDAE)

The "edge effect," whereby isolated host plant individuals tend to receive disproportionate egg loads, has been documented in a variety of insects, and several authors have commented recently on mechanisms to account for it in butterflies. These mechanisms may be arranged in a proximate-ultimate causal hierarchy and may not be mutually exclusive, but attention has focused primarily on whether the "edge effect" is an adaptive characteristic produced by natural selection, or essentially a statistical artifact with no evolutionary significance (Shapiro, 1981, Am. Nat. 117:276–294; Courtney & Courtney, 1982, Ecol. Entomol. 7:131–137; Mackay & Singer, Ecol. Entomol. 7:299–303).

Another phenomenon affecting egg dispersion in various insects, including butterflies, is "egg-load assessment," wherein ovipositing females react positively or negatively to the presence of previously laid, usually highly conspicuous, eggs (for butterflies see Rausher, 1979, Anim. Beh. 27:1034–1040; Shapiro, 1980, J. Lepid. Soc. 34:307–315; Shapiro, 1981, Am. Nat. 117:276–294; Singer & Mandracchia, 1982, Ecol. Entomol. 7:327–330). The interactions of these two phenomena may be complex and difficult to interpret in analyzing field egg-dispersion data.

TABLE 1. Distribution of *Euchloe ausonides* eggs on *Brassica* inflorescences at Suisun City, California, 28 March 1983.

Number of inflorescences bearing:	Red eggs	Green eggs
8	1	0
14[a]	0	1
3	1	1
6	0	2
1	0	3
3	0	4
19	0	0
Totals: 54 (35 with eggs)	11	44

Mean red eggs/inflorescence having only red eggs: 1.00.
Mean red eggs/inflorescence having both red and green eggs: 1.00.
Mean green eggs/inflorescence having only green eggs: 1.71.
Mean green eggs/inflorescence having both red and green eggs: 1.00.
[a] Includes 1 egg laid on adjacent leaf (Fig. 1).

The large marble, *Euchloe ausonides* Lucas, is a member of the red-egg, inflorescence/infructescence-feeding pierid guild in western North America, and engages in egg-load assessment (Shapiro, 1981, op. cit.): the mean number of eggs/inflorescence bearing any eggs is normally almost exactly unity. During the winter of 1982–83 in northern California, rainfall totals generally exceeded 175% of 30-year norms, and 200% was not unusual. At Suisun City, Solano County, where I have studied a population of *E. ausonides* since 1973, much of the breeding habitat was inundated from 4–11 weeks to a depth of 15–30 cm. This unusual situation permitted a test of the flexibility of oviposition behavior, given a drastic shortage of sites: would the characteristically even dispersion of eggs change as "edge effect" became more important than "egg-load assessment"?

Host plants—weedy mustards of the genus *Brassica*—are normally abundant at Suisun. By late March, from two to four species may be in a suitable phenophase (flower buds present) for oviposition by *E. ausonides* to occur. Between 1973 and 1981, the first flight was between 6–16 March at this site, oviposition commencing almost at once. (1982 populations were so sparse that the dates may not be reliable.) In 1983 the first males were seen on 26 March. By 28 March both sexes were common, and an egg census was done. Every *Brassica* plant in a 1.5 ha field was examined thoroughly. Normally this would be impossible—there would be many thousands—but on this occasion only 140 plants could be found. Of these only 22 had any inflorescences judged suitable for oviposition—a total of 54 of them. At least three females were observed ovipositing on the site on 28 March. The distribution of eggs on the 54 inflorescences is given in Table 1.

More than a third of the inflorescences bearing eggs bore more than one. *Euchloe ausonides* eggs are green when laid, changing to red by the next day. For green (same day) eggs only, the mean number of eggs/inflorescence bearing eggs was 1.71. Before 28 March I had never seen a four-egg inflorescence, but on that day I found three. One female was seen laying on an inflorescence known to bear one green egg. One egg was found on an upper leaf adjacent to a very rudimentary inflorescence, too small to permit the female to balance upon it while laying. This is the first *E. ausonides* egg I have ever found on a leaf. Fig. 1 illustrates some of these situations.

The distribution of the eggs among *Brassica* species is of interest. All four known hosts at the site were present, but their phenologies differ enough that their reactions to the flood were quite different. *B. campestris* L., the first to germinate and bloom, was represented by only three individuals—all past bloom, bearing green fruit and no eggs. *B. Kaber* (DC.) Wheeler, on the average somewhat later, had been harmed most. Six individuals were present, all in flower; three of these had usable buds, and all the susceptible inflorescences received multiple ovipositions. *B. nigra* (L.) Koch, last of the annual mustards to bloom, had germinated as the flood receded and was still mainly vegetative. It was the commonest species, but few plants had well-defined buds—the one

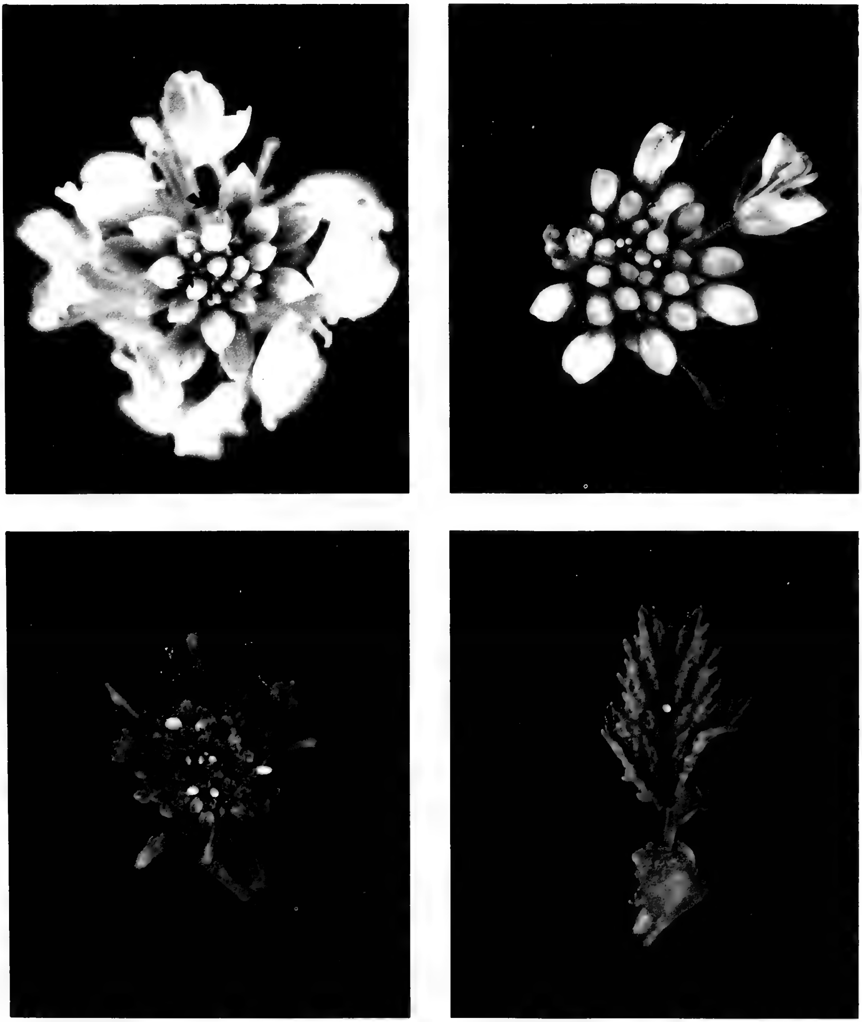

FIG. 1. *Brassica* inflorescences collected at Suisun City, California on 28 March 1983 showing unusual ovipositions by *Euchloe ausonides*. **Upper left:** *B. Kaber* with one red and one green egg. **Upper right:** *B. Kaber* with four green eggs. **Lower left:** *B. geniculata* with four green eggs. **Lower right:** *B. nigra* with egg laid on cauline leaf adjacent to rudimentary buds. (Photos by Samuel W. Woo.)

illustrated, with an egg on a leaf, was one of the two most advanced—and very few eggs were found on them. *B. geniculata* (Desf.) J. Ball, a short-lived perennial, had survived the flood and bolted. It was in prime condition for oviposition—early flowering, with many buds—and received most of the eggs. The most important criterion for oviposition was obviously phenophase and not species or size.

Previous studies (Shapiro, 1981, op. cit.) have shown that newly laid, green eggs are not deterrent to females in the red-egg guild and have failed to support the existence of an oviposition-deterrent pheromone. This "natural experiment" supports these conclusions. The greatly increased incidence of multiple oviposition suggests that when host density is reduced by 3–4 orders of magnitude while population density is normal, the *entire stand* of hosts may demonstrate "edge effect"—at least early in the flight, when most eggs are green. Theoretically, as the flight proceeds, the presence of more red eggs should deter multiple ovipositions and perhaps encourage female dispersal. Unfortunately, it was not practical to test this prediction, given the rate of turnover of inflorescences and the rapid maturation of the many *B. nigra* at the Suisun site. The ability of "edge effect" to dominate the pattern of egg dispersion in this unusual situation, however, does tend to confirm that "edge effect" is a statistical consequence of female behavior; it does not clarify the evolutionary origin of that behavior.

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EPIBLEMA LUCTUOSANA A. BLANCHARD, A HOMONYM, IS CHANGED TO ***EPIBLEMA LUCTUOSISSIMA*, NEW NAME**

From Dr. Leif Aarvick (Tårnveien 6, N-1430 Ås, Norway), I received the following information, for which I thank him very much: "Blanchard describes a species which he calls *Epiblema luctuosana*. Unfortunately there is another *Epiblema luctuosana* in Europe (*E. luctuosana* Duponchel, which is a synonym of *E. scutulana* Den. & Schiff). Thus *luctuosana* A. Blanchard is a homonym."

I propose to change the name of the species I described as *E. luctuosana* (1979, J. Lepid. Soc. 33(3):184) to *Epiblema luctuosissima* A. Blanchard.

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SCHIZURA RUSTICA (SCHAUS), A NOTODONTID MOTH DEFOLIATING *HERRANIA* AND *THEOBROMA* SPECIES (STERCULIACEAE) IN COSTA RICA

Herein, I report for the first time the association of the "medium-sized" (approx. 37 mm spread wingspan), dull brown and mottled gray notodontid moth *Schizura rustica* (Schaus), with *Herrania albiflora* Goudot (Sterculiaceae) as a larval food plant at one locality in Costa Rica and the acceptability of the closely related *Theobroma cacao* L. (also Sterculiaceae) as an alternate food plant. My report includes observations on the role of this moth as a serious defoliator of *H. albiflora* as well as offering some preliminary autecological and natural history notes on the life cycle and larval feeding behavior. Although much information has accumulated over the years on the insect herbivores associated with *T. cacao* throughout the tropical regions of the world (e.g., Entwistle, P. F., 1972, Pests of Cocoa, Longman, London; Saunders, 1979, Plagas Insectiles De America Central, Turrialba, Costa Rica: CATIE). Given the very close evolutionary affinities within the Sterculiaceae, particularly for *Theobroma* and *Herrania* (Cuatrecasas, 1964, Contrib. U.S. Nat. Mus. 35:379–614), it would not be unexpected to discover in nature that herbivorous insects associated with one or the other genus successfully feed on the other genus as well. After all, there is at least one documented example of a genus of notodontid moth successfully exploiting both bombacaceous and sterculiaceous larval food plants (Young, J. Lepid. Soc. 37: 182–186), and these two Neotropical tree families are very closely related as well (Cronquist, 1981, An Integrated System of Flowering Plants, Columbia Univ. Press, New York).

On 26 February 1983, I discovered two clusters of caterpillars on a "sapling" of *H. albiflora* (about 1.5 m tall and D.B.H. = 2.0 cm) planted along with a second individual of this species in a *Theobroma* and *Herrania* "garden" (n = approx. 30 trees for total of 5 species) at "Finca Experimental La Lola," near Siquirres (10°06′N, 83°30′W), Limon Province. The locality is within lowland tropical rain forest characteristic of the Atlantic watershed of Costa Rica. The locality experiences a short and irregular dry season between December and March each year, although there are seldom days with no rainfall at all.

When discovered one group contained 15 larvae all aggregated on the ventral side of two adjacent leaflets, and the second group had 10 larvae on a separate leaf. All larvae appeared to be 21–26 mm in body length, and based upon subsequent rearing data, were probably third or fourth instars. An eventual determination of the species resulted from rearing a sample consisting of one of the two groups, the second group being left undisturbed on the food plant. Once collected and confined to a large clear-plastic bag kept tightly shut, the larvae were transferred to *T. cacao* leaves, in order to determine acceptability of this species for successful development. The second group, left on the food plant, served as a control on this study. What initially led to the discovery of the larvae was the fact that the treelet was heavily defoliated, with more than half of the large, stellate-type leaves either completely missing (but not fallen off) or with only midribs remaining (Fig. 1).

Caterpillars remain aggregated on leaves of both *H. albiflora* and *T. cacao,* although groups fragment into smaller clusters in the fifth instar (Fig. 1). Characteristically, individual caterpillars feed from the already eaten edge of leaves and also rest in these positions when not feeding (Fig. 1). The leaves of *Herrania* are usually blotched in shades of light green and brown, a color combination that is matched by the mottled colors of the caterpillars (Fig. 1). Caterpillars feed and rest from loose webbings of silk spun over the leaves and lengthy petioles of *Herrania* leaves.

A single mature leaf of *H. albiflora* consists of usually five leaflets, arranged in a stellate fashion. The "crown" of the treelet consists of a whorl of leaves in the absence of branches, and the very long petioles give the appearance of branches (Fig. 1). At the time of discovery, the treelet had a total of nine leaves, of which two were completely defoliated and the remaining ones with one to four leaflets missing on each (although five of the nine each had three leaflets missing). Thus the defoliation of the treelet by *S. rustica* was very advanced by this time. Absent were any new flushes of young leaves; no flowers and fruits were present. By 12 March (two weeks after initial discovery) only one of the original aggregate of ten caterpillars was left, and this individual was 45 mm long. Based upon the simultaneous rearing on *T. cacao,* this caterpillar (Fig. 1) was judged to be in the final instar. Presumably the others had matured and left the food plant for pupation by this time. The adjacent (about 3 m away) *H. albiflora* had no caterpillars, nor did it have any signs of the defoliation characteristic of this notodontid. The second tree, however, was in advanced stages of defoliation by an unidentified species of leaf-cutter ant, *Atta* sp. (Hymenoptera: Formicidae). Caterpillars kept on *T. cacao* thrived, many of these eventually pupating by 23 March while the sample was being hand-carried on an aircraft between Costa Rica and Nicaragua. Pupae are chestnut-brown and range in body length from 18 to 20 mm. They eclose in 12–14 days, although the length of the pupal stage may vary greatly with temperature and other

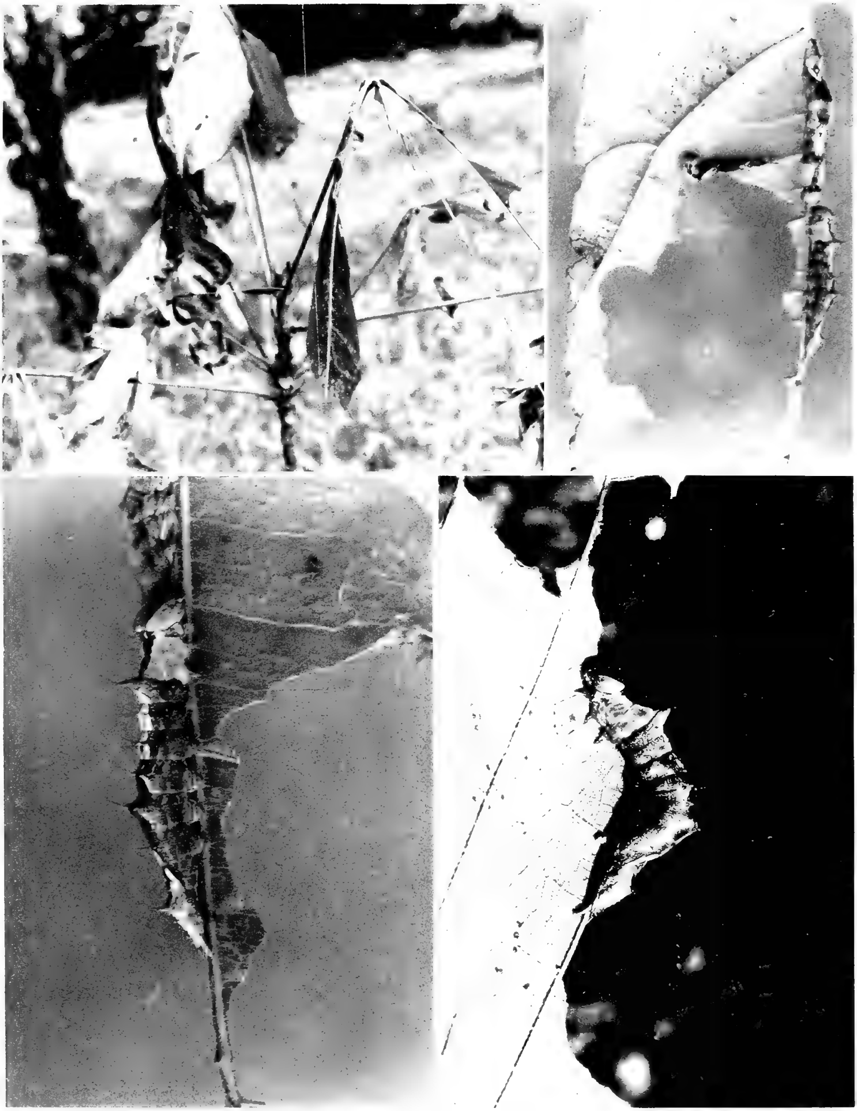

FIG. 1. Caterpillar stage of *Schizura rustica* and associated defoliation activity. Beginning in upper left and clockwise: defoliated *Herrania albiflora*; three fourth instar caterpillars perched on partly devoured mature leaf; fifth instar caterpillar feeding and resting on partly devoured mature leaf (bottom two photographs).

factors associated with husbandry. All adults eventually reared had been fed *T. cacao* following the time of the discovery. On *H. albiflora* in nature caterpillars were seen feeding during daylight hours, with intermittent periods of non-feeding. As typical for various notodontids, including temperate-zone *Schizura* (e.g., Packard, 1893, J. New York

Entomol. Soc. 1:22–78; Forbes, 1948, Mem. 274, Cornell Univ. Agricult. Expt. Sta.), the caterpillars of S. *rustica* are exceedingly cryptic in coloration and in the habit of positioning themselves along the damaged edge of a leaf on which they are feeding.

What follows here is a general macro-description of the final instar caterpillar. Head capsule 4.5 mm high by 4.0 mm at widest lateral area; dull light brown background with heavy speckling of tiny dark brown spots laterally. Frontally with double band of vertical dark brown lines angling towards medial line about ⅔ down head capsule. Three pairs of frontal-to-lateral black setae about ½ down head capsule and a series of three pairs of clustered setae at base of head capsule in lateral areas. Double dark brown bands of frontal area forming a rough hourglass pattern when viewed frontally. Mandibles glossy brown and entire head capsule thrust forward basally. Light brown areas of head capsule speckled with very tiny brownish flecks, much lighter than those of dark brown areas. First thoracic segment forms a conspicuous "neck" ring with vivid yellow spot dorsomedially bordered laterally in very dark brown, almost black, diffuse bands. These bands give way more laterally to light brown. The dark brown bands bordering yellow spot each contain a small cream-colored spot. Below spiracle the segment is expanded posteriorly into wedge-shaped yellow flap. This segment with five pairs of black setae: one pair arising from dorsal dark brown bands; two pairs in lateral light brown area; two pairs arising from dorsal edge of spiracles. Legs light brown. Second and third thoracic segments light green with a prominent dorsomedial stripe that tapers near the end of the abdomen. This stripe is really a composite of a central thick yellow band bordered laterally with a mottled gray and brown area which is edged in a thin dark line of brown on either side. Green areas of these and other segments bearing tiny flecks of purple. Second thoracic segment with five setae when viewed laterally. Third segment begins a conspicuous rise in the dorsal area, forming a prominence that fuses with similar configuration of first abdominal segment. Spiracles absent on second and third thoracic segments. Legs on both segments also light brown. All abdominal segments various shades of brown. First abdominal segment light brown and mottled with a lacework of small dark brown lines; dorsally with a medial prominent biforked chitonous glossy peak. This prominence is reddish brown with one stout black seta oriented upwards on each. Spiracular opening at the anterior border of this segment; ventrally all abdominal segments light green; two pairs of black setae readily visible laterally on first abdominal segment. The brownish lacework of abdominal segments 2–4 form a "saddle-like" configuration laterally; spiracles of these segments more centrally located on each side. Prolegs present on abdominal segments 3, 4, 5, and 6, and this entire region ventrally appears arched up; prolegs orange with reddish streaks. Three pairs of black setae on most abdominal segments, and most of these often arising from reddish bulbous basal structures. Abdominal background color becomes more blackish gray beginning with the third abdominal segment, developing into a broad dorsal band on the following three segments. The fifth abdominal segment bears a smaller dorsomedial prominence and continues on segments 5 and 6, forming a second "peak" along the body axis. Dorsally the posterior half of the sixth segment is white, branching out into two bands on the seventh. The eighth segment with a very small dorsal prominence, and all three prominences biforked (as described above for the first "peak"). Abdominal segment 8 with a lacework of dark brown lines as seen in first two abdominal segments, but now more reticulate over a light, reddish brown background. Spiracles ending on the eighth segment. The white dorsal area of the seventh segment, which branches laterally, abruptly ends with the eighth segment, and the dorsal area is colored with a blackish gray medial band again. This band continues on the ninth and tapers into the anal clasper. The tenth segment is orange-brown and bears two pairs of black setae laterally, while the ninth segment has three pairs. Anal clasper orange with reddish terminal area. The caterpillar grows to about 45 mm prior to pupation. The overall appearance of the caterpillar, and its habit of resting on devoured edges of leaves (Fig. 1), suggest a general strategy of crypsis, a trait presumably shared with earlier instars.

Although some temperate-zone notodontids feed almost exclusively on young, soft tissue leaves of the larval food plants, others selectively feed on mature leaves (e.g., McFarland, 1979, J. Lepid. Soc. 33: Supplement). Aggregated feeding habits in the caterpillars of some Lepidoptera, which often result in severe defoliation, are considered to be adaptations to food plant resources having very patchy distributions and therefore present in very limited supply (e.g., Tsubaki & Shiotsu, 1982, Oecologia 55:12–20; Fitzgerald & Peterson, 1983, Anim. Behav. 31:417–423). At least one temperate-zone species of *Schizura* is polyphagous (Ferguson, 1975, U.S.D.A. Tech. Bull. No. 1521) and the possibility of such a habit being shared with *S. rustica* in Costa Rica cannot be ruled out. Both monophagous and polyphagous notodontids are known from the Neotropical Region (Seitz, 1907, Macrolepidoptera of the World, Stuttgart, A. Kernan). And, aside from the recent report of the notodontid *Lirimiris meridionalis* (Schaus), there are no other published accounts of Neotropical notodontids being associated with Sterculiaceae, and the present reports add a second genus and species to our knowledge of such associations. Given the close evolutionary affinities of *Theobroma* and *Herrania* (Cuatrecasas, op. cit.), the observed interchangeability of leaves from both trees to later instars of *S. rustica* is not a surprising or unexpected finding. Yet, in nature, other factors associated with the trees may select for egg-placement by this notodontid to be primarily a response to *Herrania*, a genus whose member species have leaf configurations and general tree profiles quite different from various *Theobroma*, including *T. cacao*. Noteworthy in this context is the fact that *S. rustica* was found only on *H. albiflora*, in spite of the fact that a handful of *Herrania* trees was surrounded by thousands of *T. cacao* ("cocoa") trees in a plantation setting.

This research is a by-product of a research grant from The American Cocoa Research Institute. I thank Dr. Gustavo Enriquez and don Alfredo Paredes for local assistance at La Lola. The moth was identified by Dr. R. W. Poole of the U.S.D.A. Systematic Entomology Laboratory, and with the cooperation of Dr. Lloyd Knutson.

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FOOD-PLANTS OF THE PIERIDAE

After studying the correspondence between Messrs. Philip James DeVries and Allen M. Young (1982, J. Lepid. Soc. 36(3):299–232), it occurs to me that a general look at the food-plant preferences of the Pieridae, taken region by region, may be of interest.

AFRICA

Pseudopontiinae—No information.
Coliadini
  Catopsilia—Cassia (Caesalpiniaceae), *Sesbania* (Papilionaceae), a somewhat dubious record of *Gossypium* (Malvaceae).
  Colias—Cassia (Caesalpiniaceae), *Medicago, Phaseolus, Sesbania* (Papilionaceae), *Oxalis* (Oxalidaceae), a somewhat doubtful record of *Ricinus* (Euphorbiaceae).
  Eurema—Cassia (Caesalpiniaceae), *Hypericum* (Hypericaceae), *Acacia, Albizzia, Entada, Parkia, Dichrostachys* (Mimosaceae), *Aeschynome, Lespedeza, Sesbania* (Papilionaceae).
Euchloini
  Pinacopteryx—Boscia, Cadaba, Capparis, Maerua (Capparidaceae).
  Euchloe—Barbarea, Iberis, Sisymbrium, etc. (Cruciferae).
Pierinae
  Nepheronia—Ritcheia (Capparidaceae), *Hippocratea* (Hippocrataceae), *Cassiporrea* (Rhizophoraceae), *Azima, Salvadora* (Salvadoraceae).

Eronia—*Capparis* (Capparidaceae), *Salvadora* (Salvadoraceae).
Colotis—*Boscia, Cadaba, Capparis, Maerua, Ritchiea* (Capparidaceae) (some species eating both groups, some one only). A very dubious record of "dwarf bamboo in captivity."
Calopieris—No records.
Gideona—No records.
Belenois—*Rhus* (Anacardiaceae) (one species only), *Boscia, Capparis, Cleome, Maerua, Ritchiea* (Capparidaceae), *Brassica* (Cruciferae), *Salvadora* (Salvadoraceae), a very doubtful record of *Solanum* (Solanaceae).
Pieris—*Brassica* (Cruciferae).
Pontia—*Alyssum, Brassica, Erucastrum, Lepideum, Sisymbrium* (Cruciferae), *Caylusia, Ochradenum, Reseda* (Resedaceae), a dubious record of *Solanum* (Solanaceae).
Dixeia—*Capparis* (Capparidaceae).
Appias—*Boscia, Capparis, Maerua, Ritchiea* (Capparidaceae), *Drypetes, Phyllanthus* (Euphorbiaceae).
Mylothris—*Loranthus, Viscum* (Loranthaceae), *Osyris* (Santalaceae) (one species along with *Loranthus*), *Hevea* (Euphorbiaceae), *Theobromum* (Sterculiaceae) (one species along with *Loranthus*), one species completely anomalous on *Polygonum* (Polygonaceae).
Leptosia—*Capparis* (Capparidaceae).

ASIA (mainly India) and AUSTRALIA

Coliadini
Catopsilia—*Bauhinia, Cassia* (Caesalpiniaceae), *Butea* (Papilionaceae).
Dercas—No records.
Gonepteryx—*Rhamnus* (Rhamnaceae), *Vaccinium* (Ericaceae) (rarely).
Gandaca—No records.
Eurema—*Caesalpinia, Cassia, Delonix, Wagatea* (Caesalpiniaceae), *Indigofera, Sesbania* (Papilionaceae). Also in Australia: *Breynia, Phyllanthus* (Euphorbiaceae), *Albizzia, Leucaena, Pithecolobium* (Mimosaceae).
Colias—*Astragalus, Oxytropis, Parochetus, Trifolium* (Papilionaceae).
Euchloeini
Euchloe—Cruciferae spp.
Pierini
Leptosia—*Capparis, Crataeva* (Capparidaceae).
Aporia—*Berberis* (Berberidaceae), Prunaceae spp., Rubiaceae spp.
Delias—*Loranthus* (Loranthaceae), *Nauclea* (Rubiaceae), *Averrhoa* (Geraniaceae) (both the latter with the remark that the food-plant is more likely to be *Loranthus* growing thereon).
Cepora—*Capparis* (Capparidaceae).
Prioneris—*Capparis* (Capparidaceae).
Anapheis—*Capparis* (Capparidaceae).
Appias—*Capparis, Crataeva* (Capparidaceae), *Hemicyclia* (Euphorbiaceae).
Pontia—*Reseda* (Resedaceae), *Sinapis, Sisymbrium, Turritia* (Cruciferae).
Ixias—*Capparis* (Capparidaceae).
Colotis—*Cadaba, Capparis, Maerua* (Capparidaceae), *Azima, Salvadora* (Salvadoraceae).
Hebomoia—*Capparis, Crataeva* (Capparidaceae).
Valeria—*Capparis* (Capperidaceae).

EUROPE

Coliadini
Catopsilia—*Cassia* (Caesalpiniaceae).
Colias—*Cistus* (Cistaceae), *Vaccinium* (Ericaceae), *Astragalus, Coronilla, Medicago, Trifolium, Vicia* (Papilionaceae).
Gonepteryx—*Rhamnus* (Rhamnaceae).

Euchloeini
  Euchloe—Barbarea, Biscutella, Ineris, Sisymbrium (Cruciferae).
  Anthocharis—Biscutella, Cardamines, Sisymbrium, etc. (Cruciferae).
Pierini
  Aporia—Crataegus, Prunus, Spiraea (Rosaceae).
  Pieris—Aethionema, Alyssum, Brassica, Iberis, Sinapis, Sisymbrium (Cruciferae), *Tropaeolum* (Geraniaceae), *Reseda* (Resedaceae).
  Colotis—Capparis (Capparidaceae).
  Zegris—Sinapis (Cruciferae).
  Leptidea—Cracca, Lathyrus, Lotus, Viccia (Papilionaceae).

NORTH AMERICA (after Ehrlich & Ehrlich's "How to Know the Butterflies")

Coliadini
  Nathalis—Stellaria (Caryophyllaceae), *Bidens, Dyssodia, Tagetes* (Compositae), *Erodium* (Geraniaceae), Helenium (??).
  Colias—Vaccinium (Ericaceae), *Amorpha, Astragalus, Hedysarum, Medicago, Parosela* (Papilionaceae), *Salix* (Salicaceae).
  Kricogonia—No records.
  Eurema—Cassia (Caesalpiniaceae), perhaps *Astragalus* (Papilionaceae) and others.
  Phoebis—Cassia (Caesalpiniaceae).
Euchloeini
  Anthocharis—Arabis, Barbarea, Cardamines, Sisymbrium (Cruciferae).
  Euchloe—Arabis, Sisymbrium, etc. (Cruciferae).
Pierini
  Pieris—Dentaria, Isomeria, Stanleya, other Cruciferae and Capparidaceae.
  Ascia—Brassica, Cleome, Polanisia, other Cruciferae and Capparidaceae.
  Neophasia—Pinus (Coniferae).

Unfortunately, I have no records for South America.

Looking at the foregoing lists as a whole, a fairly coherent pattern emerges. The Coliadini are almost entirely confined to the leguminous subfamilies Papilionaceae and Caesalpiniaceae, with *Gonepteryx* confined to the Rhamnaceae. The other pierine tribes show a decided preference for plants containing mustard oil glucosides, i.e., Cruciferae, Capparidaceae and Salvadoraceae but with a few divergent groups or species; for example, *Delias* and *Mylothris* feeding mainly on Loranthaceae and *Aporia* on Rosaceae, Rubiaceae and Berberidaceae, among others. I am unable to trace any record for Lauraceae apart from Mr. Young's, and, although that does not completely preclude the family as a pierine food-plant, it makes it less likely.

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Journal of the Lepidopterists' Society
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ANTHOCHARIS LANCEOLATA (PIERIDAE) FEEDING ON A RARE ENDEMIC *STREPTANTHUS* SPECIES (CRUCIFERAE)

Anthocharis lanceolata Lucas is recorded on several species of *Arabis* (Cruciferae) in various parts of its range. On 14 July 1983 it was found infesting the rare endemic *Streptanthus howellii* Wats. about 10 km southwest of O'Brien, Josephine County, Oregon. The plants are on and adjacent to a disturbed roadside and power-line cut on a serpentine substrate and are confined to otherwise bare or nearly bare soil. Including small vegetative individuals, there are at least 100 and possibly 200 plants in the area, making this one of the largest populations of S. *howellii* known.

Streptanthus howellii is confined to dry, brushy serpentine exposures between 650 and about 1000 m in the Siskiyou Mountains of Josephine and Curry counties, Oregon and Siskiyou and Del Norte counties, California. It is apparently a short-lived perennial or, perhaps, biennial. It is a candidate species for Federal listing under the Endangered Species Act, Category 2, USFWS (Federal Register 45:82480–82569, Dec. 15, 1980). Further information and figures are available (R. J. Meinke, 1982, Threatened and Endangered Vascular Plants of Oregon, An Illustrated Guide, USFWS, Office of Endangered Species, Region 1, Portland, Ore., pp. 314–315).

At the O'Brien site most of the large plants (about 15% of the population) bore one or more larvae of A. *lanceolata*. The single largest individual seen, a much-branched specimen over 1 m tall, had seven larvae and two eggs. Many of the smaller plants bore one or two eggs, generally on buds or on the axis of the raceme, rarely on leaves. Larvae were feeding actively on buds, flowers, and green fruit, and most of the siliques on the large plants were more or less damaged. A few plants had the entire inflorescence/infructescence destroyed. Oviposition appeared to be correlated with phenophase, such that the most advanced plants bore the largest larvae; plants mostly in flower bore younger larvae and a few eggs; and plants in bud bore either eggs or nothing. No *lanceolata* were flying, and the latest plants to mature appeared likely to escape predation altogether. About a third of the eggs observed were dead, but the cause was not determined. Eight larvae were brought back for rearing; seven pupated and one produced an undetermined braconid parasitoid (Hymenoptera).

Meinke (loc. cit.) speculates that S. *howellii* may have "a poor reproductive capacity." If this is the case, seed predation by pierid larvae, perhaps not limited to A. *lanceolata*, may be an important factor in its biology. At O'Brien up to 75% of the seed crop appeared to be threatened (possibly less if the plants were able to regenerate and reproduce after the pierid feeding season) in 1983. Some other *Streptanthus* species on serpentine soils have evolved butterfly egg-mimics as an adaptation to predation-avoidance (Shapiro, 1981, Amer. Nat. 117:276–294), but S. *howellii* does not have them, and it is not known whether A. *lanceolata* engages in egg-load assessment (though its eggs are typical of species which do). If other pierid-crucifer systems are at all typical, we may expect the impact of predation on S. *howellii* to vary drastically from year to year, depending on how weather modifies the phenology of the plants and insects.

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Journal of the Lepidopterists' Society
38(3), 1984, 252–253

HACKBERRY BUTTERFLIES: DENSE SWARMS INVOLVED IN A LITIGATION IN SOUTHERN LOUISIANA (NYMPHALIDAE: *ASTEROCAMPA*)

Hackberry butterflies (Nymphalidae, genus *Asterocampa*) are common insects of the central United States, ranging from southern New England westward throughout the mid-central United States to the Gulf of Mexico. They are especially abundant in the southern states of Arkansas, Texas, Mississippi, Louisiana, Alabama and western Tennessee. In this region there are three annual broods beginning about May and extending into July, with the greatest number of insects occurring in June and July (Holland, 1947, The Butterfly Book, Rev. Ed., Doubleday and Co., Garden City, NY, 424 pp.; Klots, 1951, A Field Guide to the Butterflies of North America, East of the Great Plains, Houghton Mifflin Co., Boston, MA, 349 pp.).

In common with other nymphalids, hackberry butterflies have long been known to occur in great clusters and swarms and to migrate. Their presence in Louisiana has been well documented on several occasions (Lambremont, 1954, Tulane Stud. Zool. 1:127–164; Ross & Lambremont, 1963, J. Lepid. Soc. 7:148–158). The fact that they occur in enormous population densities in the mid-southern United States has been recorded as long ago as 1888. For example, in May of that year enormous numbers were noted in flight, and the banks of the St. Frances River in Arkansas were reported to be lined with *Asterocampa celtis* Boisduval and Leconte for a distance of over thirty miles (Webster, 1888, Holtzgang, 1888, Insect Life 1:29 cited in Williams, 1930 below). In that same year it was reported that hackberry butterflies were swarming in great numbers over the southern United States and appeared to be migrating in a southerly direction (Williams, 1930, The Migration of Butterflies, Biol. Monogr. and Manuals Nr. 9, Edinburgh, Oliver and Boyd, London, 473 pp.).

In the months of June and July of 1980 I noted a very large swarm of hackberry butterflies in East Baton Rouge Parish, Louisiana. A particularly dense cluster was observed over a period of about three weeks in the southern part of the city of Baton Rouge. Several thousand could be seen at any given time throughout any sunny day in my backyard. The insects were clustered on fig trees, feeding on the ripe fruit. Some individual figs often had five to ten butterflies resting and feeding. Many alighted on me while I spent many hours watching their behavior and abundance. Both *A. celtis* and *A. clyton* Boisduval and Leconte were identified, with *A. celtis* being far more abundant, comprising about 90% of the total swarm. The behavioral habit of hackberry butterflies alighting on people, even as they work, has been noted in the earlier literature during dense swarms of these insects (Williams, 1930, op. cit.).

About a year later I was approached by a local attorney to identify an insect that factored in litigation between a homeowner and a painting contractor in West Baton Rouge Parish, Louisiana, directly across the Mississippi River from the City of Baton Rouge. The suit by the homeowner was to recover damages and cost of correcting poor workmanship in the exterior painting of a house. Large numbers of insects were stuck in the paint, and the painting workmen stated that they could not complete their work on the date promised because of large swarms of "moths" that were alighting on them and the freshly painted surfaces.

The homeowner had taken numerous color photographs of the house including many close-up views of the insects themselves. Since several thousands of dollars were involved, I was asked to serve as an expert witness and was provided a photograph dated July 1980. The photograph revealed intact male and female specimens and many detached wings, legs, antennae, and scales of *Asterocampa celtis*. From statements made at the trial, this species was swarming in numbers even greater than I had observed in the city. Their density and swarming and their behavior pattern of alighting on people as brought out in the hearings and well documented in the scientific literature, played a mitigating role for the defendants in this case.

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Journal of the Lepidopterists' Society
38(3), 1984, 254–256

BOOK REVIEW

PHENETICS AND ECOLOGY OF HYBRIDIZATION IN BUCKEYE BUTTERFLIES (LEPIDOPTERA: NYMPHALIDAE). John E. Hafernik, Jr., University of California Publications in Entomology, Volume 96. 118 pp., 35 line drawings, 15 halftones, February 1983, $16.50, ISBN 0-520-09649-5.

This work analyzes the ecological and phenetic ordinant relationships of *Junonia* in North and Central America, exclusive of the Caribbean. Hafernik assesses competition in the field between *J. coenia, J. nigrosuffusa,* and *J. zonalis* and infers their genetic relationships. The text has 42 pages divided into five sections: Intraspecific and Interspecific Crosses; Courtship Behavior; Population Size, Vagility and Dispersion of South Texas *Junonia*; Larval Resource Partitioning; and Phenetics.

Hafernik notes that while electrophoretic assays of enzyme variability allow quantitative estimates of genetic differentiation between taxa, he prefers hybridization studies, because they illuminate hybrid fitness via egg fertilities, embryo viabilities, skews of sex ratios and progeny mortality. He investigates these relationships within *Junonia* by crossing F_1 and F_2 hybrids, and backcrossing among *J. coenia* from California and Texas, *J. nigrosuffusa* from Texas, and *J. zonalis* from Guatemala. Hybrid matings were obtained by substituting a different female in the middle of a natural courtship. Data for egg fertility, egg viability and percent of hatch were not statistically analyzed. Data on sex ratios were analyzed using chi-square to compare both individual broods and pooled values of like broods with an expected 1:1 ratio. Noncontrolled rearing environments precluded quantitative comparisons of generation times, but these data, as well as mortality estimates, emergence synchronies of the sexes, and incidences of aberrations were compared qualitatively.

Hafernik's hybridization data suggest that North and Central American *Junonia* are one polytypic species rather than a circle of races, since interpopulation genetic compatibility is high regardless of geographic distances. These findings are in contrast with other studies of papilionoids; Hafernik reviews many similar studies.

Hafernik states that *Junonia* lack complicated courtship rituals. Males rest on a bare spot on the ground and pursue suspect females pugnaciously. Visual stimuli, especially background color of the dorsal wing surfaces, appear to trigger male responses. Hafernik tested male response to females using various wing marking and obscuring techniques and also tested models and wing transplant females. Color differences limiting *coenia* and *nigrosuffusa* courtship interactions are considered unrelated to either thermoregulation or crypsis. Aposematicity was not tested (*Junonia* and *Euphydryas* share similar hosts in the Scrophulariaceae with iridoid glycosides). There is no evidence of pheromone involvement in *Junonia*, although no experimentation was carried out in this vein.

Hafernik's estimates of population dynamics and vagility for *Junonia* are based on populations at Brazos Island, Texas. Mark/recapture studies followed Ehrlich and Davidson (1960, J. Lepid. Soc. 14:227–230), with vagility analyzed between two sectors over distances of ca. 2 km using Scott's (1972, Ph.D. thesis, U. of Calif., Berkeley) technique. Jolly's (1965, Biometrika 52:225–247) method was used for estimates of population. Dispersion was analyzed using the variance mean ratio and Morisitas indices (Southwood, 1966, Ecological Methods, Methuen, London). Hafernik concludes that *coenia* and *nigrosuffusa* have similar vagility patterns with males markedly more aggregated due to mating and females more dispersive for host selection. The micro-distribution of females in the environment is different for these species, with *nigrosuffusa* using and spending more time at clumped host plants, while *coenia* spend more time in transit between unclumped hosts. Males showed similar highly contagious distributions but had little spatial overlap. Male *coenia* chose short vegetation for loitering, while *nigrosuffusa* chose taller vegetation, chiefly stands of sedges. Hafernik postulates that *coenia* males may have a competitive advantage in short vegetation, based upon sympatric interaction with male *nigrosuffusa* and upon the latter's behavior and mating area choice, in Arizona under allopatric conditions.

Studies on larval resource partitioning involved eight localities in Texas over three years and one location in Arizona. While larvae of *coenia* and *nigrosuffusa* could not be distinguished, reared adults were identified using Discriminant Function Analysis (DFA) (see below). Host palatability was tested by presentation of hosts to allopatric populations of larvae of *coenia, nigrosuffusa* and *zonalis*. Adult female oviposition preferences in cages were also noted. Hafernik's data indicate considerable host overlap in south Texas with *coenia* chiefly using *Agalinis maritima,* and *nigrosuffusa* using *Stemodia tomentosa* in the presence of *coenia* but also *A. maritima* in allopatry. *J. nigrosuffusa* shows better larval development on the latter, whereas, *coenia* is limited by the leaf pubescence of *Stemodia*. Hafernik postulates that the perennial and annual habits of *Stemodia* and *Agalinis,* respectively, may account for falling numbers of adult *coenia* in winter, while adult *nigrosuffusa* populations remain high. He speculates on the implications of this regarding hybrid introgression. *J. zonalis* from Guatemala showed more restricted host preferences than *coenia* or *nigrosuffusa,* and ovipositing females rejected the favored hosts of the latter two.

In the Phenetics section, Discriminant Function Analysis (DFA) and Principal Component Analysis (PCA) were used to demonstrate the relationships between known parental and hybrid reference groups and between reference groups versus unknowns from Mexico and Central America. Hafernik chose 25 wing characters (7 continuous, 17 coded [discrete]) for his analyses. While he states that the coded characters violate the parametric assumptions of the DFA's and PCA's, he notes: (1) a statement by Blacklith and Reyment (1971, Multivariate Morphometrics, Academic Press, New York) that DFA and PCA are "robust" enough to handle [minor] violations of normality, and (2) that the derived DFA classifications of F_1 hybrids were empirically correct (his figure 18). Traditionally, however, inclusions of nonparametric data in such analyses account for less than 20 percent of characters. In Hafernik's work, they equal 68 percent and dominate the vectors. Thus, the discriminators chosen by the DFA are specifically antagonistic to the assumptions of the analyses. This bothers me, though the DFA scatter-plots are undoubtedly plausible. Interestingly, Hafernik (p. 39) states that principal component 1 of the PCA ("unlike DF1") shows moderate to high loadings for all coded characters; this demonstrates the sensitivity of the analyses to variation differences between the continuous versus coded characters used. The use of only continuous characters for the DFA would have avoided this philosophical conflict, as would have the use of Principal Coordinate Analysis or Nonmetric Multi-dimensional Scaling instead of PCA, if coded characters were retained.

Hafernik infers genetic relationships based upon DFA and PCA results, citing empirical evidence for this conclusion *via* multivariate analysis examples of Rohwer (1972, Syst. Zool. 21:313–338), Rohwer and Kilgore (1973, Syst. Zool. 22:157–165), Jackson (1973, Evolution 27:58–68) and Thaeler (1968, Evolution 22:543–555). These authors, however, followed traditional constraints in using nonparametric data in DFA and PCA. Hafernik's apparent major deviation contracts the logical consistency employed by those he cites. Not that I doubt the probability of biological (genetic) correctness of Hafernik's results (it is hard to argue against "proven" empiricism), but rather I find the results an analytical curiosity and testament to the "robustness" of multivariate analyses. One could argue, however, that in the transparent guise of "robustness" of statistical methods, the philosophy that "the end justifies the means" is a bit too visible.

In essence, I found Hafernik's work excellent biology and very interesting reading. The text is lucid and Hafernik reviews his subjects well during discussion. Seldom is this much information produced on a subject such as hybridization unless team efforts are involved. The work leaves a hunger for the answers to those inevitable questions one can ask only when well into research. I only hope Hafernik or another population ecologist will explore the other side of this coin—the electrophoretics.

On the negative side, some of the graphics could have been improved, especially labeling on histograms and scattergrams, and as stated above, parametric variables should have been used in the phenetic analyses.

Interestingly, the text of this volume is typeset, unlike some previous University of

California Publications in Entomology serials, which were typewritten. I hope this unpredictable luck continues, since appearance alone does have implications for the quality of any series (are you listening U.C. Press?).

At $16.50, Hafernik's work is well worth its price and will be necessary for any "lep'er" who claims to be a biologist or biologist who researches leps.

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Journal of the Lepidopterists' Society
38(3), 1984, 257–258

OBITUARY

HAMILTON ALDEN TYLER (1917–1983)

Hamilton A. Tyler, a versatile scholar, died at his home in Healdsburg, California, on 14 December 1983. He was born in Fresno on 20 October 1917, the son of Hazel Tyler and John G. Tyler, the latter having been a well-known ornithologist of the Fresno area.

Tyler was known in recent years for his studies of the Papilionidae of the New World: "The Swallowtail Butterflies of North America" (1975). At the time of his death he was writing, with Paul Spade, an article on Colima swallowtails. This manuscript is being prepared for publication by Michael Parsons under the title of "Notes on the Biology of Seven Troidine Swallowtail Butterflies (Lepidoptera: Papilionidae) from the State of Colima, Mexico."

Hamilton Tyler's first entomological studies were on the Tenebrionidae, especially the beetles of the genus *Eleodes,* of which he had a large collection. As a young man, after studies at the University of California, Berkeley, and an episode as a soldier in the Spanish Civil War, he returned to the University as an English major and published papers on the poetry of Milton and Donne.

In 1955 he became interested in the Southwest and began a study that resulted in three books on Pueblo myths that were published by the University of Oklahoma in their *Civilization of the American Indian* series.

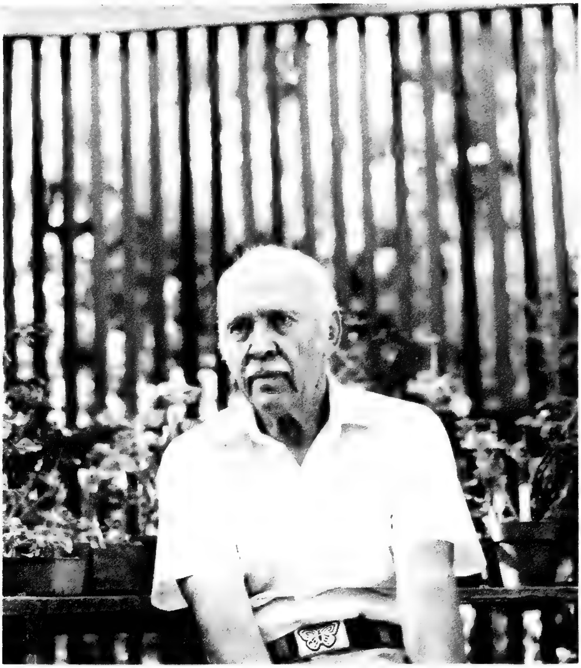
Tyler's interest in plants led to several published articles on geraniums, two books on gardening and the editorship of a quarterly international publication called "The Pelargonium Breeder."

He was also interested in birds, which led to the publication of *Owls by Day and Night* with Don Phillips in 1978. He and Phillips had also prepared, but had not yet published, a detailed manuscript on the owls of the Southwest and Mexico.

Following his death, his collection of swallowtails and reference materials pertaining was given to the University of California at Davis. Of this collection, Dr. Arthur M. Shapiro writes: "Hamilton Tyler was an extremely active amateur lepidopterist who did much to foster research on the biology and systematics of his favorite group, the Swallowtails (Papilionidae). His collection, obtained by collaboration, purchase, and exchange, represents one of the largest accumulations of this family in private hands in North America. It is most notable for containing specimens with full data of many very rare and prized entities."

Dr. Shapiro also writes: "Basically, acquisition of the Tyler collection allows scholars and researchers in the region and in general to pursue evolutionary and phylogenetic studies of this important group without having to go to the British Museum, U.S. National Museum, or Allyn Museum (Sarasota, Florida). Mr. Tyler was working on a book of the Papilionidae of the Americas at the time of his death; most of the documentation is in the collection. He knew the group well enough to be a connoisseur and to obtain the 'key' species for his work, which are likely to be critical for future workers as well."

The variety of publications by Tyler is best explained in the following statement by him: "Almost all of my books have been on topics of my own choosing and were thereby expressions of deep personal interest rather than material written to fit a publisher's demands. By good fortune on this chancy route, all completed titles have eventually reached publication despite some tortuous turns and delays. My interests have been diverse, as the varied titles indicate, and I have dug in some unusual corners but I think there is an overall logic which relates the works. My primary interest is in examining the different views men may take of the world about them, especially as these concern birds, mammals, insects, and plants, or relationships in the realm of nature. These approaches seem to fall into two great and familiar divisions which are often held to be mutually exclusive—but they are not so for me. On the one side there is the scientific attitude which distinguishes the species of bird, mammal, insect or plant, by describing its form, life history, and habitat. On the other side there are views, such as those held by the Pueblo Indians, which are more poetic. Collectively these can be called the



Hamilton Alden Tyler

mythologic approach to nature and on this side stand religions, at least until they become highly sophisticated. For me, both the mystic-poetic and the scientific outlooks illuminate man's place in nature and the cosmos and are thus equally valid. Indeed, the two views complement each other. Both aesthetics and science are needed to establish man's place, for they are the two hemispheres of the one world we all inhabit."

The following is a chronological listing of his publications:

PUBLICATION	PUBLISHER	DATE
Mr. Eliot and Mr. Milton	Circle, Berkeley	1944
Finnegan Epic	Circle, Berkeley	1946
Pueblo Gods and Myths	University of Oklahoma	1964
Organic Gardening Without Poisons	Van Nostrand Reinholt	1970
French Type of Tetraploid "Geraniums" in The Geranium Gazette Yearbook		1971
John Tyler (with John R. Arnold)	Auk, vol. 88:228–229	1971
Gourmet Gardening	Van Nostrand Reinholt	1972
Pueblo Animals and Myths	University of Oklahoma	1975
The Swallowtail Butterflies of North America	Naturegraph	1975
Owls by Day and Night (with Don Phillips)	Naturegraph	1978
Pueblo Birds and Myths	University of Oklahoma	1979

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OBITUARY

IN MEMORIAM

RICHARD FABIAN TOWNSEND (1939–1983)

Dr. Richard Fabian Townsend died 12 September 1983 in Anderson, California. He was born 8 November 1939 in Los Angeles, California and lived in the state all his life. In 1962 he married Diane Moseman of Canoga Park, California. He received an A.A. degree in pre-pharmacy from Los Angeles Valley College, then his Pharm. D. from the University of Southern California. He worked as a pharmacist for Thrifty Drugs in Redding, then was a pharmacy consultant for the state. His last employment was as a biological technician for the U.S. Forest Service, Redding.

I first met Dick in 1955 at the Lorquin Entomological Society, Los Angeles County Museum of Natural History, where so many budding professional and amateur entomologists have received enlightenment. Dick and I were especially encouraged by Mr. Lloyd Martin and Dr. Fred Truxal of that institution. We took our first extended field trip together in June 1955: eight days (without a bath!), sleeping in a pup tent, while chasing such "wonders" as *Colias eurydice, Papilio bairdii bairdii* and *Speyeria coronis semiramis* near Barton Flats in the San Bernardino Mountains of southern California. I will never forget our efforts to prevent ground squirrel maraudings into our food supply,

Dr. Richard Fabian Townsend

nor the expletive-charged argument as to who was at fault for our failure to net the only Baird's swallowtail seen! Later that summer, and again the following one, my mother sacrificed considerable time and effort to become "expedition leader" while Dick and I chased butterflies and beetles over much of Arizona. Highlights of those trips include Dick misplacing our only road map into the ice chest and his animated (to put it mildly) reaction to being stung on one of his private parts by an angry harvester ant! These are just some of the many memories we enjoyed over the years.

During succeeding years, until about 1961, Dick and I collected together and in the company of others, mostly on short trips in southern California but also as far afield as southeastern Arizona. Shortly thereafter, Dick made two extensive collecting trips to Mexico; one by bus. By this time Dick's interests tended more towards Coleoptera. He donated most, if not all, his earlier butterfly collection to the Universidad Nacional Autónoma de México, under the care of Dra. Leonila P. Vazquez G.

Dick and I enjoyed a special camaraderie during those early years of our friendship, one which decreased only spatially as we pursued disparate education and careers. During Dick's years of practicing pharmacy his interest in entomology gave way largely to such pastimes as fishing, hunting and prospecting for old bottles and other artifacts. However, during his employment with the U.S. Forest Service his "first love" was rekindled and butterflies came to be his primary objective. We kept in touch over the years and, especially during the last two, were able to renew our collecting together.

The Dick Townsend Collection will be donated to the Los Angeles County Museum of Natural History. It comprises a specialized collection of approximately 250 Lepidoptera, many of which were reared, including some excellent material in the genus *Papilio*; and 2800 Coleoptera, almost entirely in the families Buprestidae, Cerambycidae and Scarabaeidae.

Dick is survived by his lovely wife and daughters (Erin and Stacie), his mother, Erma Townsend and sister, Linda Hensley. He was my friend of longest standing. We will all miss him very much. So too will his fellow lepidopterists.

RICHARD L. WESTCOTT, *Oregon Department of Agriculture, Salem, Oregon 97310-0110.*

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Contributions to the *Journal* may deal with any aspect of the collection and study of Lepidoptera. Contributors should prepare manuscripts according to the following instructions.

Abstract: A brief abstract should precede the text of all articles.

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Literature Cited: References in the text of articles should be given as, Sheppard (1959) or (Sheppard 1959, 1961a, 1961b) and all must be listed alphabetically under the heading LITERATURE CITED, in the following format:

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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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THE LEPIDOPTERISTS' SOCIETY

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Cover illustration: Head (antennae mostly missing) of *Paranthrene tabaniformis* (Rottemburg). This drawing was prepared by George Venable, Smithsonian artist, for inclusion in the Sesiidae fascicle for the Moths of America North of Mexico. The dusky clearwing, a Holarctic species, is a borer in the exposed roots, stems and branches of willows and poplars.

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HYBRIDIZATION BETWEEN *CALLOSAMIA* AND *HYALOPHORA* (SATURNIIDAE)

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ABSTRACT. Several intergeneric crosses involving *Callosamia* and *Hyalophora* were attempted. Male and female F_1 adults were obtained from the cross *C. angulifera* ♂ × *H. cecropia* ♀. All stages were intermediate, exhibiting characteristics of both parent species. Other crosses, which did not produce adults, are discussed.

Although Ferguson (1972) restored *Callosamia* and *Hyalophora* to full generic rank, he acknowledged that they were undoubtedly closely related. In spite of this apparent close relationship I know of no natural intergeneric hybrids. The only attempts to artificially induce hybrids are those mentioned by Peigler (1978) and Collins and Weast (1961). Efforts to obtain intergeneric hybrids might produce information which would help clarify the relationship between *Callosamia* and *Hyalophora*. In this paper I describe my hybridization attempts and results. The discussion includes a comparison of these results with those of other hybridization studies involving these genera and *Samia cynthia* (Drury).

METHODS AND MATERIALS

In June 1979, using hand-pairing techniques described by Peigler (1977), a male *Callosamia angulifera* (Walker) from Boone Co., West Virginia was mated to a female *Hyalophora cecropia* (L.) from Lucas Co., Ohio. The moths were transferred to a foothold where they remained coupled for ca. three hours, after which the female oviposited freely in a paper sack.

Three additional matings of the same combination were subsequently obtained. Often, the movement of the very large females threatened to dislodge the males. This was prevented by placing the female on a flat surface and pinning paper strips over the folded wings. Pins were also placed at strategic points alongside the female's abdomen to further minimize movement. After copulation, females were placed in a common container where they oviposited freely.

Resultant larvae were reared on tuliptree (*Liriodendron tulipifera* L.). Large cloth bags (sleeves) were placed over branches with the larvae confined within.

RESULTS

The first female, which was confined separately, deposited nearly 200 ova, 33% of which hatched. Unfortunately, because the remaining three females were confined in the same container, variation in fertility could not be determined. Of the 600 ova deposited hatch was again 33%. Upon eclosion I retained 150 of the larvae and gave the remainder to Dana Gring, Toledo, Ohio. His results were similar to those described in this paper, but I have no specific data.

Most larval losses occurred in the first and second instars. Disease did not appear to be a major factor in these losses. Unidentified predacious stinkbugs (Hemiptera: Pentatomidae) pierced and killed larvae from outside the rearing sleeves. Later attacks were prevented by covering the first sleeve with a second one.

A total of 74 cocoons was obtained. Six females and 36 males emerged the following summer. The remaining cocoons contained either dead pupae or females that were unable to escape their cocoons.

A brief description of the various stages follows: First and second instar larvae appeared structurally similar to *H. cecropia*. Color became lighter with age, eventually more closely resembling *C. angulifera*. The third and fourth instars appeared much more intermediate structurally and in overall color, basically resembling the mature larva.

The fifth instar larva (Fig. 1) had the ground color blue-green. The first two pairs of thoracic scoli were deep red, bearing minute setae; the third pair was orange with yellow bases. The remaining dorsal scoli were lemon-yellow. The subdorsal and subspiracular tubercles appeared as raised points, varying in color from dark to light blue in different individuals. The yellow subspiracular stripe found on *C. angulifera* was absent.

Pupae were intermediate in size. The brown color was very close to that of *C. angulifera*. Cocoons were also intermediate in size, averaging 5.3 cm in length, with a double wall as in both parent species. Color was dark brown and uniform in all examples. Two larvae attached their cocoons to branches lengthwise as in *H. cecropia*. Two others spun weak leaf stem attachments; all remaining larvae spun unattached cocoons amongst leaves or in folds of rearing sleeves.

The adult male (Figs. 2, 3) had antennae intermediate in size with

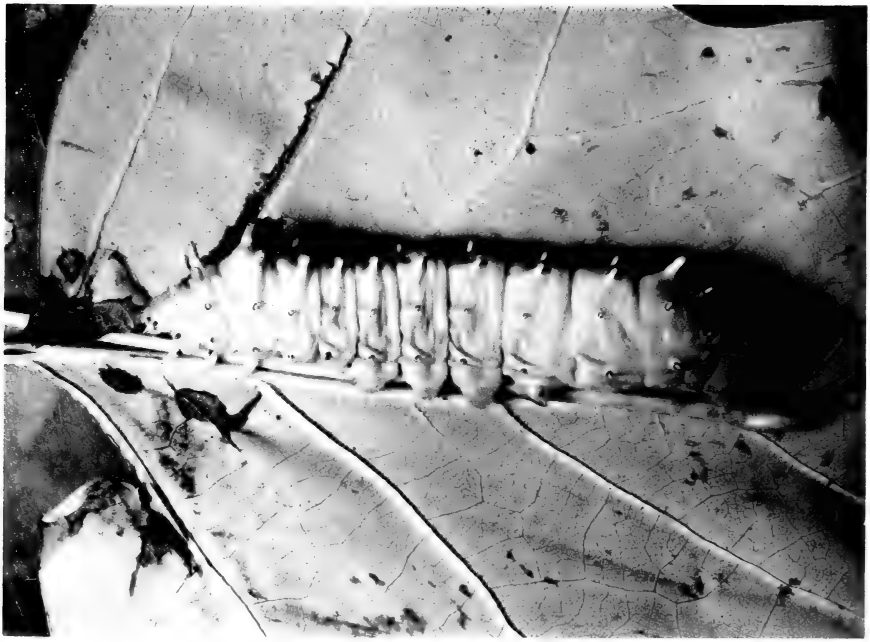

FIG. 1. Hybrid fifth instar larva from *C. angulifera* ♂ × *H. cecropia* ♀.

the medium brown coloring like *C. angulifera*. The body was dull wine-red. The prothoracic collar was usually a poorly defined gray, and a few had some white shading. White segmental rings were present on the abdomen, as in *H. cecropia*. The ground color of the wings was dark brown overlaid with a wine-red cast. Grayish suffusion was limited to the forewing costa. Antemedial lines were intermediate, more prominent than in *C. angulifera*, and sharply angled on the forewing, with an inner white shading, as in *H. cecropia*. Each discal spot had a prominent anterior tooth. The white postmedial line was shaded outwardly with purplish pink, this color being more diffuse than the sharply delineated red of *H. cecropia*. The overall coloring of the underside was red-brown inside of the postmedial line and had a pink shade outwardly; the overall aspect being reminiscent of *C. angulifera*. The underside of the hindwing had a wide white costa.

A genitalia study (Fig. 5) of three males indicated a complete development of the aedeagus which failed to exhibit a distinguishable tendency toward either parent species. In two of the specimens the valvae could best be described as shapeless due to a lack of sclerotization, which may or may not be an artifact of preparation. The remaining male possessed genitalia with an exaggerated development of

FIGS. 2–4. Adult hybrids from *C. angulifera* ♂ × *H. cecropia* ♀. **2,** male (dorsal view, **upper left**); **3,** male (ventral view, **upper right**); **4,** female (dorsal view, **lower**).

the median lobes of the valvae into long and pointed processes which are characteristic of *C. angulifera.*

Two female forms were obtained. In the first form (Fig. 4) the ground color of the body and wings was bright reddish brown, dorsal thoracic collar gray, and white segmental rings of the abdomen not as prominent as in the male. The antemedial and postmedial lines were as described for the male; the anterior tooth of each discal spot was present but not as prominent as in the male; underside was similar to the male but lighter brown in color. The second form (one specimen) was considerably larger than the others, with a ground color of light brown with no reddish cast; the anterior tooth of each discal mark was barely present, resembling *H. cecropia.* The white abdominal rings and lateral chain-like ornamentation of the abdomen was barely discernable; the pink shading of postmedial lines was very faint, nearly absent. Each female contained very few ova.

Hybridization attempts involving other combinations of species within these genera produced no adults. The cross *H. cecropia* ♂ × *C. angu-*

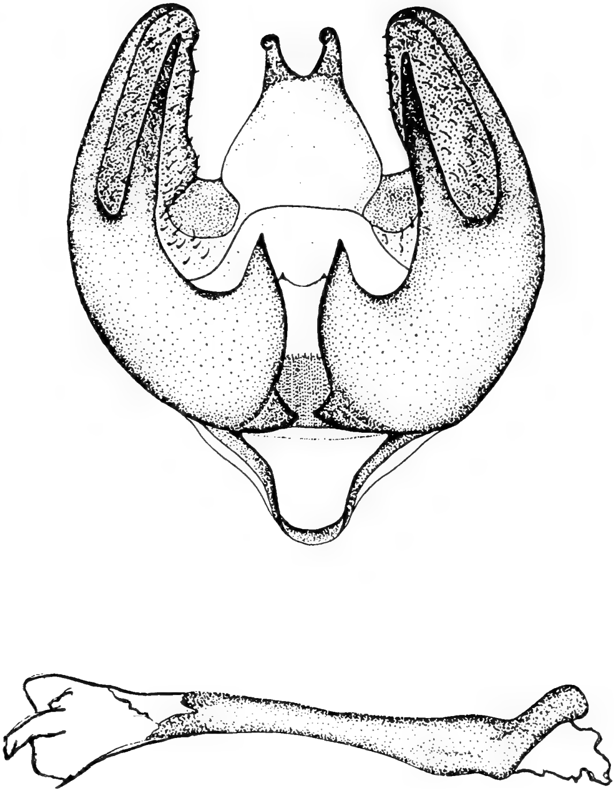

FIG. 5. Male genitalia of hybrid from *C. angulifera* ♂ × *H. cecropia* ♀.

lifera ♀ produced two larvae which resembled pure *C. angulifera*. They were very weak and did not feed, expiring after a few hours. The cross *H. cecropia* ♂ × *C. promethea* (Drury) ♀ produced one larva which fed on common chokecherry (*Prunus virginiana* L.) for three days before expiring. Ova from the reciprocal cross did not hatch.

Discussion

Hybrid males were vigorous and easily escaped their cocoons. As previously noted, the majority of females failed to emerge, apparently being too weak to do so. Cutting open cocoons to expose the pupae would probably have helped alleviate the problem. Peigler (1977) reported a similar problem with the emergence of *C. promethea* ♂ × *C. securifera* (Maassen) ♀ hybrids.

One hybrid female was observed attempting to emit pheromone around 2100 h. Her efforts were very brief and she deposited three or four infertile ova shortly afterward. Males confined in the same emergence cage did not respond to the female's calling efforts.

Several males were backcrossed to *H. cecropia* females. The males responded to the calling females during the latter's normal mating time (0430 h to 0600 h), and the pairs remained coupled until early evening. Although females oviposited freely, no eggs hatched. Jim Tuttle (pers. comm.) observed a hybrid male respond to and mate with a calling *C. angulifera* female at 2200 h. The ova did not hatch. None of the hybrid males exhibited any difficulty clasping onto females. They apparently did not possess the shapeless valvae previously described, since such a developmental failure would probably be an obstacle to successful copulation.

It is of interest to compare the results of this study with those of Peigler's (1978) *C. angulifera* ♂ × *S. cynthia* ♀ hybrid. Peigler experienced more difficulty throughout his study, as many of his larvae were lost to disease, several pupae died prior to emergence and no females were obtained.

Collins and Weast (1961) obtained larvae from the cross *H. cecropia* ♂ × *S. cynthia* ♀. They stated, "The larvae were raised to maturity on ailanthus and then lost." The author has obtained several matings with *S. cynthia* as one parent and *C. angulifera*, *C. promethea* or *H. cecropia* as the other. Results have ranged from ova that did not hatch to larvae that failed to survive beyond the first instar. The less spectacular results of hybridization studies involving *S. cynthia* lend support to the notion that *Hyalophora* and *Callosamia* are more closely related to one another than either genus is to the Asiatic *Samia*. Populations of *S. cynthia* in other faunal regions, including North America, are results of introductions by man.

As noted in the introduction, no natural hybrids between *Callosamia* and *Hyalophora* are known. The natural mating times for *Callosamia* are mid-morning for *C. securifera* (Maassen), mid-afternoon for *C. promethea* and the hours preceding midnight for *C. angulifera*. *Hyalophora* species mate in the hours immediately preceding dawn, thus, circadian mating behavior effectively eliminates intergeneric encounters.

Examples of my hybrids are in my collection, in the collection of the Ohio Historical Society, Columbus, Ohio and in the United States National Museum of Natural History.

ACKNOWLEDGMENTS

I wish to thank Jim Tuttle, Troy, Michigan, for reviewing this paper, for his drawing and written description of the male genitalia, and for the photographs of the adult moths.

Glenn Firebaugh, Toledo, Ohio, photographed the mature larva. Thanks are also due Dr. Paul Brand, Toledo, and Dr. Paul M. Tuskes, Houston, Texas, for reviewing the text and offering many helpful suggestions.

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REVISION OF THE GENUS *PARACHMA* WALKER (PYRALIDAE: CHRYSAUGINAE) OF NORTH AMERICA NORTH OF MEXICO WITH DESCRIPTION OF A NEW GENUS

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ABSTRACT. The genus *Parachma* Walker is redescribed. A lectotype is selected for *P. borregalis* Dyar, and *P. borregalis* is synonymized under *P. ochracealis* Walker. The color variation of *P. ochracealis* is discussed. A new genus, *Basacallis,* is described and *P. tarachodes* Dyar is designated the type species. Complete data and distribution maps are presented for all specimens examined.

Twelve species have been placed in the genus *Parachma* Walker. Of these, two species, *P. ochracealis* Walker and *P. borregalis* Dyar were known from the United States and listed by Barnes and McDunnough (1917). A third species, *P. tarachodes* Dyar, listed in Hodges et al. (1983), was collected in the southeastern United States but remained unidentified in many collections. The present work, based on the accumulation of more specimens and intensive studies of genitalia, venation, and head characters, has resulted in a redescription of the genus *Parachma*. *Parachma borregalis* is treated as a synonym of *P. ochracealis*. *Parachma tarachodes* is removed from this genus and is designated as the type species for a new genus, *Basacallis.*

Genus *Parachma* Walker, 1866
(Figs. 1–5, 8–11)

Parachma Walker, 1866:1263. Type species: *Parachma ochracealis,* by monotypy.
Zazaca Walker, 1866:1269. Type species: *Zazaca auratalis* (=*Parachma ochracealis* Walker), by monotypy.
Perseis Ragonot, 1891:538. Type species: *Asopia culiculalis* Hulst (=*Parachma ochracealis* Walker), by monotypy.
Artopsis Dyar, 1908:95. Type species: *Artopsis borregalis* Dyar (=*Parachma ochracealis* Walker), by original description.

Description

Head. Labial palpus sharply upturned, about one-third longer than eye diameter, second segment about twice length of first and third segments; maxillary palpus vestigial, two segmented, hidden beneath scaling; proboscis well-developed, scaled at base; frons rounded, smoothly scaled; vertex smoothly scaled; antenna filiform, about seven-tenths forewing length, two rows of scales to each segment, uniformly pilose beneath; ocellus directly behind base of antenna; chaetosema formed by row of fine setae along ocular suture laterad and posterad to the ocellus.

Thorax (Fig. 5). Forewing triangulate; Sc nearly straight, intercepting costa at about one-half length; R_1 short and arising just before anterior angle of discal cell; R_2, R_3, R_4, and R_5 stalked together; R_2, extremely short and weak, arising the same point as R_3 or short-stalked with R_3; R_4 and R_5 stalked together, M_1 separate, arising from anterior angle of discal cell; M_2 and M_3 stalked together with Cu_1; Cu_2 from below posterior of discal cell; 1A absent; 2A and 3A separate at base, anastomosed briefly a short distance from the base then divergent; retinaculum normal. Hindwing with frenulum normal; Sc and Rs anastomosed beyond the discal cell; M_1 from anterior angle of discal cell; M_2 and M_3 coincident and stalked with Cu_1, arising proximad to the posterior angle of the discal cell. Legs moderate in length; foreleg smoothly scaled; midtibia, midtarsi, hindtibia, hindtarsi with heavy scale tufts.

Abdomen. Moderately long and slender.

Male genitalia (Figs. 8, 9). Uncus moderately broad and hood-shaped, apex broadly rounded, lateral arms for articulation of gnathos relatively long; tegumen narrow dorsad; pedunculus strongly modified for articulation of gnathos; vinculum narrow ventrad, without a well-developed saccus; gnathos moderately long, not extending past apex of uncus; transtilla weak and incomplete; valva moderately developed with apex rounded, inner surface clothed with long setae directed dorsad; juxta relatively small and U-shaped; aedeagus moderately developed, cylindrical with base slightly broadened and without a caecum; vesica with microspines and two plate-like cornuti armed with a row of several spurs.

Female genitalia (Fig. 10). Ovipositor moderately short; papillae anales moderately broad with apex unilobate; anterior apophysis broad at base, longer than posterior apophysis; eighth segment relatively short; ostium bursae membranous and without a well-developed lamella postvaginalis; antrum relatively long and lightly sclerotized, constricted at inception of ductus seminalis; ductus bursae broadened and sclerotized posteriad; anterior half narrowed and membranous; corpus bursae simple and without signa.

Remarks

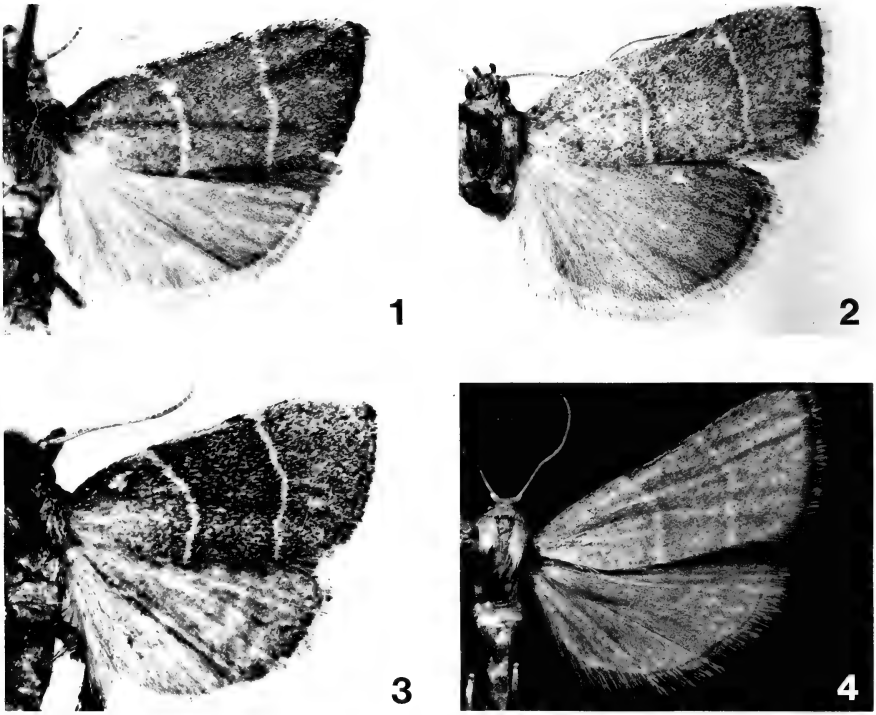
Parachma is allied to *Caphys* Walker, 1863, *Acallis* Ragonot, 1891, and *Zaboba* Dyar, 1914c, as indicated by the venation and genitalia. All four genera have the forewing M_2 and M_3 long-stalked and Cu_1 separate, but in *Parachma* Cu_1 arises from the stem of M_2 and M_3. In all four genera, forewing 2A and 3A anastomose briefly as described above. The hindwing shows a similar relationship with M_2 and M_3 coincident and stalked with Cu_1 except in *Acallis* where Cu_1 is separate or arises from the same point on the discal cell.

The male genitalia of *Parachma, Acallis, Caphys*, and *Zaboba* are similar in structure, having a simple well-developed valva, uncus, and gnathos. The uncus of *Parachma* is broad with a well-rounded apex, whereas in *Caphys* it is relatively narrow and tapered posteriad (Munroe, 1970, fig. 8). The uncus of *Zaboba* and *Acallis* is shorter than that of *Parachma* and more rounded than *Caphys*.

The female genitalia are more diverse. *Parachma* and *Acallis* have an ovipositor that is moderate in length and without a lamella postvaginalis. *Caphys* and *Zaboba* have an extended ovipositor with the lamella postvaginalis reduced to two small elongated plates.

Parachma ochracealis Walker, 1866

Parachma ochracealis Walker, 1866:1263.
Zazaca auratalis Walker, 1866:1269.
Asopia culiculalis Hulst, 1886:147.
Artopsis borregalis Dyar, 1908:95. NEW SYNONYMY.
Artopsis nua Dyar, 1914a:164.
Parachma ochracealis a culiculalis, Barnes and McDunnough, 1917:138.



FIGS. 1–4. Wing maculation of *Parachma ochracealis*: **1,** male, reddish brown form, Key Largo, FL; **2,** female, reddish brown form, St. Petersburg, FL; **3,** male, grayish brown form, Key Largo, FL; **4,** female, pale ochreous form, Alpine, TX.

Description

Alar expanse. 13 to 23 mm.

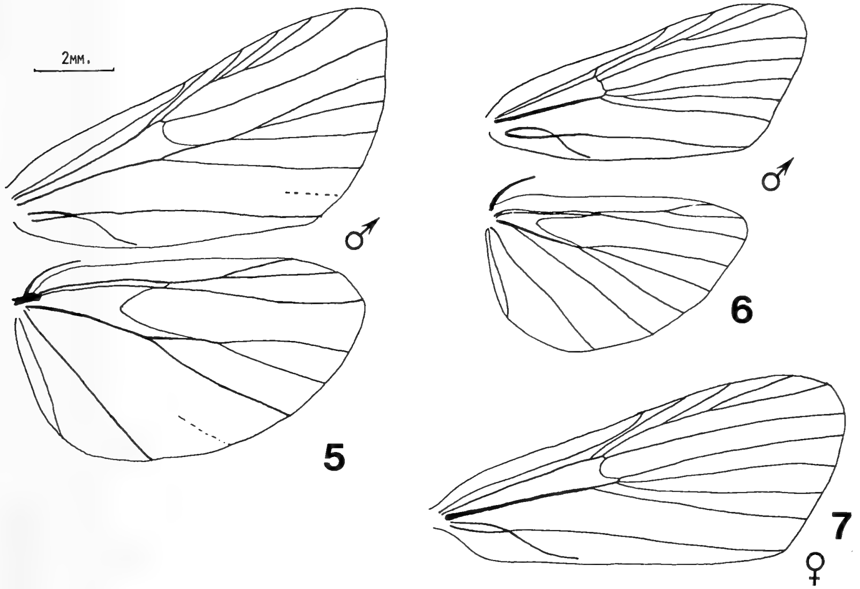
Head. Labial palpus ochreous with light to dark reddish brown laterad; frons and vertex ochreous, in darker specimens overscaled with dark reddish brown.

Thorax. Dorsum light reddish brown to dark reddish brown or ochreous-gray, ventrum dark reddish brown to grayish brown. Forewing (Figs. 1–4) ochreous to reddish brown or ochreous-gray; antemedial line ochreous, extending from one-third costa excurved to about one-third hind margin; postmedial line ochreous, extending from about two-thirds costa to two-thirds hind margin, nearly straight; terminal line reddish brown; fringe ochreous; undersurface orange-brown to reddish brown, costa darker. Hindwing light to medium orange-brown; fringe ochreous; undersurface ochreous, overscaled with reddish brown to fuscous and with an ochreous median line. Legs dark reddish brown to fuscous; midtarsi ochreous, hind tibial spurs ochreous with band of dark reddish brown.

Abdomen. Dorsum concolorous with wings, ventrum darker.

Genitalia (Figs. 8–10). As described for the genus (Figs. 8–10).

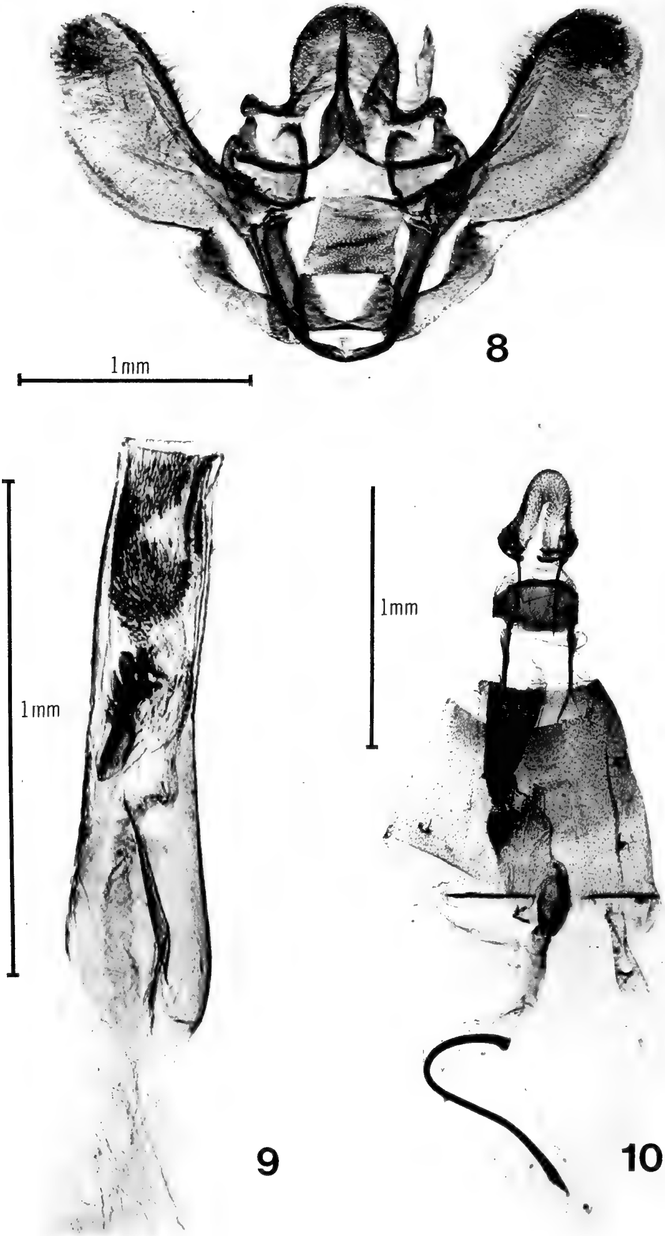
Type data. *Parachma ochracealis* Walker, holotype, male, no data, genitalia slide BM 10729, in the collection of the British Museum (Natural History); *Zazaca auratalis* Walker, holotype, female, no data, genitalia slide BM 10730, in the collection of the British Museum (Natural History); *Aspoia culiculalis* Hulst, holotype, male, Florida (no other data), in the collection of the American Museum of Natural History; *Artopsis borregalis*



FIGS. 5–7. Wing venation: **5,** male, *Parachma ochracealis*: **6,** male, *Basacallis tarachodes*; **7,** female forewing.

Dyar, four male syntypes [with identical labels], Los Borregos, Brownsville, Texas, June 5, 1905, H. S. Barber (I hereby designate one of these syntypes as the lectotype of *Artopsis borregalis* and have so labeled it), U.S. National Museum Type No. 11921; *Artopsis nua* Dyar, holotype, male, Lakeland, Florida, March 1913, C. N. Ainslie, U.S. National Museum Type No. 19081.

Specimens examined (182 males (M), 109 females (F); Fig. 11). UNITED STATES, *Arkansas:* Hempstead Co., Hope, 12-VI-1926(1F), L. Knobal (CNC). Logan Co., Mt. Magazine, Cameron Bluff, 6-VI-1964(1F), 10-VI-1964(1M), gen. sls. EDC662, 765, J. F. G. & T. M. Clarke (USNM). *Arizona:* Cochise Co., Paradise, VI(1F), gen. sl. EDC759 (USNM). Yavapai Co., Mayer, 18-VI-1959(1M), 25-VI-1959(2M), 11-VII-1959(1M), M. O. Glenn (INHS); 5 mi. N Prescott, 1-VII-1973(1F), 22-VI-1973(1F), elev. 5450 ft., L. M. Martin (LACM); 4 mi. N Prescott, 27-VI-1973(1F), 4 mi. N Prescott, Granite Dells, 4-VII-1971(1M), L. M. Martin (LACM). *Florida:* Alachua Co., 3 mi. SW Gainesville, Archer Road Lab., 8-IV-1975(2M), J. B. Heppner (JBH), u.v. light; 9 mi. NW Gainesville, 26/27-II-1975(1M), G. B. Fairchild (JBH), malaise trap; 9 mi. NW Gainesville, 5-IV-1975(1M), H. N. Greenbaum (JBH), malaise trap; Gainesville, 9-IV-1963(1M), R. P. Esser (FSCA), 13-IV-1967(1M), R. P. Esser (FSCA); 18-IV-1968(1F), F. W. Mead (FSCA); 26-VII-1967(1M), J. W. Perry (FSCA), blacklight, 3-VI-1975(1M), D. H. Habeck (JBH), DHH rearing A1383, on media; Gainesville, Pine Hills Estates, 20-VII-1969(1M), H. V. Weems, Jr. (FSCA). Brevard Co., Cocoa Beach, Cape Kennedy, 9-VII-1967(1M), R. H. Leuschner (RHL); Cocoa Beach, Cape Kennedy, 17-VII-1967(1M), R. H. Leuschner (RHL). Charlotte Co., Punta Gorda, III-1956(2M), 30-III-1941(1M), 14-IV-1956(1M,1F), 25-IV-1941(1M), 15–30-IV-1941(1F), H. Ramstadt (INHS). Clay Co., Keystone Heights, 6-III-1953(1M), H. E. Woodcock (FSCA), Lake Geneva, 16-III-1953(1M) H. E. Woodcock (FSCA). Dade Co., Florida City, 25-III-1936(1M), gen. sl. EDC743, J. G. Franclemont (CU); Homestead, 3-VII-1964(1M), 7-VII-1964(1M), 28-VII-1964(1M), 30-VII-1964(4M), 6-VIII-1964(1M), 13-VIII-1964(1M), 2-IX-1964(1M), 29-IX-1964(1F), D. O.



FIGS. 8–10. Genitalia of *Parachma ochracealis*: **8,** male, ventral view, aedeagus removed, Benton Co., MO, slide EDC 1017; **9,** aedeagus, lateral view of cornuti, Cochise Co., AZ, slide EDC 753; **10,** female, ventral view, spermatophore in corpus bursae, Benton Co., MO, slide EDC 1018.

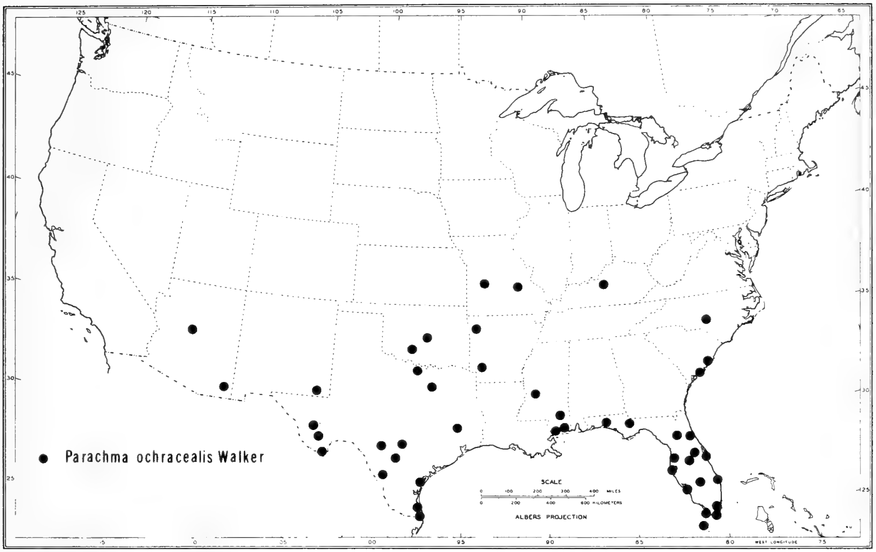


FIG. 11. Documented locality records for *Parachma ochracealis*. One dot represents more than one locality where collection sites are adjacent.

Wolfenbarger (MCZ). Hernando Co., Weeki Wachee Springs, 6-III-1955(1F), 14-III-1955(3M,1F), 20-VII-1955(1M), 29-III-1955(1M,1F), J. F. May (MCZ), 14-III-1955(1F), J. F. May (CNC), 14-III-1955(1M), J. F. May (MCZ), 14-III-1955(1F), J. F. May (CNC), 14-III-1955(1M), J. F. May (FSCA). Highlands Co., Archbold Biol. Stat., Lake Placid, 15–31-VII-1948(1M), A. B. Klotts (AMNH), Lake Placid, VII-1945(1F), gen. sl. 749, J. G. Needham (CU). Liberty Co., Torreya State Park, 1-V-1952(1M), gen. sl. EDC666, J. R. McGillis (CNC); 1-V-1952(1M), O. Peck (CNC), 1-V-1952(1M), G. S. Walley (CNC). Manatee Co., Oneco, IV(2M), IV-1954(1M,1F), 5-V-1953(2M), 14-V-1953(1M), 6-VI-1953(1M,2F), 3-VII-1953(1F), 15-VII-1953(6M), 3-VIII-1953(1F), 27-VIII-1954(1F), 15-X-1953(1M), 30-X-1954(1F), P. Dillman (MCZ,CNC,FSCA). Marion Co., 12 mi. NW Salt Springs, Lake Delany Campground, u.v. light, 12-IV-1974(1M,2F), J. B. Heppner (JBH). Martin Co., Port Sewall, 7–11-II-1950(1M), 20-III-1938(1M), J. Sanford (AMNH). Monroe Co., Big Pine Key, 4-IX-1972(1M), at u.v. light, J. B. Heppner (JBH); Key Largo, 19-I-1967(1F), 26-I-1967(2M), 1-II-1965(1M,1F), 4-II-1967(1F), 10-II-1967(2M,1F), 11-II-1968(1F), Mrs. S. Kemp (LACM), 13-II-1967(1M,1F), 14-II-1967(1M), 21-II-1966(1F), 27-II-1966(1F), 28-II-1967(1M), 11-III-1967(2M,1F), 14-III-1967(1F), Mrs. S. Kemp (MCZ), 31-III-1952(1M), G. S. Walley (CNC), 26-IV-1966(1F), 5-V-1966(1M), 12-V-1966(1F), 22-VI-1966(1M), 17-VII-1965(1F), 25-VII-1966(1M), 22-VIII-1966(1M), Mrs. S. Kemp (MCZ); No Name Key, 20-IV-1974(1M,1F), at u.v. light, J. B. Heppner (JBH); Plantation Key, 4-IV-1966(3M), in blacklight trap, Zeigler & Weems (FSCA); Tavernier, 13–16-VIII-1955(2M,3F), J. N. Todd (CNC,FSCA). Okaloosa Co., Shalimar, 11-V-1964(3M), H. O. Hilton (FSCA). Orange Co., Orlando, 31-III-1942(1M), gen. sl. EDC767, D. F. Berry (CNC); Winter Park, VII-1946(1M), A. B. Klotts (AMNH). Pasco Co., 2 mi. E Land O Lakes, 4-VII-1973(7M,6F), E. D. Cashatt (ISM), live oak forest. Pinellas Co., St. Petersburg, 12-IV-1915(1F), at light, gen. sl. EDC742, R. Ludwig (USNM); IV(1F), gen. sl. EDC110 (USNM). Polk Co., Lake Alfred, 5-VII-1928(1M,1F), gen. sl., EDC737,109, L. J. Bottimer (USNM). Putnam Co., 2 mi. S Welaka, 20-IV-1973(2F), at u.v. light, J. B. Heppner (JBH). Sarasota Co., no locality, 14-V-1946(1F), 25-V-1946(1M), C. P. Kimball (CNC,MCZ); Sarasota, 20-III-1946(1M), 26-III-1946(5M,2F), gen. sl. 744-8, 750-1, J. G.

Needham (CU), 5-VII-1951(1M), at light, H. L. King (MCZ); Siesta Key, 30-II-1966(1M), 30-III-1964(1M), 12-IV-1964(1M), 25-IV-1957(1M), C. P. Kimball (MCZ). Volusia Co., Cassadaga, 14-IV-1965(2M), 17-IV-1964(3M), 19-IV-1965(1M), 21-IV-1965(1M), 23-IV-1965(1F), 24-IV-1953(1F), 28-IV-1965(2F), 5-V-1961(1F), 6-V-1961(1F), 28-V-1962(1F), 1-VI-1962(1F), 5-VII-1964(1F), 11-VII-1953(1M), 13-VII-1953(1M), 20-VII-1953(1M), 2-VIII-1953(1M), 4-VIII-1955(1M), 7-VIII-1962(1F), 27-VIII-1962(1F), 28-VIII-1962(1F), S. V. Fuller (FSCA). Walton Co., DeFuniak Springs, 13-III-1958(1M), C. L. Dickenson (FSCA). No County Given, no date(1M,1F), P. Orange (INHS); V(1F), G. P. Hulst (AMNH); no date(3M), Acc. No. 26226, Mrs. A. J. Slosson (AMNH). *Kentucky:* Nelson Co., Leslie Farm, near Boston, 23-VI-1971(1M), G. Florence (UL). *Missouri:* Benton Co., 4 mi. NW Warsaw, 6-VI-1970(4M,1F), 9-VI-1971(2F), gen. sl. EDC1018, u.v. light; near Warsaw, 3-VI-1967(1M), 3-VI-1971(1M), 9-VI-1971(1M), gen. sl. EDC1017, J. R. Heitzman (JRH). Franklin Co., Meramac St. Park, 7-VI-1972(1F), J. R. Heitzman, old deciduous forest (JRH). *Mississippi:* Forrest Co., Hattisburg, 29-V-1966(1F), Roshore (BM), VI-1944(1M), C. D. Michener (AMNH). Handcock Co., Big Biloxi, 12-V-1972(1M), 13-V-1973(1F), 15-V-1971(1M), 20-V-1972(1M), Kergosien (BM). Harrison Co., Bay St. Louis, 1-VI-1978(2F), 2-VI-1971(1M), 3-VI-1971(1M), 4-VI-1979(1M,1F), 15-VI-1971(1M), 27-VI-1979(1M), 4-VII-1979(1F), 13-VII-1979(1M), 8-VIII-1971(1M), Kergosien (BM); Handsboro, 30-IV-1967(1M), Taylor (BM); Pass Christian, 1-VI-1979(2M), 25-VI-1979(1M), Kergosien (BM). Hinds Co., Clinton, 7-VI-1959(1M), 20-VI-1980(1F), B. Mather (BM), 15-VI-1979(1F), Hartfield (BM). Jackson Co., Biloxi, 24-V-1964(1M), Taylor (BM), Ocean Springs, 27-V-1960(1M), 28-V-1960(1M), 30-VIII-1960(1F), K. Dawson (BM), 5-IX-1960(1M), gen. sl. EDC769, 9-IX-1960(1M), 17-IX-1960(1M), gen. sl. EDC768, K. Dawson (CNC). *North Carolina:* Moore Co., Southern Pines, 8-VI-1915(1F), gen. sl. EDC760 (USNM). *New Mexico:* Eddy Co., Whites City, 15-V-1950(1F), E. C. Johnson (CNC). *Oklahoma:* Cleveland Co., Norman, 22-V-1949(1F), W. J. Reinthal (CNC). Comanche Co., Wichita Mts., 6-V-1950(3M), 26-V-1950(1M), W. J. Reinthal (CNC). *South Carolina:* Charleston Co., 7 mi. NE McClellanville, Wedge Plantation, 6-VII-1973(2M,1F), E. D. Cashatt (ISM). *Texas:* Blanco Co., no locality, VIII(1F), G. D. Hulst (AMNH). Brewster Co., Alpine, 22-V-1950(2F), E. C. Johnston (CNC); Big Bend, 15-30-VII-1926(1M), O. C. Poling (CNC). Cameron Co., Brownsville, 20-III-1908(1M), at light, no collector (USNM), 23-VIII-1931(1M), gen. sl. EDC734, T. N. Freeman (CNC), 7-XI(1M), gen. sl. EDC755 (USNM); San Benito, 8-VII-1915(1M), gen. sl. EDC732 (USNM), 16-VII-1923(2F), gen. sl. EDC101 (USNM). Dallas Co., Irving, 2-V(1F), no collector (FSCA). Jeff Davis Co., Fort Davis, 20-V-1950(1M), E. C. Johnston (CNC); Limpia Canyon, 20-V-1950(6M), E. C. Johnston (CNC). Montague Co., no locality, 10-V-1941(1M), L. H. Bridwell (CNC). Nueces Co., Corpus Christi, 8-V-1943(1M), gen. sl. EDC735, W. M. Gordon (USNM), VII-1943(1M), at light, W. M. Gordon (CU). Walker Co., Stubblefield Lake, 12-V-1977(1M), u.v. light, Peigler & Brown (USNM). Zavalla Co., Nueces River, 28-IV-1910(1M), gen. sl. EDC102, F. C. Pratt (USNM). No County Given: X(1F), F. G. Schaup, gen. sl. EDC757 (USNM); IV(1M,1F), G. D. Hulst (AMNH); V(1M), G. D. Hulst (AMNH); VII(1F), G. D. Hulst (AMNH); VIII(1M), G. D. Hulst (AMNH); no date(1M,6F), no collector (INHS).

Life history. Dr. Dale H. Habeck, University of Florida, has reared larvae on a slightly modified Shorey and Hale (1965) pinto bean medium. The natural food habits and larval habits are unknown.

Remarks

The synonymy is a result of the wide range of color variation and size. The moths at hand indicate a clinal color relationship between the western and the southeastern specimens. Specimens from the warmer and more humid areas in Mississippi, Texas, and Florida are darker and more reddish. The lighter colored and larger moths were collected from Arizona, New Mexico, and western Texas (Fig. 4). Some smaller specimens taken on the Gulf Coast are grayish brown (Fig. 3) and were described as *Artopsis borregalis,* a separate genus and species by Dyar (1908). The reddish form (Figs. 1, 2) was named *culiculalis* by Hulst (1886) and *Artopsis nua* by Dyar (1914a). One specimen from southern Florida has an ochreous forewing with a dark reddish brown median band. A few specimens exhibit variation in the arching and distance between the antemedial and postmedial lines. On examining a large series of specimens, I discovered a gradation of all of these characters. As Kimball (1965) so aptly stated, "There is no question about the variation in color, as well as size, but it is difficult, if impossible, to fit specimens into the named forms." I have examined all type specimens and have studied the genitalia. There are no apparent morphological differences between the ochreous, reddish brown, and grayish brown forms.

This species comes in readily to a blacklight at night. The resting posture is distinctive, as for most of the Chrysauginae. The wings are positioned somewhat parallel to the substrate, not held roof-like over the abdomen. The legs are held at right angles from the body, displaying the heavy scale tufts on the mid and hindtibia.

Genus ***Basacallis*** Cashatt, NEW GENUS
(Figs. 6, 7, 10–17)

Type species: *Parachma tarăchodes* Dyar, 1914b.

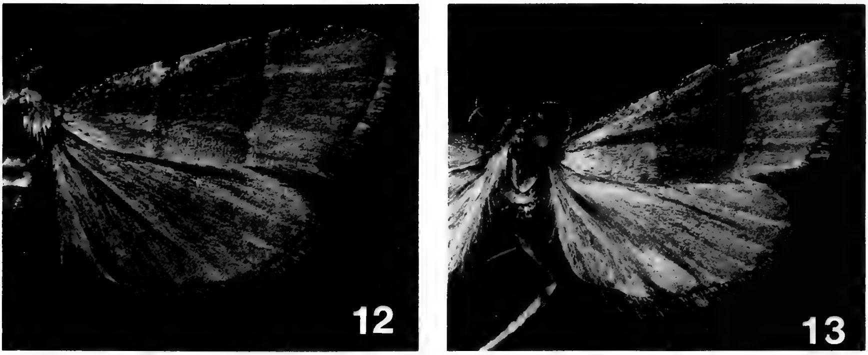
Description

Head. Labial palpus curved upward, about one-fourth longer than eye diameter, first and third segments subequal in length, second about one-third longer; maxillary palpus vestigial, hidden beneath scaling; proboscis well-developed; frons rounded and smoothly scaled; vertex roughly scaled; antenna filiform, about seven-tenths length of forewing, each segment with two rows of scales, uniformly pilose beneath; ocellus posteriad to antenna base, chaetosema formed by a row of fine setae along ocular suture posteriad to ocellus.

Thorax (Figs. 6, 7). Forewing long, relatively narrow and triangulate; Sc long; R_1 intercepts Sc in male, separate in female; R_3 and R_4 coincident and stalked with R_5; male discal cell about one-third wing length, female discal cell about one-half wing length; M_1 separate, arising from anterior angle of discal cell; M_2, M_3, Cu_1, and Cu_2 all separate and arising from posterior angle of discal cell in male, Cu_2 arising proximad to posterior angle in female; 2A and 3A separate at base, briefly anastomosed a short distance from base; retinaculum normal. Hind wing with frenulum normal; Sc and Rs anastomosed beyond discal cell; discal cell extremely short with posterior angle long; M_2 coincident with M_3 and arising from the posterior angle of the discal cell; Cu_1 and Cu_2 separate. Legs moderately long; midtibia with two scale tufts.

Abdomen. Moderately long with no lateral scale tufts.

Male genitalia (Figs. 14, 15). Uncus relatively short, tapered posteriad, lateral arms strongly modified for articulation with gnathos; tegumen narrow dorsad; pedunculus strongly modified for articulation with gnathos; vinculum moderately broad; gnathos long, slender and aculeate with apex hooked dorsad; valva moderately long and wide with tip curved mediad, sacculus slightly expanded, transtilla weak; juxta narrower at base; aedeagus long and slender, distal one-third bent ventrad.



FIGS. 12, 13. Wing maculation of *Basacallis tarachodes*: **12,** male; **13,** female; both from Pensacola, FL.

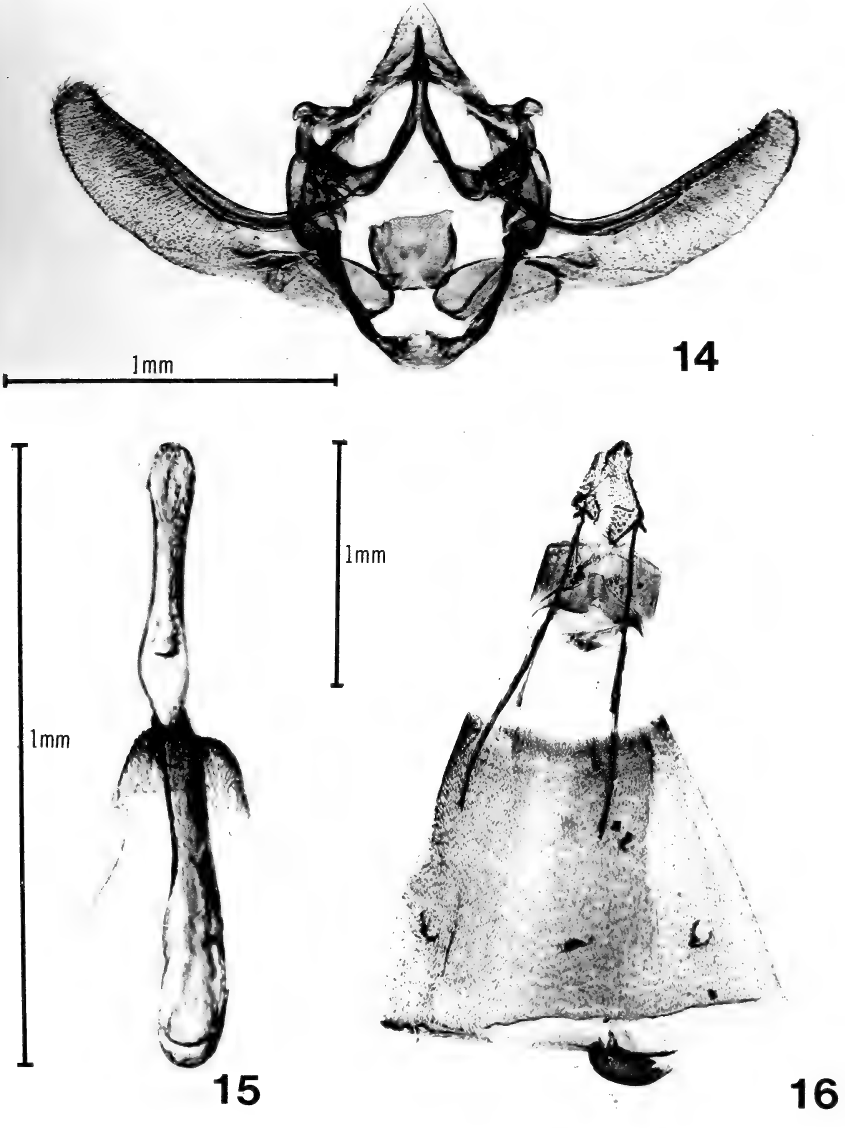
Female genitalia (Fig. 16). Ovipositor relatively short; apex of papillae anales unilobate; anterior and posterior apophysis slender and moderately long, approximately the same length; lamella postvaginalis triangulate with anterior margin cleft; ostium bursae relatively small and membranous; ductus bursae extremely slender.

Remarks

The type species of *Basacallis, tarachodes* Dyar, is not congeneric with *P. ochracealis*, but belongs in a separate genus allied to *Humiphila* Becker (1974), a genus described for a saprophagus species (*H. paleolivacea* Becker) in Costa Rica. The male and female genitalia show relatively close relationships between *H. paleolivacea* and *B. tarachodes* in the gross morphology. In particular, the aedeagus (Fig. 15) is acutely bent in these two species.

Of the North American fauna *Basacallis* shows the closest natural relationships with *Caphys* and *Acallis*. Hindwing M_2 and M_3 are coincident and the discal cell is reduced. Vein $M_2 + M_3$, and Cu_1 are short-stalked or arise separately from the posterior angle of the discal cell as in *Caphys* and *Acallis*. *Basacallis* is distinguished from the related genera by forewing M_1 and M_2 arising separately and not stalked as in *Caphys* and *Acallis*. The male genitalia more closely resemble *Acallis* except for the acutely bent aedeagus. The bursa copulatrix is relatively slender and delicate in *Acallis* and *Basacallis* except for the sclerotization of the ductus bursae just below the inception of the ductus seminalis. I have found the structure of the bursa copulatrix to be extremely delicate and difficult to dissect and interpret.

The name *Basacallis* is feminine in gender and formed by combining the Greek word for foundation and the genus name *Acallis* (*Bas* + *acallis*).



FIGS. 14–16. Genitalia of *Basacallis tarachodes*: **14,** male, ventral view, aedeagus removed; **15,** aedeagus, slide EDC 872; **16,** female, ventral view, slide EDC 873; all from Pensacola, FL.

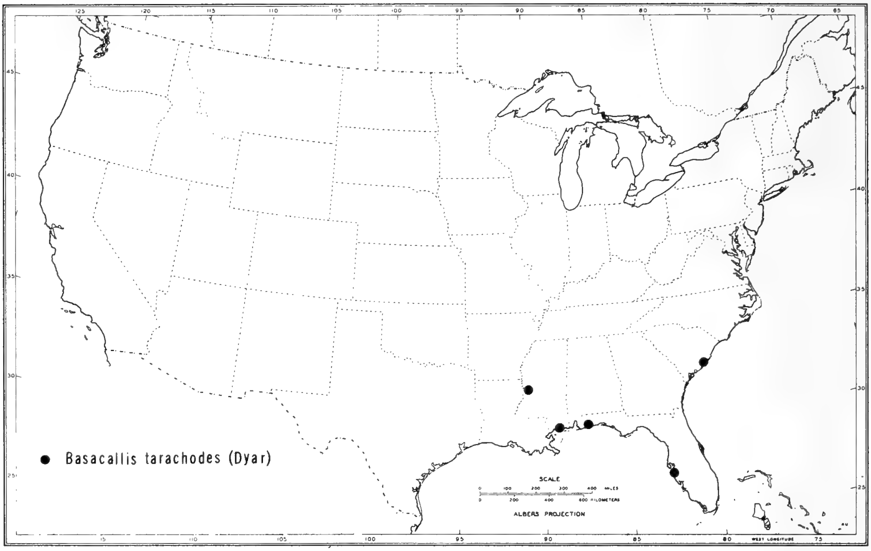


FIG. 17. Documented locality records for *Basacallis tarachodes*. One dot represents more than one locality where collection sites are adjacent.

Basacallis tarachodes (Dyar), NEW COMBINATION

Parachma tarachodes Dyar, 1914b:306.

Description

Alar expanse. 16 to 23 mm.

Head. Labial palpus gray, brownish laterad; frons, vertex, and antenna gray.

Thorax. Dorsum gray, ventrum reddish-brown. Forewing (Figs. 12, 13) light gray, with darker gray median band across middle one-third, antemedial and postmedial nearly straight and distinct in male, more diffuse and slightly excurved in female; terminal line fuscous; fringe reddish to purplish brown, sometimes invading distal portions and fading proximad; underside purplish red with short fuscous antemedial and postmedial lines from the costa. Hindwing grayish white with outer margin purplish, fading proximad, terminal line fuscous; fringe ochreous with base reddish brown; females darker, underside reddish to purplish brown with an ochreous median band. Legs reddish brown to fuscous, scale tufts fuscous, midtarsi ochreous; hindtibia and tarsi ochreous overscaled with fuscous.

Abdomen. Dorsum ochreous-gray, ventrum light reddish brown.

Genitalia (Figs. 14–16). As described for the genus.

Type data. Holotype, female, Portobelo, Panama, April 1912, genitalia slide EDC878, Type No. 16297, in the U.S. National Museum.

Material examined (8 males (M), 6 females (F); Fig. 17). UNITED STATES, *Florida:* Escambia Co., Pensacola, III-1961(1M), 12-IV-1962(1F), 19-IV-1961(1M), 20-IV-1961(1M), gen. & wing sl. EDC872, 20-VIII-1961(1F), gen. & wing sl. EDC873, S. Hills (MCZ). Manatee Co., Oneco, IV-1954(1M), 14-V-1953(1F), V-1954(1F), gen. sl. EDC878, P. Dillman (CNC). *Mississippi:* Harrison Co., Handsboro, 16-IV-1966(1M), Taylor (BM). Warren Co., Bovina, 14-IV-1972(1M), 26-VII-1976(1M), 21-IX-1972(1M); Vicksburg, 3-IX-

1981(1F), 20-IX-1978(1F), B. Mather (BM). *South Carolina:* Charleston Co., McClellanville, Wedge Plantation, 3-V-1973(1M), at light, R. B. Dominick (RBD).

Life history. Unknown.

Remarks

Unrecognized in many collections, this species was referred to in Kimball (1965) as, "5801,3 [X.] SP. — either *Xantippe, Parachma,* or a closely related genus." Of the few specimens examined, the size and maculation varies considerably between males and females. The alar expanse ranges from 16 to 18 mm in males and 19 to 23 mm in females. The forewing median band is sharply defined by distinct antemedial and postmedial lines in the male. In females the antemedial and postmedial lines are less distinct and the median band is darker than that of the male.

ACKNOWLEDGMENTS

I am grateful to the following persons and/or institutions for their patience, assistance and the loan of their specimens, without which this study would not have been possible: American Museum of Natural History (AMNH); British Museum (Natural History), Bryant Mather (BM); Canadian National Collection (CNC); Cornell University (CU); Charles V. Covell, Jr., Dale H. Habeck, Florida State Collection of Arthropods (FSCA); Illinois Natural History Survey (INHS); Illinois State Museum (ISM); John B. Heppner (JBH); J. R. Heitzman (JRH); Museum of Comparative Zoology (MCZ); Richard B. Dominick (RBD); Ronald H. Leushner (RHL); University of Louisville (UL); United States National Museum (USNM). Genitalia photographs were taken by Scott Kilborne, Southern Illinois University Medical School. Thanks go to James R. Purdue, my associate, for his assistance with the word processor and to George L. Godfrey, Illinois Natural History Survey, for his review of the manuscript.

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THE BIOLOGY AND DISTRIBUTION OF CALIFORNIA HEMILEUCINAE (SATURNIIDAE)

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ABSTRACT. The distribution, biology, and larval host plants for the 14 species and subspecies of California Hemileucinae are discussed in detail. In addition, the immature stages of *Hemileuca neumogeni* and *Coloradia velda* are described for the first time. The relationships among the *Hemileuca* are examined with respect to six species groups, based on adult and larval characters, host plant relationships and pheromone interactions. The *tricolor, eglanterina,* and *nevadensis* groups are more distinctive than the *electra, burnsi,* or *diana* groups, but all are closely related. Species groups are used to exemplify evolutionary trends within this large but cohesive genus.

The saturniid fauna of the western United States is dominated by moths of the tribe Hemileucinae. Three genera in this tribe commonly occur north of Mexico: *Hemileuca, Coloradia,* and *Automeris.* Although no *Automeris* are native to California about 50% of the *Hemileuca* and *Coloradia* species in the United States occur in the state. The absence of *Automeris* and other species from California is due to the state's effective isolation from southern Arizona and mainland Mexico by harsh mountains, deserts, the Gulf of California, and climatic differences. The *Hemileuca* of northern Arizona, Nevada, and Utah are very similar to that of California, while those of Oregon, Washington, and Idaho represent subsets of the northern California fauna.

The majority of the saturniid species in the United States have had little or no impact on man, but some Hemileucinae have been of economic importance. In California, the larvae and pupae of *Coloradia pandora* have been utilized by indians as a food source (Aldrich, 1911, 1921). Other species, especially in the genera *Automeris, Hemileuca* and *Saturnia* have urticating spines which can inflict a painful sting; the resulting welt can persist for days. Larvae of the range caterpillar, *Hemileuca oliviae,* have often reached pest status by damaging range grasses utilized by cattle in Oklahoma and Texas (Ainslie, 1910; Watts & Everett, 1976; Huddleston et al., 1976; Coleman, 1982). The larvae of *Coloradia pandora* undergo periodic outbreaks at which time the larvae have damaged or defoliated large stands of pines (Chamberlin, 1922; Patterson, 1929; Wygant, 1941). In California, *pandora* reaches the status of a pest about once every 30 years. Other species have been nuisances locally on crops or ornamentals but have never consistently been abundant or caused economic losses.

In the last 30 years there have been two major publications dealing with the Saturniidae of the United States. In his work on the Saturniidae of the Western Hemisphere Michener (1952) dealt with the morphology, phylogeny, and classification of the group. Ferguson (1971, 1972) authored a two part series on the Saturniidae of the United States and Canada and illustrated in color most of the species, presented line drawings of the male genitalia, and summarized their biology. Ferguson's work condensed most of the available information on the saturniid fauna north of Mexico. It became clear that relatively little was known about the distribution, biology, and immature stages of many western species, particularly in the tribe Hemileucinae. The purpose of this paper is to discuss the Hemileucinae of California and to present new information regarding their biology, distribution, and immature stages.

Unless specifically indicated, diagnostic information on adults or immature stages is not intended as redescriptions but merely to help the reader recognize the uniqueness of each taxon. Distribution records are based on a review of specimens in the collections of: The University of California at Berkeley, Davis, and Riverside; California State Universities at San Diego, San Jose, Fresno, and Humboldt; Natural History Museums of San Diego, Los Angeles, and Santa Barbara as well as the collection at the California Academy of Science, San Francisco; the private collections of Steve McElfresh, Ken Hansen, John Johnson, Mike Collins, Sterling Mattoon and the author. In addition the author has traveled and collected extensively in this area and has reared all of the species occurring in the western states. Information on flight period is based on observation and capture records for wild specimens in collections; emergence dates from specimens which were obviously reared were excluded, as was distribution data on mislabeled specimens. Distribution maps are provided to show trends, and in most cases the maps should be considered as a conservative estimate (Fig. 5).

Genus *Hemileuca* Walker

Hemileuca are medium to large moths with wingspans ranging from 3 to 9 cm. Moths in this genus include nocturnal and diurnal species and occur from desert to alpine habitat. Although some species are widely distributed with ranges from Mexico to Canada, the majority are restricted to Arizona, California, Nevada, Texas, and Mexico. Eight species of *Hemileuca* occur in California representing four of the six species groups. Michener (1952) recognized four subgenera and treated *Pseudohazis* as a junior synonym of *Hemileuca* based on adult morphology. Ferguson (1971) and Tuskes (1978) presented additional information which supports the merger of *Pseudohazis* and *Hemileuca*. *Hemileuca chinatiensis* (Tinkham) and *H. griffini* Tuskes (Fig. 2m) have genitalia, wing shapes, wingspans, sexual dimorphism and larval characters which place them at a transitional point between *Hemileuca*

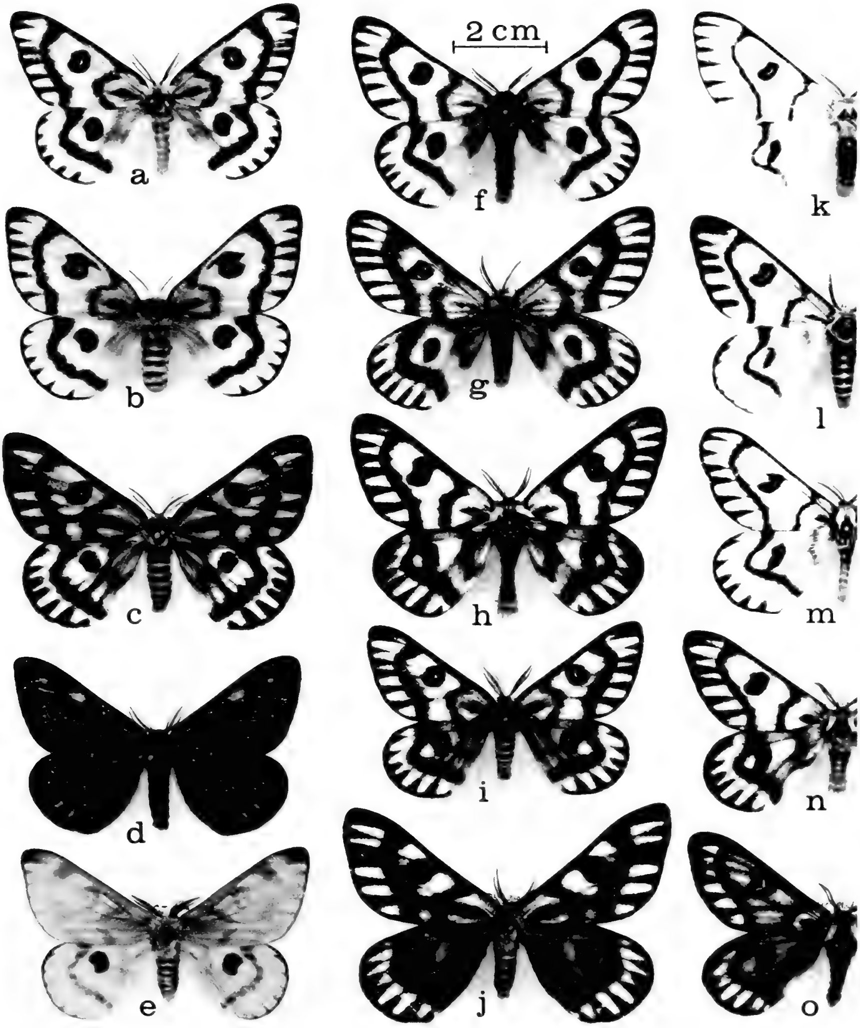

FIG. 1. *Hemileuca* of California. **a & b.** *H. eglanterina eglanterina,* ♂ & ♀; **c & d,** *H. eglanterina shastaensis*; **e,** *H. eglanterina eglanterina* form denudata; **f & g,** *H. nuttalli uniformis*; **h,** *H. hera hera*; **i,** *H. eglanterina annulata*; **j,** *H. eglanterina annulata,* Elko Co., Nevada; **k,** *H. hera marcata,* Klam. Co., Oregon; **l & o,** *H. hera hera,* Modoc Co., Calif.

and *Pseudohazis* (Table 1). Within the genus there are six distinct species groups which are based on male genitalia, wing pattern, external adult morphology, behavior, larval morphology, and larval host plant preferences at the family level (Table 1).

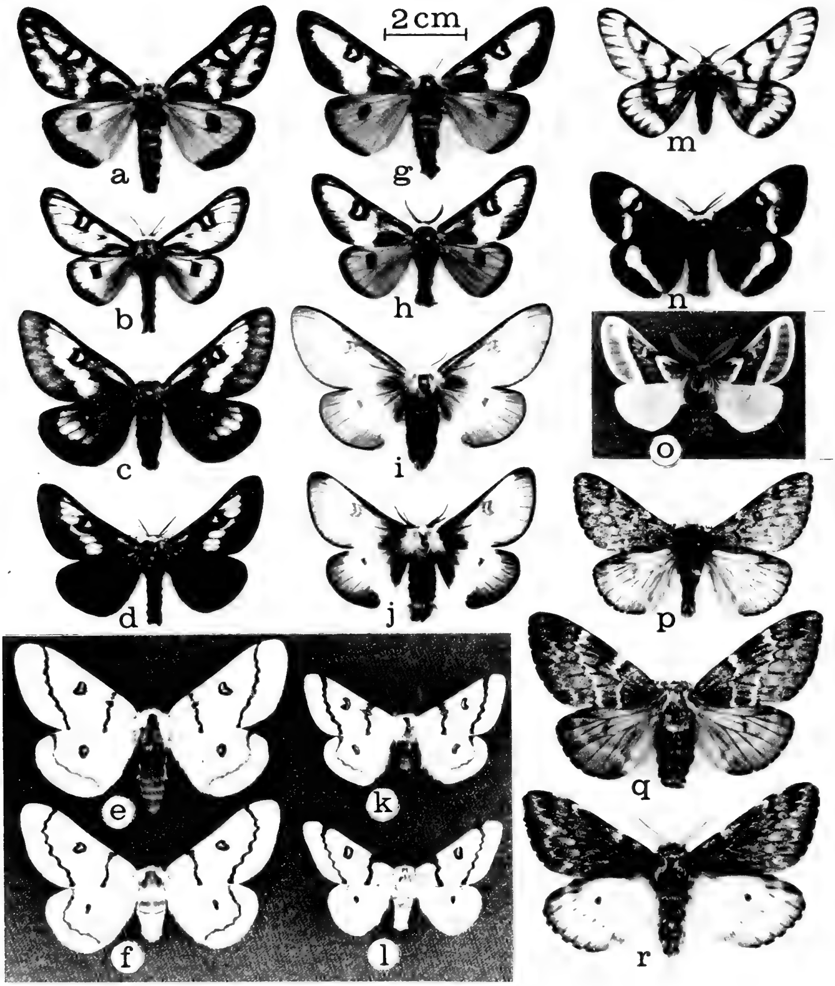

FIG. 2. *Hemileuca* and *Coloradia* of California. **a,** *H. electra electra* ♀; **b,** *H. electra electra* ♂; **c,** *H. juno* ♀; **d,** *H. juno* ♂; **e,** *H. neumoegeni* ♀; **f,** *H. burnsi* ♀; **g,** *H. electra clio* ♀; **h,** *H. electra clio* ♂; **i,** *H. nevadensis* ♀; **j,** *H. nevadensis* ♂; **k,** *H. neumoegeni* ♂; **l,** *H. burnsi* ♂; **m,** *H. griffini* ♂, Az.; **n,** *H. diana* ♂, Az.; **o,** *H. tricolor* ♂, Az.; **p,** *C. velda* ♂; **q,** *C. velda* ♀; **r,** *C. pandora lindseyi* ♂. *Hemileuca griffini*, *H. diana*, and *H. tricolor* do not occur in California but were included as representatives of species groups or transitional taxa discussed in the text; the latter three species are from Arizona.

Pheromone attraction tests show positive interaction between many species groups (Table 2). For example, female *electra* will attract and mate with males of *burnsi*, *diana*, and *eglanterina* as well as all *eglanterina* subspecies. Females of *nevadensis*, which are superficially sim-

TABLE 1. Relationships among the *Hemileuca* of the United States.

Male genitalia grouping*	Primary hostplant	Time of oviposition	♀ much larger than ♂	Larval paniculum concolor	Pupation in soil/leaf litter
electra group					
electra	Polygonaceae	day/night	yes	no	yes
juno	Leguminosae	day/night	yes	no	yes
burnsi group					
burnsi	Compositae/Rosaceae	night	yes	no	yes
neumoegeni	Rosaceae/Anarcadiaceae	night	yes	no	yes
diana group					
diana	Fagaceae	day	yes	no	yes
grotei	Fagaceae	day	yes	no	yes
maia group					
nevadensis	Salicaceae	day	yes	no	yes
maia	Fagaceae/Salicaceae	day	yes	no	yes
lucina	Rosaceae	day	yes	no	yes
eglanterina group					
eglanterina	Rosaceae/Salicaceae/Celastraceae	day	no	yes	yes
nuttalli	Caprifoliaceae/Rosaceae	day	no	yes	yes
hera	Compositae	day	no	yes	yes
griffini	Rosaceae	day	some	some	yes
chinatiensis	Leguminosae	day	yes	no	yes
tricolor group					
tricolor	Leguminosae	night	yes	no	no
oliviae	Gramineae	night	yes	no	no
hualapai	Gramineae	night	yes	no	no

* Wing pattern grouping is the same.

ilar to those of the *diana* group, will not attract either *diana* or *grotei* males. Based on Tables 1 and 2, the *tricolor*, *eglanterina* and *nevadensis* groups are the most distinctive, and any further revision which might reestablish *Pseudohazis* to generic status would have to recognize the *tricolor* and perhaps the *nevadensis* groups as unique. Such splitting would accomplish little, and hide the morphological, biological, and behavioral relationships which they share. Much needs to be learned about the Mexican species before the status of the entire group can be dealt with properly. Presently the *Hemileuca* appear to be a rather cohesive group containing distinctive but closely related assemblages of species.

Biology of *Hemileuca*

Adult moths emerge from their pupation site in the soil or leaf litter during the morning and climb shrubs or grasses prior to wing expan-

TABLE 2. Intrageneric attraction and mating between 11 western species of *Hemileuca*. Unless otherwise indicated tests were made with caged females and wild males in the field.

Calling female	Male tested	Results At./Ma.	Calling female	Male tested	Results At./Ma.
burnsi	*electra*	no*	*electra*	*eglanterina annulata*	yes
chinatiensis	*diana*	no*	*electra*	*eglanterina shastaensis*	yes
chinatiensis	*eglanterina*	no	*electra*	*hera*	no
chinatiensis	*nevadensis*	no*	*electra*	*nuttalli*	no/yes*
chinatiensis	*eglanterina shastaensis*	no	*electra*	*burnsi*	yes
diana	*nevadensis*	no*	*electra*	*diana*	yes
diana	*grotei*	yes	*electra*	*electra clio*	yes
diana	*juno*	no?	*hera*	*eglanterina*	no
eglanterina	*nuttalli*	yes	*hera*	*nuttalli*	no
eglanterina	*hera*	no	*juno*	*diana*	yes
eglanterina	*eglanterina shastaensis*	yes	*nevadensis*	*grotei*	no
eglanterina	*eglanterina annulata*	yes	*nevadensis*	*lucina*	yes*
eglanterina	*nevadensis*	no*	*nuttalli*	*hera*	no
electra	*eglanterina*	yes	*nuttalli*	*eglanterina*	no/yes*

At./Ma. = attraction and mating.
* = male reared and caged with female.

sion. Newly emerged females release pheromones that may attract dozens of males to their location within a few minutes. Usually females begin to emit pheromones after their wings have expanded. Mating requires 20 minutes to an hour, during which time the pair remain almost motionless. In captivity, male *eglanterina* have mated consecutively with three females, each of which produced fertile ova.

Shortly after mating the female deposits ova in a ring (Fig. 3k) around the branch she is perched on (if it is the host plant) or may fly for a short period of time prior to oviposition. After the first egg ring is completed she frequently flies for five to 15 minutes and then deposits a second egg ring which usually contains fewer eggs than the first. Depending on the species, eight to over 300 ova may be deposited in a ring. Oviposition generally occurs on stems 2 to 8 mm in diameter. Although females of our western species usually mate only once, in certain populations of *H. maia* the female may mate again after depositing the first egg ring.

The majority of eggs in any given ring usually hatch within two days of each other. Early instar larvae are black, but as they mature, species specific color patterns develop. Since many of the western species hatch between December and April, the dark coloration and their gregarious nature may play an important role in their thermoregulation (Fig. 3l). Larval phenotypes of *eglanterina, nuttalli, griffini,* and

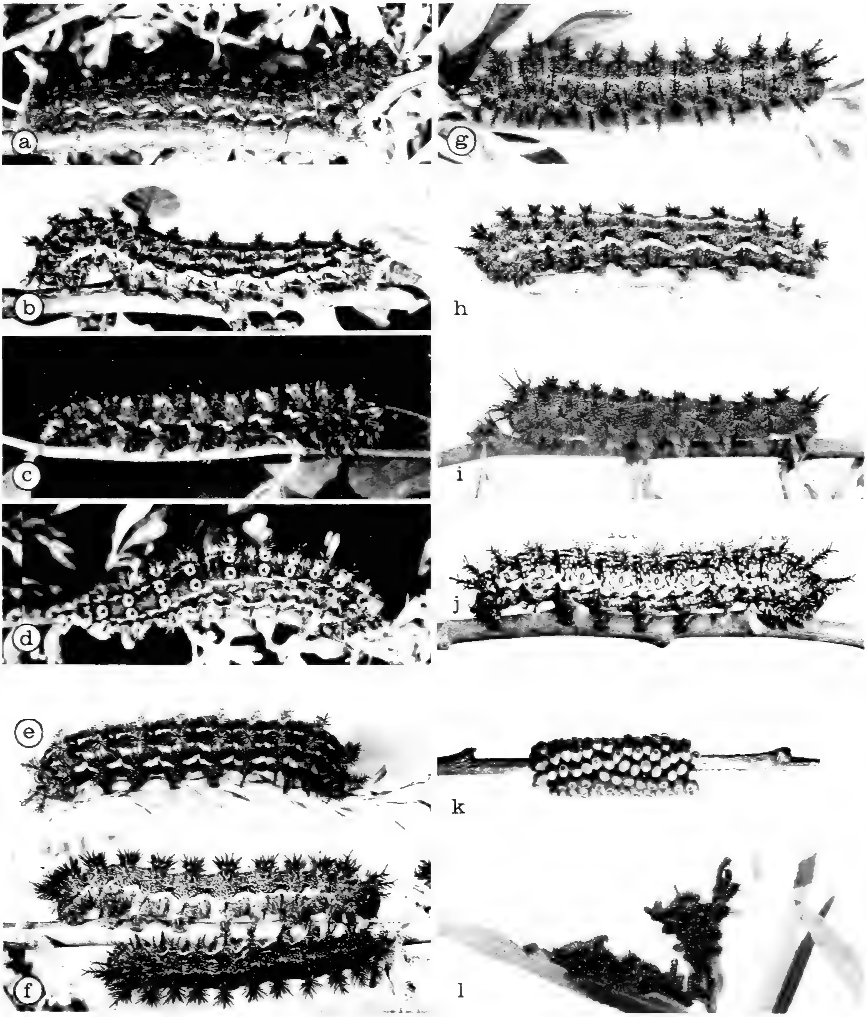

FIG. 3. Last instar *Hemileuca* larvae of California. **a,** *H. eglanterina shastaensis*; **b,** *H. eglanterina annulata*; **c.** *H. nuttalli uniformis*; **d,** *H. nuttalli nuttalli*; **e,** *H. hera hera*; **f,** *H. neumoegeni*; **g,** *H. burnsi*; **h,** *H. electra electra*; **i,** *H. juno*; **j,** *H. nevadensis*; **k,** *H. nevadensis* egg ring; **l,** First instar larvae of *H. nevadensis* feeding on willow.

nevadensis are generally consistent within a population, but striking differences are often found between different populations (Figs. 3a, b, c, d). The larvae of *electra, burnsi, juno, neumoegeni,* and *hera* usually exhibit little variability. A key to the last instar saturniid larvae of the West Coast has been published, and includes some host plant and habitat data (Tuskes, 1976). All *Hemileuca* larvae are covered with

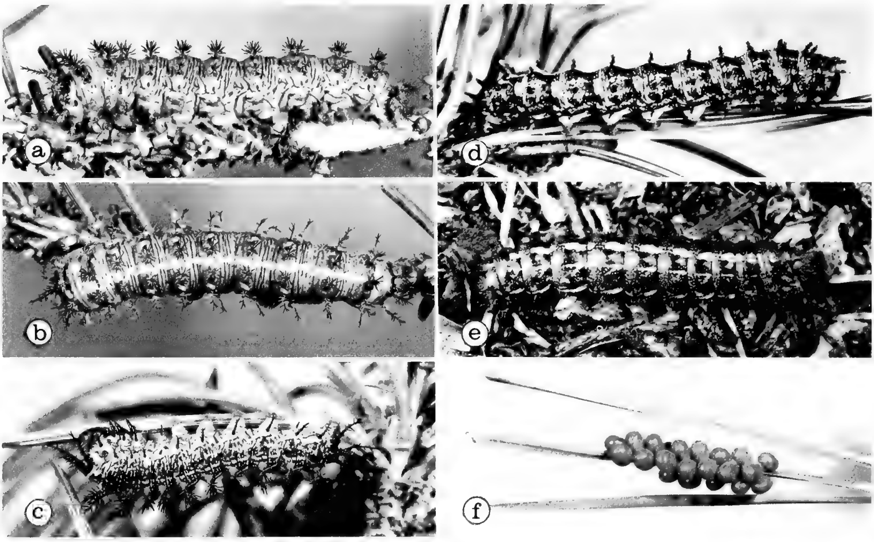

FIG. 4. *Coloradia* larvae of California. **a,** *C. velda,* mature; **b,** *C. velda,* mature; **c,** *C. velda* (4th instar); **d,** *C. pandora lindseyi,* mature blackish phenotype (Mono Co., Ca.); **e,** *C. pandora lindseyi,* mature brown phenotype (San Diego Co., Ca.); **f,** *C. pandora lindseyi* egg cluster on pine needle.

short secondary setae and various types of urticating scoli on the dorsal and lateral surfaces. When disturbed gregarious larvae may respond by moving the body segments anterior to the prolegs back and forth at a frequency of about 1 cycle per second. At times almost every larva in the cluster may oscillate in synchrony. The urticating scoli of *Hemileuca, Automeris,* and *Saturnia* larvae are capable of inflicting a severe sting. The irritation may last for half an hour, and the affected area may discolor; welts lasting from one to 14 days may develop. The intensity of the pain inflicted by the larval scoli seems to vary from one species to the next.

In the 4th or 5th instar the larvae lose their gregarious tendencies and feed individually. At this time they disperse over a wider area of the host plant or to surrounding plants. When a larva is mature it leaves the host plant and wanders on the ground in search of a suitable location to pupate. All of the California species pupate either in the leaf litter, under objects such as rocks, burrow into the ground, or utilize deep cracks in the soil. The pupal cell consists of debris or soil held together with a loose matrix of silk which forms a cup over the pupa with little or no silk below. The cell is fragile and merely picking it up often results in its destruction. An exception are the members of the *tricolor* group, many of which spin a loose but complete silken cocoon that is attached to vegetation.

The length of time spent in the pupal stage for any given species varies from population to population. In areas with a long growing season, overwintering eggs hatch in the spring, develop, and emerge as adults later that same summer. Where the growing season is short (e.g. coastal fog belt, or subalpine) adults and larvae from different generations may overlap. Pupae from spring larvae may emerge, mate, and deposit eggs, or overwinter and hatch the following summer. Thus, in some populations, eggs and pupae rather than just eggs function as the overwintering stage. I refer to this as an asynchronous two year life cycle with an adult flight each year. All of the California species have the ability to spend two or more years in the pupal stage.

Hemileuca eglanterina eglanterina (Boisduval)

Hemileuca eglanterina (Figs. 1a, b, e) is the only western saturniid with a dorsal forewing that is yellow, black, pink, and occasionally beige. The antemedial and postmedial lines and margin are black. In some populations the females have more pink on the forewing than males. Dorsally, the hindwings are black and yellow. The ventral wing surface is always black, yellow, beige, and frequently pink. The abdomen of both sexes is alternately banded black and yellow, but in some individuals one color may dominate the pattern. There is a great deal of geographic variation within this species. Specimens from southern California are often smaller and have less pink on the forewings than northern populations. The form "denudata" is widespread in populations from central California to Washington, although the frequency of its occurrence varies greatly from one population to the next. All specimens expressing the "denudata" trait have been males in which the black markings are either greatly reduced or absent, therefore the wings are predominantly pink or yellow. Another distinctive phenotype is one in which the yellow has been replaced by brown.

Typical *eglanterina* blends into the Great Basin subspecies, *annulata,* along the passes on the east slopes of the Sierra Nevada. A second subspecies, *shastaensis* is characterized by melanic adults and occurs in extreme northern California and southern Oregon. Male and female *eglanterina* are of similar size. California specimens of the nominate form have wingspans that range from 63 to 72 mm.

The flight season extends from late June to early October, but the majority of the records are from mid-July through the last week of August. Both males and females are active day flyers.

Hemileuca eglanterina occurs in a wide variety of habitats. In dry areas such as the Central Valley, *eglanterina* occurs in the riparian habitat where the larval host plants are various species of *Salix*. In the chaparral community, as well as in pine, oak, or redwood forests, the larvae feed extensively on *Ceanothus* and *Cercocarpus*. Host plants which are used less frequently or by specific populations include: *Prunus, Pyrocantha, Purshia, Rubus, Quercus,* and *Symphoricarpos*. On occasion this species has been common in residential areas and orchards.

Although the phenotype of the last instar larva is fairly uniform within a given population, there is a great deal of variability between populations. Last instar larvae have 1 to 3 complete cream colored lateral lines, but in some populations they are absent. The ventral surface, intersegmental area, and prolegs vary in coloration from black to red. The ground color is black, dark gray, or dark brown; the dorsal scoli are yellow and black.

Egg rings on *Salix* are easily located during the winter. Each ring may consist of 75 to over 250 ova. In the Central Valley the eggs begin to hatch in mid to late March, and last instar larvae can be collected from mid-May to mid-June. At the lower elevations *eglanterina* has a one year life cycle, but at higher elevations or along the coast it has an asynchronous two year life cycle with an adult flight each year.

Hemileuca eglanterina shastaensis (Grote)

Hemileuca eglanterina shastaensis (Figs. 1c, d) is distinguished from typical *eglanterina* by its melanic tendencies and distribution. Although some males are totally black on the dorsal surface, the majority have a moderate amount of pink on the forewing and yellow on the hindwing. Even the darkest males express 3 of the 4 basic *eglanterina* colors on the ventral wing surface: black, yellow, and pink. Males exhibit a full range of phenotypes from black to only slightly melanic. Females have a definite tendency to be lighter in coloration, and some appear similar to the nominate form except for having a more extensive rose-pink coloration on the dorsal forewing. Specimens in California collections have wingspans which range from 65 to 78 mm.

The flight season extends from mid-June to mid-August, but the majority of the records are from mid-July. Both males and females are active day flyers and are usually closely associated with the chaparral plant community.

Larval masses have been collected by the author numerous times on *Purshia tridentata* (Pursh) in California and Oregon and reared to maturity in captivity on *Cercocarpus*. Wild cherry is another possible host according to Ferguson (1971). All of these plants are in the family Rosaceae, a group commonly used by typical *eglanterina*. Early instar larvae of *shastaensis* may be collected in May or June, and mature larvae looking for pupation sites are frequently observed crossing roads in mid-July to August. Mature larvae measure 50 to 70 mm in length and are reddish brown with bold cream colored lateral lines; the intersegmental area is deep red. This subspecies has a two year asynchronous life cycle on Mt. Shasta as adults and larvae can be collected at the same time. Larvae reared in the Central Valley exhibited a one year life cycle (Fig. 3a).

A cross between a female *shastaensis* and a typical male *eglanterina* produced offspring that appeared almost identical to the male parent, except that they had a deep rose color on the forewing which is characteristic of many *shastaensis*. Because of staggered emergence the F_1 could not be backcrossed or selfed. Additional matings between *shastaensis* and nominate *eglanterina* are needed to determine their relationship to each other.

Hemileuca eglanterina annulata Ferguson

Hemileuca eglanterina annulata (Figs. 1h, i) has the typical *eglanterina* pattern but may be distinguished from the nominate form by the reduction or absence of pink on the forewing and a tendency for the black markings to be more extensive, often with a smudged appearance. In California, specimens of *annulata* may be confused with *H. nuttalli uniformis,* but the two species may be separated by examining the hindwing postmedial black line between vein M_3 and the inner margin of the wing; this line is straight or convex in *annulata* and concave in *nuttalli*. In addition, the ventral surface of California *annulata* is usually black, yellow, and beige, while California *nuttalli* are black and yellow. Some *annulata* females are only black and yellow; if so, the forewing postmedial coloration will separate them from female *nuttalli*. In Nevada and Arizona, *annulata* is larger than *nuttalli*. California specimens have wingspans that range from 60 to 73 mm. Specimens from Nevada and Arizona reach 85 mm and are frequently darker.

The flight season of *annulata* extends from late June to early September, with the majority of the records from mid-July to mid-August. Both males and females are active day flyers from 1000 to 1630 h, with a peak near 1200 h.

In California, *annulata* is restricted to the Great Basin habitat on the dry eastern slopes of the Sierra Nevada, where it integrates with the nominate form. Specimens from this area are the same size as the nominate form but usually have smudged black maculation and lack bold pink markings on the forewings. Some individuals have a slightly diffuse pinkish yellow cast over the forewing, while other populations have little or no pink. Although California populations are variable and are both smaller and lighter in coloration than Nevada and Arizona populations, they are best described as *annulata* with some genetic input from typical *eglanterina*. The adults are usually seen flying near the larval host plants which include: *Prunus emarginata* (Dougl.), *Ceanothus velutinus* (Dougl.), *Purshia tridentata* (Pursh), and *Symphoricarpos vaccinoides* (Rydb.). Mature larvae from California are similar to those from the Central Valley except the cream colored lateral stripes are more prominent, and the ventral surface is usually light red (Fig. 3b).

Hemileuca nuttalli uniformis (Cockerell)

The forewing of male *nuttalli uniformis* (Figs. 1f, g) is cream to beige dorsally, with a black basal patch, antemedial, and postmedial line, discal spot, and margin. In addition (as in *eglanterina* and *hera*), black wedge-shaped marks extend from the margin towards the postmedial line. The forewing of the female is very similar to the male, but the area between the margin and the postmedial line is yellow in the female rather than beige as in the male. The ventral surface of the fore- and hindwings are yellow and black. The thoracic tufts are yellow, and the abdomen has alternate bands of black and yellow. This species is frequently sympatric with *annulata*, and the two are often confused. For diagnostic differences see *H. eglanterina annulata*. Male and female *nuttalli* are of similar size; wingspans range from 60 to 68 mm. Specimens from Arizona and Nevada are frequently larger, 66 to 78 mm, and their pattern is more diffuse.

In California, *nuttalli* flies from mid-July to perhaps mid-September, with the peak flight period in August. Both males and females are active day flyers.

This subspecies inhabits the eastern slopes of the Sierra Nevada from Inyo Co. north to Alpine Co. at elevations generally ranging from 2150 to 3400 m. Although probably widespread in this area, limited access to the proper habitat has resulted in relatively few collecting records. Specimens from Nevada and northern Arizona are slightly larger, and the black markings are frequently more diffused than Sierran material. Ferguson (1971) suggested that the *uniformis* phenotype may be the result of its cool environment. On two occasions the author reared Sierran *uniformis* in the hot Central Valley, and the resulting adults expressed the *uniformis* phenotype.

Although frequently sympatric with *H. eglanterina annulata* and *H. hera* in the mountains, *uniformis* infrequently occurs on the high plateau east of the Sierra, an area dominated by sagebrush and saline soils. Collins and Tuskes (1979) found that male *uniformis* are attracted to and will mate with female *eglanterina*. Such interspecific matings are minimized in the wild by a partially allochronic flight period. Female *uniformis* have a tendency to mate later in the day than female *eglanterina*. Male *uniformis* fly from 1030 to 1800 h, with 75% of their flight activity after 1330 h. Male *eglanterina annulata* at the same location flew from 1030 to 1630 h, with about 75% of their flight activity prior to 1330 h. Female *uniformis* did not attract male *annulata*.

Overwintering egg rings hatch in late April or May and pupation occurs in July. The larval host plants in California are *Purshia tridentata* (Pursh) and *Symphoricarpos vaccinoides* (Rydb.). In the Sierra Nevada *uniformis* has an asynchronous two year life cycle with an adult flight each year. When reared at lower elevations *uniformis* has a one year cycle. The larvae of *uniformis* from Monitor Pass, Mono Co. have 1 prominent and 2 poorly developed cream colored lateral lines. The ground color is black and there are numerous grayish short secondary setae; the dorsal rosette setae are yellow and black. The head is black and mature larvae measure 53 to 63 mm in length (Fig. 3c).

Hemileuca nuttalli nuttalli (Stecker)

Adult *nuttalli nuttalli* differ from *nuttalli uniformis* in subtle ways. The nominate form is said to be larger and the black markings well defined rather than diffused as in *uniformis* (Ferguson, 1971). In addition, the forewing of female *nuttalli* has a uniform yellow cast with black maculation, while that of *uniformis* is beige with a yellow cast only between the postmedial line and wing margin; the maculation is also black but slightly more diffused.

Flight data were not available since all of the California records have been from reared specimens. In Oregon this form flies during July and August. Both males and females are active day flyers.

Typical *nuttalli* is common in southern Oregon and has been collected in extreme northern California. In Siskiyou Co. the larvae have been found feeding on *Purshia tridentata* and *Symphoricarpos*. Pupation occurs during July and early August; adults emerged the following August. The larvae of *nuttalli* are extemely variable. MacFarland (1974) described mature nominate *nuttalli* from eastern Oregon as black, with no maculation, and with black scoli. Larvae from Siskiyou Co., CA have prominent yellow dorsal scoli, and 3 distinct cream colored lateral lines; the ground color is black, and there are numerous short secondary setae on the segmental areas (Fig. 3d).

Hemileuca hera hera (Harris)

The fore- and hindwing of *H. hera* (Fig. 1h) are white with a black basal patch, antemedial line, postmedial line, discal spot, and marginal areas. The costal area is black, and the veins between the marginal and postmedial line are covered with triangular-shaped patches of black scales. The head and anterior portion of the thorax are yellow, dorsal thoracic area black, thoracic tufts white. The abdomen is alternately banded with yellow, black, and occasionally white. Specimens from the Sierra Nevada are frequently darker than those from the adjoining Great Basin. Both male and female *hera* are of similar size; the wingspan of California specimens ranges from 59 to 73 mm.

The flight season extends from late June to mid-September with the majority of the records from July to early August. Both males and females are active day flyers.

The larvae of *hera* feed almost exclusively on one species of sage, *Artemisia tridentata* Nutt. (Basin sagebrush), but when larval populations are dense they have been found occasionally feeding on various *Lupinus* and *Eriogonum*. Although *A. tridentata* is widespread in California, *hera* occurs only in the Great Basin habitat on the east side of the Sierra-Cascade ranges; from Inyo Co. north to Modoc Co., and is common in adjoining areas of Nevada and eastern Oregon.

Some populations of *hera* in northern California exhibit a great deal of variation. A series from Davis Creek, Modoc Co. contained typical specimens, melanic individuals, and the form *marcata* which has been treated as a subspecies (Figs. 1l–o). The form "marcata" (Fig. 1k) is one in which the black markings on the wings are greatly reduced; this form may be similar to "denudata" in *H. eglanterina* populations. The extent of variation observed in the Davis Creek area is almost identical to that found in nearby populations of *H. eglanterina shastaensis*. Further study is needed to determine the status of "marcata" and the extent of variation in the southern Oregon populations. *Hemileuca hera magnifica* (Rotger) is a subspecies from Colorado and New Mexico for which little biological data are available. Larvae from both states were collected and reared on *A. tridentata*. The larvae of *magnifica* were virtually identical in color and pattern to nominate *hera* larvae from Monitor Pass, Mono Co., California (Fig. 3e).

In California, overwintering eggs hatch in late April or May. Early instar larvae are black and gregarious; pupation occurs during July and August. Populations express a two year asynchronous life cycle with adults flying each year. When reared at lower elevations the moth expresses a one year life cycle, although some may hold over in the pupal stage for up to two years. McFarland (1974) published a partial description of a mature larva. A complete description of a mature 5th instar larva from Mono Pass, Mono Co., California is presented (Fig. 3e).

Description of Last Instar Larva

Head: Shiny black with numerous white secondary setae; diameter, 4.5–5.0 mm. Clypeus black with 4 long setae. **Body:** Length 55 to 62 mm; width, 9 mm. Ground color black. Ventral surface, light gray intersegmentally and gray-brown to black elsewhere. Sublateral scoli black. Lateral scoli with yellow rosette and branching black stalk. Dorsal scoli from thoracic segment 3 to abdominal segment 8 yellow rosette type. Body covered with numerous white secondary setae. Dorsal and lateral surfaces black. Body with 3 distinct lateral and 1 dorsal cream-white colored lines. Line I most conspicuous, passing through the sublateral scoli and extending length of larva. Line II, slightly ventral to lateral scoli and best developed in intersegmental area. Line III, midway between lateral and dorsal scoli, appearing as series of dashes. Line IV consists of series of dots or lines in intersegmental area and anterior portion of each segment paralleling black middorsal line. Thoracic shield, anal shield, and lateral shields of prolegs black. True legs black. Spiracles orange.

Hemileuca electra electra Wright

The dorsal forewing surface of *electra* (Figs. 2a, b) has a white medial area; the discal spot, costa, postmedial line, and margins are black. Although the forewing postmedial line is present in the females, its occurrence is variable in the males. The ventral surface of the forewing and both surfaces of the hindwings are red and black. The thorax is gray to black with white thoracic tufts and collar. The abdomen is red dorsally and black and white ventrally. *Hemileuca electra* can be distinguished from the Mojave Desert subspecies *clio,* by the well developed black postmedial line on the forewing of nominate females and the white area or series of white patches that occur between the postmedial line and the black wing margin. The latter characteristic is usually but not always diagnostic. In male *electra* the dark postmedial line or smudged area on the forewing touches the discal spot, whereas, in California *clio* populations it does not; male and female *clio* lack the dark postmedial line. The wingspan of male electra ranges from 45 to 54 mm; the females range from 53 to 62 mm.

Hemileuca electra flies from late August to early December with the majority of the records from mid-September to early October. Both sexes are active day flyers.

Nominate *electra* is restricted to the coastal chaparral plant community of five southern California counties and portions of northern Baja California, Mexico. Males have a fast erratic flight except when approaching a female. Adults fly from about 1000 to 1500 h and may be collected as they perch on various chaparral plants in the evening. Although wild females are infrequently captured, larvae and egg rings are frequently locally abundant.

The egg rings are deposited in the fall on the floral stems of *Eriogonum fasciculatum* Benth. Each egg ring contains 30 to 60 greenish ova which hatch in December or January. The host plant grows commonly in disturbed habitats such as road cuts and hill slides. In nondisturbed areas it is frequently associated with *Rhus laurina* and coastal sages. Mature larvae are found in late March or April. Comstock and Dammers (1939) described the mature larva and reported its length to be 45 mm, but most mature field collected larvae are larger. The larva is black with many secondary white setae extending from white pinacula giving it a gray-brown appearance. There are three continuous lateral cream-yellow colored lines extending the length of the body. The intersegmental area is red, and the setae of the dorsal rosette are yellow and black (Fig. 3h).

Hemileuca electra clio Barnes & McDunnough

Hemileuca electra clio (Figs. 2g–h) is similar in coloration to typical *electra,* but there are major differences in the pattern of the forewing. In *clio* from California the white medial patch of the forewing is well-defined and the postmedial line is undefined. Male and female *clio* are very similar in appearance. Specimens of *clio* from Arizona are usually larger, darker, and have a slightly different flight period than California populations. Some of the Arizona populations are almost completely black dorsally except for the basal area of the hindwing which is red. The wingspan of male *clio* from California ranges from 51 to 59 mm; females 51 to 69 mm.

California records indicate the flight period of *clio* is shorter than typical *electra*. Collecting records range from the first week of September to the first week of November with the peak flight period occurring in mid-September. Male *clio* are active day flyers, while females are usually captured in the afternoon and have been collected numerous times during the early evening at blacklights.

Hemileuca electra clio is found in the high desert regions of southern California and is frequently sympatric with *H. burnsi* and *H. neumoegeni*. The area occupied by *clio* has less precipitation, hotter summers and colder winters than the coastal chaparral community occupied by typical *electra*. Some populations of *clio* (in Riverside, San Bernardino, Imperial, and San Diego counties) on the eastern passes of the mountains which separate the chaparral from the desert plant community have hybrid like phenotypes suggesting that gene exchange has or does occur between the two taxa.

The author has crossed nominate *electra* from San Diego Co. with a wild male *electra clio* from Phelan, San Bernardino Co. The F_1 females were extremely variable, but definitely expressed the *clio* phenotype. The smallest female had a wingspan of 53 mm, was infertile, and had melanic forewings. The other females had melanic tendencies and wingspans that ranged from 63 to 68 mm. The males from this cross were similar in appearance to, but on the average (54–58 mm) slightly larger than, normal *clio*.

The egg rings of *clio* contain 7 to 26 large gray eggs. The ova of *clio* are a different color, larger, and the rings contain far fewer eggs that those of typical *electra*. The larvae of *clio* feed on *Eriogonum fasciculatum* var. *polifolium* and are distinguished from typical *electra* by their larger size and coloration. Last instar larvae of *clio* from California and Arizona are similar in appearance; they have fewer white pinacula than *electra electra* and are darker in appearance. In addition the dorsal rosettes are solid black in *clio* but black and yellow in typical *electra*. Smith (1974) also noted these and other differences between the larvae.

Hemileuca juno Packard

The forewing of *juno* (Figs. 2c, d) is black with a white medial area. The hindwing of the male is black except for the center of the discal spot which is white. Females usually have lightly marked white medial area on the hindwings. Some specimens, especially females, have a gray-brown rather than black wing coloration. The thorax of the male is black while that of the female is frequently gray. The abdomen of the male is black anteriorly and red posteriorly; females are black with a red tip. The pattern of *juno* is similar to that of *electra clio* from Arizona. The wingspan of male *juno* from Arizona ranges from 52 to 59 mm; females 58 to 64 mm.

Although *juno* is widespread from Idaho to northern Mexico (Comstock and Dammers, 1939), it is infrequently collected except in Arizona and southern New Mexico. *Hemileuca juno* is assumed to occur in southern California, but the only record is from San Diego (Co.) and was collected in 1908. The larval host plant, *Prosopis juliflora* DC. (mesquite), grows commonly in the area of Anza-Borrego and many other locations in southern California. Despite a great deal of collecting activity in this area, there are no recent reports of larvae or adults from the California desert. The moth has been collected on the California–Arizona border at Yuma (XI-10-64).

In Arizona, first instar larvae are found in late April or early May. Although larvae will feed on the leaves of the host plant, they prefer the buds and flowers which develop in clusters. In captivity some larvae refuse to feed on anything but the flowers or buds. Pupation occurs in leaf litter near the surface of the ground during late June.

The mature larva measures about 50 mm in length and is black with numerous secondary setae extending from white pinacula which gives the larva an overall gray appearance. The head and true legs are black and the prolegs and ventral surface are gray-brown. The dorsal rosette setae are uniquely colored with red at the base and black at the tips of the spines. There are 3 white and 1 black lines, all of which appear as a series of dashes on the lateral surface and extend the length of the larva. Comstock and Dammers (1939) described and illustrated the mature larva of *juno,* but their description was not complete (Fig. 3i).

Adults have been captured from late September to early December, with the majority of the records from later October to early November. Emergence occurs in the morning, and males begin to fly between 1000 and 1130 h. During a peak flight in 1982 females were observed ovipositing from late afternoon to at least sunset. The male flight dropped off considerably by 1530 h, and shortly thereafter, males were found perched on the host plant. By 1700 h most moths that were observed flying were females; although uncommon, females have been collected at blacklights.

Hemileuca burnsi Watson

The wings of *H. burnsi* (Figs. 2f, l) are chalk white and black. The antemedial black line is solid and is never intersected by an elongated spot as in *H. neumoegeni.* The black discal spot appears as a ring on the forewing but on the hindwing is often reduced to a simple black dot. The postmedial band is well developed on the forewing but frequently reduced or absent from the hindwing of males. Although the abdomen of the female is usually white, it may have semicircular bands of red and/or black; the abdomen of the male is white. The wingspan of male *burnsi* ranges from 48 to 52 mm; females 58 to 62 mm.

Collection dates indicate that the flight season extends from the last week of August to the first week of November, with the majority of the records from the second and third weeks of September. Records from Arizona, Nevada, and Utah also indicate September to be the month of the peak flight period in those states.

Male *burnsi* are active day flyers, generally flying between 0900 and 1500 h. They seek virgin females that remain perched on desert shrubs and transmit pheromone during the day. Females oviposit at night and are strongly attracted to light for the first few hours after it becomes dark and less frequently through the rest of the night. Upon emergence males are chalk white, but with age some become cream colored. Older specimens in collections are frequently light yellow.

The eggs overwinter and usually hatch in late February or early March. Early instar larvae are black and gregarious. Late instars are black with white pinacula, giving them a gray appearance. In addition the mature larva has at least two cream colored lateral lines extending the length of the body. Pupation occurs in April or early May. Comstock and Dammers (1937) described the first and last instar larva as well as the pupa of *burnsi* (Fig. 3g).

In the Reno area of Nevada the larval host plants are *Tetradymia glabrata* Gray and *Dalea fremontii* Torr. In southern California they utilize *Tetradymia axillaris* Nels. = *T. spinosa* H. & A., *Prunus fasciculata* (Gray), and various species of *Dalea*. Other plants associated with the *burnsi* habitat on the higher desert slopes near Little Rock and Phelan include: *Artemisia, Chrysothamnus, Ephedra, Eriogonum fasciculatum* var. *polifolium* (Benth.), *Larrea, Lycium, Purshia,* and *Yucca.* Although late instar larvae have been collected on *Eriogonum fasciculatum var. polifolium,* I have found that early instar larvae cannot survive on that host. After the 4th instar, successful development on *Eriogonum* did occur, and the resulting adults were of normal size.

Hemileuca burnsi is sympatric with *H. electra clio* in many areas of Kern, Los Angeles, Riverside and San Bernardino counties. I have seen one male specimen which may represent a hybrid between these two species. On occasion male *burnsi* have been attracted to a calling female of *H. electra.*

Hemileuca neumoegeni (Henry Edwards)

The wings of *H. neumoegeni* (Figs. 2e, k) are lustrous white. The distal spot of the fore- and hindwings is black and sickle-shaped with white centers; the antemedial and postmedial lines are also black. An elliptical black spot with a white center may occur in the antemedial forewing line. The thorax and head are red and the thoracic tufts are white. The abdomen of both sexes are similarly marked; red dorsally and laterally with a red and white ventral surface. Some females have white scaling on the dorsal posterior portion of the abdomen. *Hemileuca neumoegeni* is occasionally confused with *H. burnsi,* but the two are easily separated. The wings of *burnsi* are chalk-white and the antemedial line on the forewing is not interrupted by an elongated spot. The abdomen of *burnsi* adults is primarily or completely white rather than red as in *neumoegeni.* Male *neumoegeni* have a wingspan of 48 to 55 mm; the females from 58 to 64 mm.

The flight season extends from the second week of August to early October, with the majority of the records from the second and third week of September. Arizona, Nevada, and Utah records also indicate September as the month when most specimens have been captured. In California it appears that the occurrence of warm thunder storms early in the flight season enhances the September flight, while cold fronts have a retarding effect. Both males and females are nocturnal flyers and are attracted to lights; most specimens have been collected prior to 2230 h.

The distribution of this species is more extensive than previously indicated (Ferguson, 1971); for in addition to Arizona, it has been collected in Utah, Nevada, and California. California records date back to the early 1930's. Adults and larvae have been collected in the Clark, Granite, Ivanpah, Mescal, Mid Hills, New York and Providence Mountain ranges of San Bernardino Co.

Adults emerge during the late morning but remain inactive during the day; mating occurs after twilight. There is some variation among the males with regard to the size and presence or absence of an orbicular-like spot in the antemedial line. Perhaps 20% of the California specimens lack or have a very reduced orbicular-like spot.

Females deposit 15 to 30 grayish ova in a ring near the terminal ends of the host plant and then move to another plant before depositing the next egg ring. In the Providence and New York Mts., egg rings and larvae have been collected numerous times on *Prunus fasciculata* (Torr.) and occasionally on *Rhus trilobata anisophylla* (Greene). Larvae in the Spring Mts. of Nevada were found on *P. fasciculata* by Eric Walter, while Mike Van Buskirk collected larvae south of Flagstaff, Arizona on *R. trilobata*. Both host plants are associated with dry slopes and washes in the Mojave and Colorado deserts above 1000 m. Bauer (1948) reported *Eriogonum fasciculatum* Benth. as the host plant and was cited by Ferguson (1971), but this record appears to be incorrect and may have resulted from misidentified larvae.

In California the ova hatch between early April and May. During the early instars the larvae are black and feed gregariously. In captivity young larvae on potted plants fed randomly throughout the day, but 4th and 5th instar larvae descended the secondary stems and remained on the main stems, frequently near the base of the plant during the day, and fed on the leaves of the terminal branches at night. Because mature *neumoegeni* larvae have a reddish brown intersegmental area and may be gray rather than black, they resemble *H. electra* larvae rather than those of *H. burnsi*, to which it is most closely related. Pupation occurs during June.

Hemileuca neumoegeni is sympatric with *Hemileuca electra clio* B. & McD. in the Providence and New York Mts., and populations of *H. burnsi* Watson occur in these same mountains. The larvae of *electra clio* feed on *Eriogonum*, primarily *fasciculatum*, while *burnsi* larvae feed on *Dalea*, *Tetradymia*, and *Prunus fasciculata*. Because of differential mating times, morning vs evening, there is little probability of interaction between *neumoegeni* and *burnsi* or *electra*. The larvae of *neumoegeni* are described here for the first time (Fig. 3f).

Description of Larval Instars

FIRST INSTAR. **Head:** Black, diameter 0.9 mm. **Body:** Length 6 mm, width 1.2 mm. Ground color, solid black. All scoli except dorsal thoracic and dorsal lateral simple with one long seta extending from each. Dorsal thoracic and dorsal lateral scoli forked at tip, with one slightly elongated seta extending from each branch. All scoli black.

SECOND INSTAR. **Head:** Black, diameter 1.4–1.5 mm. **Body:** Length 10–11 mm, width 2.4 mm. Ground color solid black. All scoli branched and black with black spines. True legs, prolegs, and spiracles black.

THIRD INSTAR. **Head:** Black, diameter 2.2–2.4 mm. **Body:** Length 17 mm, width 4.1 mm. Ground color solid black. Larva similar to second instar only larger.

FOURTH INSTAR. **Head:** Black, diameter 2.8–3.1 mm. **Body:** Length 24–36 mm. Ground color black. Ventral surface black with some white setae. Lateral surface with single undulating continuous white line extending length of larva and passing through base of lateral scoli. Faint traces of second white lateral line appears in segmental area only, in line with dorsal lateral scoli. Segmental area with numerous short secondary setae, some of which extend from cream to light pink pinacula. Intersegmental areas black. Mid dorsal area black. All scoli black and branched type. Prolegs black and covered with short white secondary setae. Planta orange. Spiracles black.

FIFTH INSTAR. **Head:** Black with numerous short white secondary setae, diameter 4–4.6 mm. Clypeus black. **Body:** Length 52–57 mm, width 10–11 mm. Ground color black to gray. Ventral surface gray with short gray secondary setae extending from white pinacula; intersegmental area red to flesh colored. Ventral and sublateral scoli with black shafts and white or black spines. Lateral scoli with black shafts with black and white spines and numerous white and black spines at base of shaft. Dorsal scoli on thoracic (T) segment 3 to abdominal (A) segment 8 of rosette type with gray centers and black tips. Three white or cream colored lateral lines divide lateral and dorsal surfaces into distinct color regions. Line I continuous and well developed undulating white-gray line extending length of larva, passing through base of sublateral scoli. Line II appears as series of gray dashes in intersegmental area only, below line of lateral scoli. Lateral surface between line I and II black with secondary setae extending from gray pinacula, giving area gray appearance. Intersegmental area with fewer pinacula and appearing black. Line III poorly developed and interrupted by reddish brown intersegmental area. Line III just ventral of dorsal scoli and extending length of larva. Segmental area between line II and III black; but secondary setae extending from gray pinacula giving area gray appearance; intersegmental area brick-red. Gray-black segmental and red intersegmental pattern continuing to black mid dorsal line. True legs black. Prolegs gray with light brown to red planta. Dorsal thoracic shield black. Proleg shield light brown to red-brown. Spiracles orange.

Hemileuca nevadensis Stretch

The wings of *H. nevadensis* (Figs. 2i, j) are black to dark gray with a wide cream colored medial band; both fore- and hindwings are similarly marked. The black discal spot on the forewing is lunate and larger than that of the hindwing. The abdomen is black; males have a distinctive red tuft at the tip, while females have a black or whitish tip. Some minor geographical variation is observed, as specimens from Nevada and northeastern California have slightly narrower black marginal borders than specimens from more southerly areas of California. The wingspan of California specimens ranges from 53 to 66 mm for the males; 58 to 67 mm for females.

The flight season extends from the third week of September to early December, with the majority of the records from the second week of

October through the first week of November. Both males and females are active day flyers.

Hemileuca nevadensis is widespread and locally abundant from extreme northern Baja California to the Los Angeles-Riverside basin and through the Central Valley to Turlock. In California this species is closely associated with the riparian habitat, where it feeds on *Salix*. The same host plant and habitat is occupied by *H. eglanterina* in the northern part of the Central Valley. This may have some influence on the distribution of *nevadensis*. There are scattered records for *nevadensis* along the Colorado River and the east side of the Sierras and Cascade ranges. Some populations on the east side of the Sierras may feed on *Populus* in addition to *Salix*.

The adults emerge in the morning and usually mate prior to noon. On cool cloudy days, moths have been seen in large numbers perched on plants along creek and river banks. Females may deposit over 200 ova in a ring on the woody thin stems of willow (Fig. 3k). The ova overwinter and hatch in late March or April. The immature stages have been described by Wright (1888), Dyar (1895), Packard (1914), and Comstock and Dammers (1939). Early instar larvae are black (Fig. 3l), but as the larva matures it develops yellow colored pinacula and assumes a black and yellow ground color. The prolegs have reddish brown patches near their base, and the prothoracic and anal shields are red. Larvae from northeastern California and Nevada have more yellow markings than those from southern or central California (Figs. 3j, l).

Genus *Coloradia* Blake

Adult *Coloradia* are characterized by their nocturnal habits, moderate to large size and their gray to black cryptic forewings. The hindwings are gray and either pink, cream, or light brown. Male antennae are quadripectinate, while those of the female are bipectinate or biserrate. Unlike *Hemileuca* the labial palps are large, separate, and not fused. Four species of *Coloradia* occur north of Mexico, two of which occur in California.

Members of the genus are widespread in pine forests of the western United States and portions of Mexico. The larvae feed on various species of pine. *Coloradia pandora* and its subspecies have caused economic damage to ponderosa, Jeffrey, and lodgepole pine forests in the western United States (Patterson, 1929; Wygant, 1941). Some species have a one year life cycle, while others usually require two years to develop from the egg to the adult. The larvae of *Coloradia* are similar to those of *Hemileuca* but have a dark gray to brown ground color and generally lack well developed cream or white lateral lines. In addition some *Coloradia* lack the finely branched or rosette type scoli, and generally the spines are not urticating.

Coloradia pandora lindseyi Barnes & Benjamin

Male and female *C. pandora* (Fig. 2r) are similar in appearance but differ in size. Dorsally, the forewings vary from gray-brown to dark gray. The antemedial and postmedial lines are black and trimmed with white; the submarginal band is light gray. The hindwing marginal area is brown to dark gray, while the submarginal portion is white to pink. There is a brown or dark gray postmedial band and a distinct black discal spot. The remainder of the hindwing is cream, gray, or pink. The head, abdomen, and thorax are dark gray to brown with tufts of white scales. In California, *pandora* could be confused with *C. velda*, but the two are easily separated by size, flight season and appearance. The hindwing postmedial line of *velda* is diffused and frequently touches the discal spot, and the majority of the wing is gray; only 20 to 35% of the basal area is pink. In *pandora* the hindwing postmedial line is well defined and does not touch the discal spot; the majority of the hindwing is light brown, cream or pink. In California the wingspan of male *pandora* varies from 65 to 76 mm; females from 74 to 95 mm.

The flight season extends from mid-July to early October, with the majority of the records from early August to mid-September. Both sexes are nocturnal flyers and are attracted to lights. During massive population buildups, moths may fly during the day.

Coloradia pandora lindseyi inhabits Jeffrey pine forests and at times may be extremely abundant. Females deposit clusters of large white ova on the branches or needles of the pines (Fig. 4f). The eggs hatch in September or October, and the larvae begin to feed on the old needles. They pass the winter in the early instars high in the trees. Mature larvae descend the trees in June and July and pupate in the soil. The pupae may hatch that year or overwinter and hatch the following summer. Mature larvae measure over 58 mm in length, and have a brown to brown-black ground color (Figs. 4d, e). The posterior portion of each segment is dark brown, while the anterior and intersegmental area is light brown. There is a thin black mid dorsal line surrounded on each side by a thick dorsal white line. Two white lateral lines extend the length of the larva. The body is covered with light brown to cream colored pinacula from which extend short brownish secondary setae. The head is light brown. All scoli are short and the branches are much less developed than those of *Hemileuca* larvae (Fig. 4d). Although not described in detail, Patterson (1929) illustrated the immature stages of *lindseyi*.

Aldrich (1911, 1921) found that the Piute Indians near Mono Lake, Mono Co. utilized the mature larvae as a food source, which they called pe-aggie. Once collected, the larvae were killed by heating, then dried and stored for future use. Engelhardt (1924) reported that indians in southern Oregon also utilized *lindseyi* larvae as a food source.

Mature larvae collected in the Laguna Mts. of San Diego Co. during early June pupated in loose soil. The pupation chamber was cup-shaped and consisted of soil and debris held together with a small amount of silk. Some adults emerged two months later in August, while others emerged in August of the following year. Similar results were observed by Aldrich (1921) with larvae collected at Mono Lake. Carolin (1971) found that *lindseyi* may remain in the pupal stage at least six years prior to emergence, but the majority emerged as adults during the first two years.

Populations of *pandora* undergo periodic outbreaks, during which time larval densities are sufficiently high to cause serious damage to commercial stands of pine. *Coloradia pandora lindseyi* damaged *Pinus ponderosa* Laws. in Oregon (Chamberlin, 1922; Patterson, 1929), but seems to prefer *Pinus jeffreyi* Grev. & Balf. in California. During the 1976 to 1982 outbreak near Mammoth Lakes, Mono Co., the larvae fed primarily on Jeffery pine but on occasion were found feeding on ponderosa and lodgepole pines (*P. contorta* Dougl.). Various papers have dealt with the biology and economic impact of *lindseyi* (Chamberlin, 1922; Engelhardt, 1924; Aldrich, 1921) but only Patterson (1929) provides much detailed information. Patterson did state that *lindseyi* is strictly a diurnal species, an observation which would distinguish this subspecies from other *Coloradia* (Ferguson, 1971). Contrary to Patterson's observations, I have collected *lindseyi* commonly at lights, and generally after 2100 h. Chamberlin (1922) apparently worked with Patterson during the 1919 Klamath Falls, Oregon outbreak and implies that the moths were attracted to lights. During the Mono Co. outbreak, the U.S. Forest Service estimates that 5000 acres of Jeffrey pine were defoliated in 1979 and about 16,000 acres in 1981 (Schaaf, 1980, 1981). Although the U.S. Forest Service only mentioned the nocturnal flights of the moth in their environmental assessment report, John Johnson informed me that some adults were observed flying during the day. It appears that the behavior of this species may change when populations are at high densities. During population explosions there is a potential for day flights, although most will probably still be active at night. At normal population levels all flight activity (mate seeking and oviposition) is at night.

Coloradia velda Johnson and Walter

The color and pattern of male and female *Coloradia velda* (Figs. 2p, q) are similar in appearance. The forewings are gray to gray-brown; the antemedial and postmedial lines are dark gray to black and accented with white scales. The forewing discal spot is darker gray, smaller, and better defined than that of the hindwing. The hindwings are primarily gray to gray-brown with a slightly darker postmedial line that is adjoined to a distal pink line. The basal ½ to ⅓ of the wing is pink, as is the inner margin of the wing. In some specimens the hindwings appear partially transparent. The thorax and abdomen are dark gray with white scales mixed throughout. The only species similar to *velda* in California is *C. pandora lindseyi*, which is a larger species that flies later in the year. The hindwing of *pandora* is predominantly white or white and pink, and the discal spot is free of the gray postmedial line. In *velda* the gray from the margin extends all the way to the discal spot, and there are no extensive white areas. For additional comments see *C. pandora lindseyi*. Male *velda* have wingspans ranging from 51 to 61 mm; females from 58 to 73 mm.

Specimens have been captured from May to the end of July, but the majority of the records are for June. The adults are nocturnal and attracted to lights.

Presently *velda* is known only from the mountains of San Bernardino County. This species was recently described as a distinct species by Johnson and Walter (1980). Prior to its description it had been assumed to be a uniquely disjunct population of *C. doris* Barns.

Only the life history of *C. pandora* and its various subspecies have been described in the literature. Based on this information, the life cycle of *velda* is notably different from that of *pandora*. Larvae of *velda* emerge from the egg in early July and feed exclusively on pinyon pine, *Pinus monophylla* Torr. & Frem. Attempts to rear them from the 1st instar on *P. jeffreyi* were unsuccessful, but mature larvae may accept alternate hosts. The larvae feed gregariously in the early instars and singly in the 4th and 5th. They develop rapidly and after five instars pupate in mid-September. Larvae enter loose soil and burrow to a depth of 10 to 15 cm, then construct a structure around them by attaching silk to large soil particles and plant debris. The resulting pupae overwinter and adults emerge the following summer. By contrast, early instar *pandora* larvae overwinter, then feed to maturity in the spring, pupate during the summer and emerge later that same summer, or as is often the case, the following summer. Adult *velda* emerge between 0930 and 1100 h. Females begin emitting pheromones within one hour after it becomes dark; some females fly prior to mating. The developmental pattern of *velda* explains its early flight and suggests how it can occur sympatrically with *lindseyi* in the San Bernardino Mts. The main flight of *velda* occurs about two months prior to that of *lindseyi*.

Larvae of *lindseyi* and *velda* are easily separated. Mature *velda*

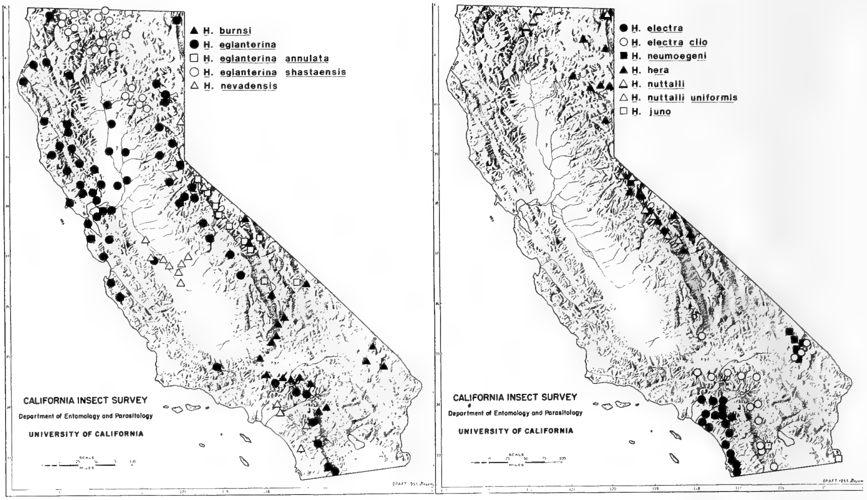

FIG. 5. The distribution of eight species and four subspecies of *Hemileuca* in California.

larvae (Figs. 4a, b) are light gray to gray-purple; the dorsal scoli are of the rosette type, orange in coloration, and similar in structure to those of *Hemileuca*. The larvae of *lindseyi* (Figs. 4d, e) have a dark brown ground color; the dorsal scoli are brown, and are a simple branched type. The larvae of *velda* are described here for the first time. The description is based on material reared from ova which were given to the author by Steve McElfresh. The ova were secured from a female collected at the type locality, Coxey Meadow, San Bernardino Mts., San Bernardino Co., on 25 June 1982 (Figs. 4a, b, c).

Description of Larval Instars

FIRST INSTAR. **Head:** Brown with sparse light brown secondary setae; diameter 1.5 mm. **Body:** Length 7.4 mm, width 2.1 mm. Ground color brown. Ventral surface yellow. Lateral surface with 3 lateral white bands. Line I encompasses the lateral scoli and extends length of larva. Line II, just ventral of dorsal lateral scoli and extends length of larva. Lateral surface between band 1 and 2 appears as dark brown band. Line III extends length of larva on dorsal side of dorsal lateral scoli. Abdominal dorsal and mid dorsal area yellow with remnants of black mid dorsal line. Dorsal thoracic segments dark brown to black. Lateral and sublateral scoli with short black spine. Dorsal lateral scoli with simple black spine twice length of lateral spine. Dorsal spines on abdominal scoli 1–8 black with brown setae at tip. Dorsal thoracic and 9th abdominal mid dorsal scoli branched with short brown setae extending from tips. Anal shield black, true legs dark brown, prolegs yellow.

SECOND INSTAR: **Head:** Brown with sparce light brown secondary setae; diameter 2.1 mm. **Body:** Length 10.2 mm, width 2.8 mm. Ground color brown. Ventral surface light brown. Lateral surface with 3 lateral white lines as in first instar. Brown line connects all dorsal scoli. Mid dorsal scoli yellow with thin brown mid dorsal line. Dorsal thoracic

FIG. 6. Habitat of desert, sagebrush and coastal chaparral species of *Hemileuca* in California. **a,** Coastal Chaparral, San Diego Co. Habitat of *H. electra electra*, *Saturnia walterorum* and *Hyalophora eurylaus*. Prominent vegetation in photo includes *Artemisia californica, Adenostoma fasciculatum, Eriogonum fasciculatum, Rhus laurina,* and *Salvia apiana*; **b,** Great Basin, Mono Co. Habitat of *H. eglanterina annulata, H. nuttalli uniformis, H. hera hera* and *Hyalophora gloveri*. Prominent vegetation in photo includes *Artemisia tridentata, Purshia tridentata* and *Symphoricarpos vaccinioides*; **c.** High Desert, San Bernardino Co. Habitat of *H. electra clio* and *H. burnsi*. Prominent vegetation in photo includes *Larrea divaricata, Yucca brevifolia, Tetradymia axillaris, Eriogonum fasciculatum* var. *polifolium,* and *Opuntia bigelovii*; **d,** High Desert Wash, San Bernardino Co. Habitat of *H. neumoegeni, H. electra clio,* and *Sphingicampa hubbardi*. Prominent vegetation in photo includes *Rhus trilobata anisophylla, Prunus fasciculata, Acacia greggii, Eriogonum fasciculatum* var. *poliofolium* and *Prosopis juliflora*.

area dark brown. Intersegmental areas white. Ventral, lateral and dorsal lateral scoli black. Dorsal scoli black on a yellow light brown pedestal. Dorsal, dorsal lateral, and mid dorsal scoli branched; thoracic scoli enlarged. True legs black. Anal shield dark brown. Prolegs light brown. Spiracles dark brown.

THIRD INSTAR. **Head:** Light brown with short white setae; diameter 2.4 to 2.7 mm. **Body:** Length 16 to 17 mm, width 4 mm. Ground color brown. Ventral surface light brown. Lateral surface with prominent white undulating line passing through base of each sublateral scolus and extending length of larva. Spiracular area light brown. 2nd white line extending length of larva, passing just ventral of lateral scoli. Brown line extending length of larva, passing through lateral scoli. 3rd white line extending length of larva, passing midway between dorsal and lateral scoli. Dorsal area white with thin black mid dorsal line. Thoracic and caudal scoli enlarged and branched. Dorsal and dorsal lateral scoli black and branched and on yellow pedestal. Sublateral and ventral scoli black and unbranched. Thoracic shield brown. Anal shield brown with white stripes. True legs black. Prolegs light brown. Spiracles brown.

FOURTH INSTAR. **Head:** Brown with light brown setae, ocellar scar dark brown; diameter 3.4–3.6 mm. **Body:** Length 28 to 32 mm, width 6 mm. Ground color gray. Ventral surface gray to yellow. Lateral surface with 3 light gray lines. Line I, undulating line extending length of larva and passing through base of each sublateral scolus. Line II, extending length of larva, passing just ventral of lateral scoli, and diffuse or absent. Line III, straight line passing midway between dorsal and dorsal lateral scoli. Mid dorsal area with thin dark brown mid dorsal line surrounded on each side by light gray line. Lateral and dorsal segmental area between light gray lines dark gray-brown with few light gray pinacula. A prominent gray dot occurs just dorsal of lateral scoli on abdominal segment 1 and occasionally on abdominal segment 7. All scoli branched. Dorsal and dorsal lateral scoli on yellow pedestal, base of spines yellow, distal portion black, except for black caudal scoli. Thoracic shield brown, anal shield brown with white stripes. True legs dark brown. Prolegs light brown to yellow. Spiracles light brown to yellow.

FIFTH INSTAR. **Head:** Light brown with few short white or hylen setae. Ocellar scar black. Clypeus brown. Mandibles dark brown. Diameter 4.5 to 5.5 mm. **Body:** Length 49 to 57 mm, width 10–12 mm. Ground color gray to gray brown. Ventral, lateral, and dorsal surface gray. Undulating subspiracular light gray fold extending length of larva. Lateral and dorsal surface with numerous folds on segmental and intersegmental area; brown line occurring at bottom of each fold. Dorsal and lateral surface sparsely covered with short hylen secondary setae. Diffuse light orange-brown area passing along base of dorsal scoli, extending length of larva, and surrounding light gray mid dorsal line. Shaft of all scoli orange. Sublateral, lateral and dorsal lateral scoli branched with white and dark brown spines. Dorsal scoli rosette type with white spines and black tips. Thoracic and anal shields light brown. True legs dark brown. Prolegs gray. Spiracles orange.

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OBSERVATIONS ON THE BIONOMICS OF *HELIOTHIS PHYLOXIPHAGA* (NOCTUIDAE) ON CLUSTER TARWEED IN SOUTHEASTERN WASHINGTON[1]

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ABSTRACT. The bionomics and brief descriptions of the life stages of *Heliothis phyloxiphaga* Grote & Robinson, a noctuid associate of the composite weed, *Madia glomerata* Hook., are presented. The moth was univoltine in southeastern Washington, with peak adult populations appearing during late July. Eggs were deposited on immature involucres, and the first- and second-stage larvae fed within the involucres on the developing achenes, while later stage larvae consumed bracts, flowers, and leaves. Pupation occurred in the soil from late August to early October. Under laboratory conditions, the life cycle of the moth from egg to adult required ca. 52 days.

The entomofaunas of many plants indigenous to North America are either unknown or inadequately characterized. Typically, little in-depth biological information is available on specific associates. This is particularly true for cluster or stinking tarweed, *Madia glomerata* Hook. (Compositae: Madiinae), a weed of the western United States and Canada.

The plant is an erect, 30–100 cm tall, yellow-flowered, summer annual that often forms dense stands in rangeland, pastures, along roadsides or ruderal areas (Dennis, 1980). Numerous stalked glands on the stems, leaves, and floral capitula produce a nauseating, tar-scented, sticky exudate that is readily transferred to clothing or animals upon contact. *M. glomerata* is rarely grazed by livestock and thus has virtually no forage value. The weed is allelopathic and prevents establishment or reduces growth of various desirable forbs and grasses (Carnahan & Hull, 1962).

In southeastern Washington, cluster tarweed was consistently attacked by the noctuid *Heliothis phyloxiphaga* Grote & Robinson. Although much biological information is available for the more important agricultural pest species of *Heliothis* such as *H. virescens* (F.) and *H. zea* (Boddie) (Hardwick, 1965), very little is known about the bionomics of the non-economically important species including *H. phyloxiphaga*. This lack of information prompted the present investigation.

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METHODS

Studies on the biology of *H. phyloxiphaga* were conducted in the laboratory and correlated with observations made in the field at several sites within a 15 km radius of Pullman (Whitman County) in southeastern Washington from 1979–83. Laboratory rearings, initiated from field-collected eggs and larvae, were maintained at 20–25°C, 40–50% RH, and 14 L:10 D hour regime. Eggs were confined to 10.0 × 1.5 cm plastic petri dishes lined with moistened paper towelling until hatching occurred. Newly emerged to mid-fifth stage larvae were reared individually in petri dishes provisioned with a moistened paper substrate and sufficient host plant material. The paper and food were replaced daily. Nearly mature larvae were transferred to ventilated 7.0 × 8.5 × 3.5 cm clear plastic boxes filled with sandy loam soil for pupation. Pupae remained in the cages until adult eclosion.

Emergent moths were sexed, paired, and placed in cylindrical (15 cm diam × 30 cm high) translucent plastic cages ventilated apically with fine mesh saran screen. A 2 dr shell vial filled with a 20% honey-water solution and plugged with cotton dental wicking along with several freshly-excised, field-collected *M. glomerata* floral shoots inserted through the Parafilm® seal of a water-filled receptacle were placed in the cage and replenished as needed. Nocturnal observation of adults was accomplished under red illumination (simulated darkness).

RESULTS

Distribution. *H. phyloxiphaga* has a distribution that ranges from the Mississippi River west to California, north to the Canadian provinces of Alberta and British Columbia, and south to Mexico, with additional records from Illinois, Massachusetts, and New York (Forbes, 1954; Crumb, 1956).

Host plants. Based upon an examination of pertinent literature, the moth has a broad host range. In addition to *M. glomerata*, the following larval food plants have been noted by Grote and Robinson (1867), Crumb (1926, 1956), Forbes (1954), Tietz (1972), and T. F. Watson (pers. comm., Univ. Arizona): COMPOSITAE: *Achillea millefolium* L., *Balsamorhiza* sp., *Chaenactis douglasii* (Hook.) H. & A., *Erigeron divergens* T. & G., *Grindelia camporum* Greene, *G. robusta* Nutt., *G. squarrosa* (Pursh) Dunal, *Hemizonia congesta* DC., *Lactuca sativa* L., *Machaeranthera canescens* (Pursh) Gray, *Parthenium argentatum* Gray; GERANIACEAE: *Erodium cicutarium* (L.); GRAMINEAE: grasses; IRIDACEAE: *Gladiolus* sp.; LEGUMINOSAE: *Lathyrus* sp., *Medicago sativa* L.; POLEMONIACEAE: *Gilia aggregata* Spreng., *Phlox* sp.; ROSACEAE: *Fragaria* sp.; SCROPHULARIACEAE: *Antirrhinum* sp.; and SOLANACEAE: *Schizanthus* sp.

Description of stages. Egg. The pearly pale yellow hemispherical egg averaged 0.63 ± 0.25 mm in height and 0.69 ± 0.03 mm in diameter (n = 25). The chorion was sculptured with numerous prominent ribs that radiated from a nipple-like micropyle positioned at the apical pole. A reddish purple band developed in the micropylar half of the egg within 72 h of deposition, and as embryogenesis proceeded the entire egg assumed a brownish grey color.

Larva. The first-stage larva was creamy grey with a blackish brown head capsule and prothoracic shield. The second-stage larva differed little except for a somewhat paler head capsule, prothoracic shield, and greenish grey color. Definitive maculation and coloring become evident in the third-stage larva and are maintained in fourth- and fifth-stage larvae. The fifth-stage larva had a greenish brown to beige head capsule mottled with brown and a light green or olive-green body. An excellent description of the mature larva is given by Crumb (1926, 1956) and abbreviated descriptions occur in Lange and Michelbacher (1937) and Stahler (1939). Lange and Michelbacher (1937) also included a photograph of the mature larva and pictured the larval chaetotaxy.

The body lengths of ten first- through fifth-stage larvae averaged 2.72 ± 0.48 mm, 5.62 ± 0.75 mm, 12.09 ± 3.89 mm, 19.56 ± 1.29 mm, and 28.15 ± 3.30 mm, respectively. First- and second-stage larvae experienced an average increase in length of 47% between successive molts, whereas, third- to fifth-stage larvae grew 65%. Mean cast head capsule widths of the five instars were 0.32 ± 0.02 mm, 0.52 ± 0.05 mm, 0.90 ± 0.10 mm, 1.61 ± 0.06 mm, and 2.55 ± 0.16 mm (n = 15), respectively.

Pupa. The pupa was obtect and glossy golden amber when first formed but became chestnut-brown as it matured. In the male, the slit-like genital opening bordered by a pair of tubercles was situated mid-ventrally on the ninth abdominal segment. In the female, the genital aperture occurred on the eighth abdominal segment. The cremaster consisted of two slightly curved, divergent spines arising from the conical apex of the tenth abdominal segment. Lange and Michelbacher (1937) provided a photograph of the pupa. The mean length of 17 pupae was 16.89 ± 3.96 mm.

Adult. Adult *H. phyloxiphaga* males and females are similar in appearance. When viewed from above, the body and forewings are a dull brownish yellow with a distinctive olive-green tinge, the forewings being marked with several brownish black spots and brown to greenish fawn irregular transverse bands. The maculation of the creamy buff hindwings consisted of a dull black discal spot and a black, broad, transverse marginal band interrupted by a central creamy buff patch. Detailed descriptions of the adult are given by Grote and Robinson (1867) and Forbes (1954). Lange and Michelbacher (1937) included a photograph of a series of adults showing subtle color and maculation variations and also illustrated the male genitalia. The mean body length and alar expanse of 25 adults was 14.5 ± 0.6 mm and 33.0 ± 1.0 mm, respectively.

Life history and habits. In the southernmost portions of its range, *H. phyloxiphaga* may be bivoltine (Lange & Michelbacher, 1937; Forbes, 1954), with first and second generation adults appearing from April–May and July–August, respectively. In Washington the moth was univoltine. Based upon field observations and examination of label data from specimens deposited in the M. T. James Entomology Collection, Washington State University, adult activity commenced in late June and extended to early September, with peak populations being recorded from mid-July to early August. Crumb (1956) reported similar findings regarding seasonal occurrence of the adults.

Adults were not commonly encountered in nature. The moths are inactive during the day and were occasionally observed clinging to stems of dead weeds or grasses and amongst leaf litter, the coloration of the closed forewings blending imperceptibly with the resting substrate, presumably affording the adult protection from predation. If disturbed, adults flew short distances before resettling. Adult feeding was not observed in the field, but individuals readily imbibed the honey-water provided in the laboratory.

Mean longevity of 24 laboratory-reared males was 13.7 ± 6.3 (range 5–30) days; longevity of females was 12.5 ± 8.9 (range 4–29) days. The sex ratio of 44 cultured adults was 1.2:1 (24 males : 20 females).

Mating behavior was not observed for *H. phyloxiphaga* but it is probably similar to that described for *H. virescens* (Lingren et al., 1977) and *H. zea* (Callahan, 1958).

The preoviposition period, from emergence to first deposition of eggs, for six females averaged 6.2 ± 2.3 (range 4–8) days. Based only upon days when these females oviposited, they laid an average of 29.8 ± 26.4 (range 1–130) eggs per day over a 12.0 ± 6.9 (range 4–23) day period, with the majority of eggs being deposited during the first seven days. Total eggs laid per female ranged from 53–536, the average being 282.3 ± 190.6.

Oviposition was generally a crespuscular activity. Plants averaging 40.0 ± 10.8 (range 17.5–62.5) cm in height (n = 125) with terminally developing inflorescences were selected for oviposition purposes. When an acceptable ovipositional site was encountered by a mated female she momentarily alighted on a cluster of flower heads and rapidly vibrated her wings prior to egg deposition. Wing movement ceased as the female appressed the tip of her abdomen to the outer surface of an involucral or receptacular bract to which she affixed an egg, the deposition process requiring only one or two sec. The female resumed flight and laid additional eggs on the same plant or on nearby plants. In the laboratory, females would often feed and/or rest for brief intervals during the oviposition period. Field observations revealed that females deposited nearly equal numbers of eggs on the bracts of the involucre or receptacle. Of 28 eggs laid on involucres, 16 (57%) were attached to the central head in a cluster, the others being affixed to peripheral heads. Egg distribution on 100 field-examined plants was as follows: 60 had a single egg, 24 had 2 eggs, nine had 3 eggs, four had 4 eggs, five had 2 eggs, and one plant had 6 eggs. Eggs were found in nature from mid-July to the first week in September.

Prior to hatching, the larva assumed a U-shape within the eggshell, with the head and caudal end tightly compressed at the micropylar end. The larva chewed a ragged hole through the chorion in the polar or equatorial region. When the orifice approximated the size of the head capsule, the larva exited by peristaltic contractions of its body. The entire hatching process required ca. 12–15 min. The chorionic remnant was generally not consumed by the neonatal larva. The incubation period of 48 laboratory-laid eggs was 5.4 ± 0.5 days. Viability of these eggs exceeded 98%.

A newly emerged larva initially fed sparingly upon the epidermis and underlying parenchyma cells of the bracts upon which the egg had been laid. Soon thereafter the larva crawled to and chewed a hole through an involucre near its mid-point or base and entered, wherein, it fed upon the developing florets and immature achenes. A sparse, irregular deposition of silk was evident upon and amongst the stalked glands of the infested involucre. The webbing and extruded frass pellets provided concealment for the feeding larva. Each cluster tarweed involucre contained ca. 12 (range 8–20) achenes that were destroyed or damaged by larval feeding. A first- and second-stage larva was each capable of destroying four to five involucres. Attacked involucres shriveled and failed to open. Third- to fifth-stage larvae were external feeders on flowers, involucral and receptacular bracts, and leaves but would not eat achenes approaching maturity. These larvae, especially in dense stands of the weed, moved from plant to plant feeding upon the succulent tissues and defoliating the flowering shoots. Larvae of this age category were highly cannabalistic, and consequently, only a single larva per plant was found in nature. The green larvae were not easily discernible among foliage and flower heads, their cryptic coloration probably affording a degree of protection from predators. Older larvae, when disturbed, either regurgitated a droplet of green fluid or dropped from the plant to the soil, assumed a coiled posture, and remained motionless for several minutes.

The duration of the first to fifth stadia averaged 4.0 ± 0.3 (range 3–5) days ($n = 53$), 3.7 ± 0.7 (range 3–5) days ($n = 43$), 4.0 ± 0.7 (range 3–6) days ($n = 34$), 6.2 ± 1.0 (range 5–8) days ($n = 26$), and 7.9 ± 1.0 (range 6–9) days ($n = 19$), respectively.

The fifth-stage larva stopped feeding during the sixth to ninth day of development. The larva became strongly positively geotactic and descended to the soil and burrowed to a depth of 1.5–4.0 cm. Having reached a suitable depth, the larva constructed an emergence tunnel and elliptical pupal cell. The smooth-walled, sparsely silk-lined chamber averaged 20 mm in length and 10 mm in diam ($n = 20$). The upward-sloping emergence tunnel was sealed with a loosely fitting plug of silk-bound soil particles.

Upon completion of the cell, the larva contracted to ca. 50% of its former length ($\bar{x} = 18.5 \pm 2.29$ mm; $n = 8$), assumed a lime green color, and became quiescent. About 24 h later, the prepupal integument ruptured medially along the dorsum of the thorax and the head of the pupa emerged through the slit. The integumental remnant was slid posteriorly by body movement of the pupa and eventually formed a loose mass at the base of the cremaster. Pupal emergence was completed in ca. five min. The duration of the prepupal period, from feeding cessation to pupa formation, was 3.2 ± 0.4 days ($n = 20$).

The pupa was usually positioned within the cell with the head directed toward the emergence tunnel. If physically disturbed, the pupa slowly rotated its abdomen in a clockwise direction.

In the field, pupation occurred from late August to early October, the pupa overwintering in an obligate diapause state. The pupal period of 59 laboratory-reared, non-diapausing individuals averaged 17.5 ± 2.1 (range 13–23) days.

Adult eclosion was facilitated through fractures in the pupal exuvium, which developed dorsally along the thorax and ventrally near the antennae. The adult then freed itself by alternate expansions and contractions of the abdomen and leverage afforded by the legs. Emergence took place within the pupal cell, and the crumpled winged adult exited through the tunnel to the soil surface where wing expansion and integument hardening was accomplished. Adult emergence was a nocturnal event, occurring between 2100 and 0300 h.

Natural enemies. The anthocorid, *Orius minutus* (L.), was observed feeding on the eggs of *H. phyloxiphaga*. However, the extent to which this predator destroyed eggs was not determined.

An unidentified braconid, a primary solitary larval parasitoid, was responsible for ca. 25% of the late stage larval mortality observed in nature. Intraspecific, internecine combat also contributed to larval mortality as previously noted.

No pupal or adult parasitoidism or predation was observed during the study.

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GENERAL NOTES

AN UNUSUAL OVIPOSITIONAL SITE FOR *AMPHIPYRA TRAGOPOGINIS* (L.) (NOCTUIDAE)

Egg clusters (4–12 eggs) of *Amphipyra tragopoginis* (L.) were found within the cavities of 30 helicoid cases of *Apterona helix* (Siebold) (Lepidoptera: Psychidae) (Fig. 1) during observations in Lenox, Massachusetts of the presence of a large aggregation of these garden bagworm larval cases attached to above ground substrates including: domiciles, wood fencing, grasses, weeds, shade trees, ornamentals, planted flowers and vegetables.

Although samples of the helicoid cases were collected from the above mentioned substrates, the only cases containing eggs were collected from untreated wood fencing.

These observations suggest that tiny crevices on tree trunks and branches or "artificial" above ground surfaces may be used by gravid *A. tragopoginis* females as oviposition sites. Two closely related species, *Amphipyra pyramidoides* (Guen.) and *A. glabella* (Morr.), oviposit in crevices on trees and twigs of their hosts (J. G. Franclemont, pers. comm.), indicating that members of this genus prefer similar oviposition sites.

It is not suggested that *A. helix* is an "obligate" in the life cycle of *A. tragopoginis* but that the cases by chance provide an appropriate stimulus for oviposition behavior by *A. tragopoginis*.

The identity of *A. tragopoginis* was confirmed by using adults obtained from larvae reared on artificial diet.

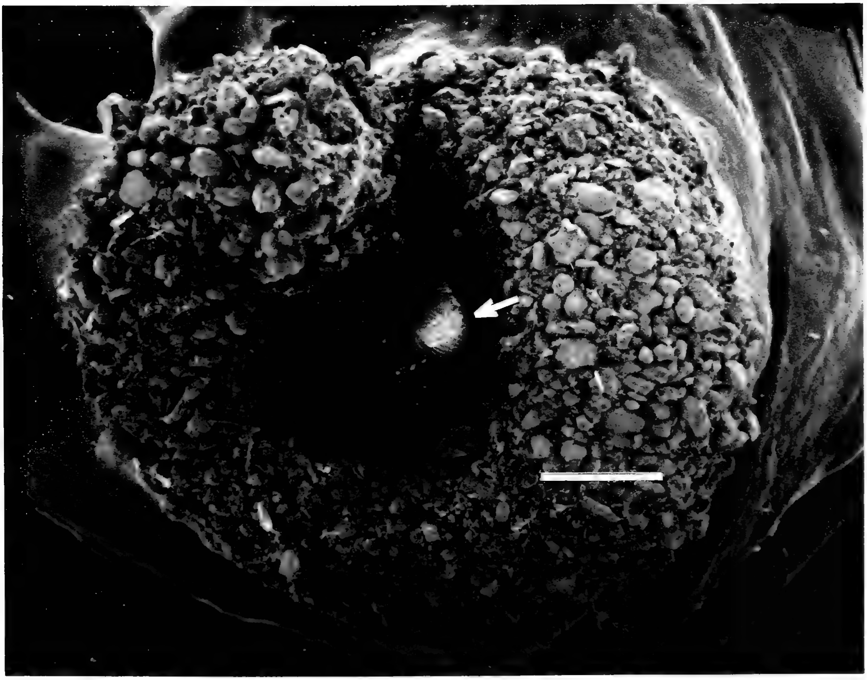

FIG. 1. SEM of egg cluster of *Amphipyra tragopoginis* (L.) (note arrow) within cavity of larval case of *Apterona helix* (Siebold). 33×. Scale line = 1 mm.

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ACER NEGUNDO (BOXELDER) AS A FOOD PLANT FOR *SYNANTHEDON ACERRUBRI* (SESIIDAE)

On 30 June 1983 quite by accident I discovered a *Synanthedon acerrubri* (Engelhardt) ovipositing on a somewhat distressed *Acer negundo* (boxelder) (Aceraceae) in my yard in Liberty, Missouri. A total of 18 *acerrubri* were caught through the 16th of July 1983. At least one specimen was caught on all of the intervening days except the 8th and 15th, two days on which I did no collecting at all. Eight females and ten males were caught. Prior to this only seven males had been collected in Missouri, to the best of my knowledge. All of my specimens were caught on one of three *A. negundo* growing in my yard. They favored the most distressed tree. Other trees in the yard and neighborhood were checked for visitation. This included other members of the maple family, plus cherry, pear, elm, hackberry and cottonwood.

Initially, I tried to catch the specimens with a net on which I had pinned male sex attractant. No males seemed attracted to the bait at that time or when I subsequently pinned the attractant to my shirt during my collecting. Almost all of the specimens were caught with a small killing jar, the moths being taken directly off the trees.

Most were seen ovipositing or resting no more than a foot from the ground on the bark of the host tree. Only three were seen or caught at a height above 4 ft. All except one specimen were caught between 1430 and 1900 h. They appeared most commonly around 1730 h. None was seen mating. A number of pupal cases were found projecting from the trunk of the most distressed looking *A. negundo* and appeared similar to that pictured in Holland (1903, The moth book, Doubleday, Page & Co.) for *Synanthedon acerni* (Clemens). It would seem logical to assume that these were pupal cases of the *S. acerrubri*, but none was seen emerging.

This may not be the normal time of emergence since it was a very late year for many Lepidoptera species in Missouri. J. Richard Heitzman (pers. comm.), who collected the other recorded specimens in Missouri of which I am aware, captured all of them in his yard in Independence. He caught five male *acerrubri* nectaring at *Asclepias syrica* (purple milkweed, Asclepiaceae) between the 10th and 29th of June over a number of years, and two male specimens were collected while responding to a specific sex attractant at approximately 1145 h, 11 July 1982 and 9 July 1983. These latter dates correspond nicely with the dates that I collected the 18 specimens.

In 1984 a total of 63 *acerrubri* were caught at the two most distressed boxelder in my yard. All were caught between 1600 and 2020 h from 9 June to 13 July. Three males came to an attractant at a different location in the yard. They were caught while resting on leaves at this location (one at 1600 h on 2 July and two at 1820 h on 9 July). A total of 65 *acerrubri* (31 males and 34 females) were caught. One specimen was sighted but not caught on 24 July. Once again pupal cases (16) were seen projecting from the trunks of the *A. negundo*.

S. acerrubri occurs in the eastern United States and is known to feed on *Acer rubrum* (red maple) and *A. saccharum* (sugar maple), according to Engelhardt (1946, The North American clear-wing moths of the Family Aegeriidae, U.S. Nat. Mus. Bull. 190). *A. negundo* is apparently an unrecorded food plant for *acerrubri*. Since the growth of boxelder is widespread, the moth may be more common than previously thought but has gone undetected.

I am grateful to J. Richard Heitzman for his aid in identifying and determining the sex of the specimens and for being so generous with his time and knowledge. My son, James Adams, deserves my thanks for reviewing this manuscript.

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ON THE ORIGIN OF SNOUT BUTTERFLIES (*LIBYTHEANA BACHMANII LARVATA*, LIBYTHEIDAE) IN A 1978 MIGRATION IN SOUTHERN TEXAS

Southern Texas periodically is the scene of migrations by the snout butterfly, *Libytheana bachmanii larvata* (Strecker). The last massive migration in Texas occurred during summer 1971 (Helfert, 1972, Entomol. News 83:49–52; Neck, 1983, J. Lepid. Soc. 37:121–128). More frequent than these "cloud-type" migrations are the smaller-scale migrations which rarely extend beyond the northeastern boundary of the South Texas Plains (line from San Antonio to the Gulf Coast north of Corpus Christi). A series of these more restricted migrations was observed during four traverses of the area in June, July and September of 1978. Comments from two observers will be integrated into personal observations. The primary thrust of the investigation of this migration was to determine the geographical origin of the migrating butterflies. A secondary thrust was to document a relationship between density of butterfly flights and local habitat.

28 June 1978. On the Coastal Plain of Texas, a low-density migration was observed from north of Refugio, Refugio Co., to south of Sinton, San Patricio Co. (Fig. 1). Density of migratory snout butterflies varied with vegetation and urban/rural settings (Table 1). Snout butterflies were not very common over recently-harvested sorghum fields, were most abundant in areas of invaded brush patches (dominated by mesquite, *Prosopis glandulosa*), and were less common but not absent from urban areas, e.g. Woodsboro (a small farming community center). Note should be made that some brush plots exhibited no flying butterflies.

Most snout butterflies were flying an approximate west-to-east flight path. Azimuth directions of compass heading of butterflies at four localities were as follows: 1) Refugio, 110°; 2) Sinton, 115°; 3) IH37/US 77 bridge over Nueces River, 85°; and 4) 5 km south of Kingsville, 80°. These flight lines were extended inland in an attempt to discover source regions of these butterflies. While no information is available on the distance flown by these butterflies, flight lines (Fig. 1) indicate a broad source area for the observed snout butterflies. Several butterflies were observed moving westward temporarily as a result of vehicle-caused air turbulence. Several butterflies were observed being forced along the axis of the highways when two semi-trailer trucks approached and passed each other. The only other butterfly species associated with the migrating snouts were occasional specimens of the queen, *Danaus gilippus strigosus* (Bates), which totaled less than five percent of the total butterfly count.

2 July. Traveling northward from Brownsville, Cameron Co., the first snout butterflies were encountered just north of Kingsville. Butterflies were traveling eastward (exact azimuths not measured) and were common to Robstown and Mathis. Snout butterflies

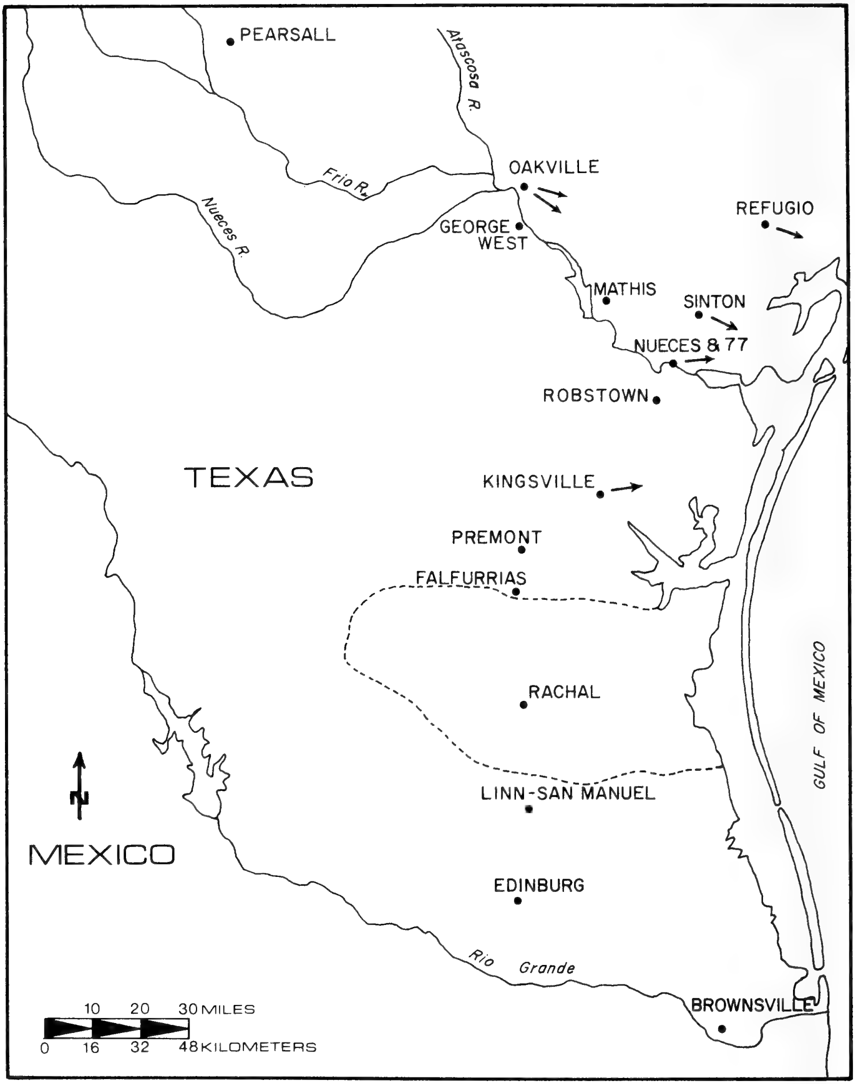

FIG. 1. Map of southern Texas with localities of observations and flight directions of *Libytheana bachmanii larvata*.

were extremely abundant southeast and north of Oakville. Flight directions were variable, but the majority were flying somewhat south of east (Fig. 1). A sample of the snout butterflies revealed that freshly-emerged adults of both sexes were migrating (no sex-ratio recorded). Associated species were (*Kricogonia lyside* (Godart) (yellow and white morph), *Eurema lisa* Boisduval and Le Conte, and *Phoebis sennae* (Linnaeus). These species were much less common than the snouts, which represented approximately 99% of the migrant butterflies.

TABLE 1. Number of snout butterflies, *Libytheana bachmanii larvata*, observed in highway driving counts, summer 1978.

Habitat	Highway length (km)	Butterfly number
28 June		
Woodsboro	1.1	5
Nueces River bridge	0.5	8
Cut sorghum field	0.5	0
Brush plot	0.5	15
26 September (south of George West)—paired habitats		
Pasture-Brush	0.6 each	5–9
Pasture-Brush	0.6 each	12–24
Pasture-Brush	0.6 each	39–47

Observation by informants. A letter dated 28 June 1978 from George Toalson of Pearsall, Frio Co., reported "thousands" of snout butterflies which exhibited no "particular direction in their flight pattern" and were observed to "congregate at damp places on roadsides and on anything that has flowers on it." Phone conversation with Toalson revealed a slow buildup in the Pearsall area. Rains had occurred in mid-May and early June. Common plants visited were virgin's bower (*Clematis drummondii*) and cowpen daisy (*Verbesina encelioides*). Many snout butterflies had been killed by pesticide which had been sprayed on a field of peas; the "ground appears brown with bodies." Note that snout butterflies had been observed in 1971 in Austin, Travis Co., feeding at internodes of bean plants (Neck, op. cit.).

J. Stephen Neck reported to me on 10 July that he observed no snout butterflies between Brownsville and Austin (via highways 77, 181, 80 and 183) on that day.

26 September. Driving south from Austin, snout butterflies were first encountered near Oakville where movements were in varied directions. In the region from 8 to 13 km south of George West, Live Oak Co., snout butterflies generally were traveling in directions between 105° and 125°. At a point 29 km south of George West (Live Oak–Jim Wells County line), they were flying as high as 3 m above the soil surface, although some individuals were observed to land upon the road bed (U.S. 281). Also present were a number of *Phoebis sennae*, some of which exhibited courtship behavior.

A series of paired brush and pasture segments between 30 and 35 km south of George West in Jim Wells Co. revealed greater numbers of snouts crossing the highway in areas with native brush communities than areas with pastures (Table 1). The effect, however, appears to lessen as butterfly density increases. In this area brush communities are dominated by brasil (*Condalia hookeri*), whitebrush (*Aloysia gratissima*), mesquite, retama (*Parkinsonia aculeata*), guayacan (*Porlieria angustifolia*) and granjeno (*Celtis pallida*). This last species is the prime larval foodplant of the snout butterfly in southern Texas. Pastures are dominated by buffelgrass (*Cenchrus ciliaris*), an exotic grass native to Africa. Butterflies flying at the same sites included *Euptoieta claudia* (Cramer), *Eurema lisa*, *Zerene cesonia* (Stoll), *Phoebis sennae*, *Papilio cresphontes* Cramer, *Danaus gilippus* and *Anaea andria* Scudder. Also present were substantial numbers of the green darner dragonfly, *Anax junius*. A few snout butterflies were observed chasing *D. gilippus*.

Moving southward I approached the southeastward edge of the area containing large numbers of snout butterflies. A few were seen in Premont, but none were seen in Falfurrias. West of Falfurrias on Farm-to-Market 285, snout butterflies were abundant. Most individuals were moving approximately southward, although some were flying in the opposite direction. One individual altered its flight direction by 180° when approached by a group of 10 to 12 snout butterflies. Migrating snout butterflies had been observed by local residents for three days. South of Falfurrias in the vicinity of Rachal, they were much less common. Very few were observed at Linn-San Manuel. No snout butterflies were observed in the Lower Valley between Edinburg and Brownsville.

29 September. Traveling northward from Brownsville again, no snout butterflies were observed until an area north of Mathis (on Farm-to-Market 359) was reached. In the area south of Mathis, a large number of butterflies were observed crossing the highway; over 90% were *Danaus gilippus*. *Anax junius* was once again common. Even in the Mathis area, snout butterflies were not common.

Origin of migrating snout butterflies. Observation of flight directions of snout butterflies in areas with near unidirectional movements (Fig. 1) indicates that some area of inland southern Texas was the source area of the 1978 snout migration. Observations along the margins of this inland area revealed large scale movements without concentrated peaks of compass directions, but with a tendency for flight away from an area still further inland. Backward tracing of flight directions and the observations of Toalson indicates a source area south of San Antonio which includes the vicinity of Pearsall. Brush communities in this area of southern Texas contain large percentages of *Celtis pallida*, the favored larval foodplant of the snout butterfly. Low densities of snout butterflies observed south of Falfurrias are indicative of the lack of *C. pallida* in the Llano Mesteno, a large area of mixed grassland and savannah.

Analysis of previous snout butterfly migrations (e.g. Neck, op. cit.) has revealed an association with exceptionally heavy rainfalls. A large, cloud-type migration in 1971 followed widespread, heavy rains in southern and central Texas. These summer rains followed the intense drought of 1970 and 1971.

The 1978 migration discussed above is believed to be related to precipitation patterns, although the system operating in 1978 differed significantly from 1971. The period from summer 1977 to spring 1978 was characterized by rainfall deficiencies (Climatological data—Texas, U.S. Department of Commerce). Drought conditions were not as severe as the situation present in early summer 1971, however. Higher than normal rainfall occurred in May and June (1978) but was spotty in distribution; general rains were not experienced at this time. Rainfall in July was generally below normal, while August was wetter than normal.

The scattered nature of the 1978 rainfall (in both time and space) resulted in a mosaic of areas with flush growth of the larval food plant, *C. pallida*. Isolated centers of butterfly concentrations developed and generated the comparatively local migrations which were observed in July and September 1978.

The lack of migrating snout butterflies in deep southern Texas was due to two factors. Lack of butterflies in the Llano Mesteno area was due to lack of the prime larval foodplant. Lack of butterflies south of the Llano Mesteno in the Lower Rio Grande Valley (area along the Rio Grande, including Brownsville) was due to lack of heavy rainfall. Continued drought in this latter area precluded rapid growth of the prime larval foodplant, *C. pallida*.

I thank George Toalson and J. Stephen Neck for observations on the movements of snout butterflies in 1978. T. B. Samsel III drafted Fig. 1.

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A BILATERAL GYNANDROMORPH OF *ANTEPIONE THISOARIA* (GEOMETRIDAE)

An interesting bilateral gynandromorph of the geometrid moth, *Antepione thisoaria* (Guenée), was collected at mercury vapor light in August 1974 about 11 km southwest of Nashville, Tennessee. This specimen (Fig. 1) has a wingspan of 34 mm with male hindwing coloration on the right side and female to the left; the irregular brown patches towards the margins of each forewing suggest a mixture of male and female traits. The wing-coupling apparatus and genitalia are of male type on the right side and of female type to the left.

I am grateful to A. Watson and Drs. D. S. Fletcher, R. W. Hodges and D. C. Ferguson for their comments concerning this specimen which is presently in the author's possession.

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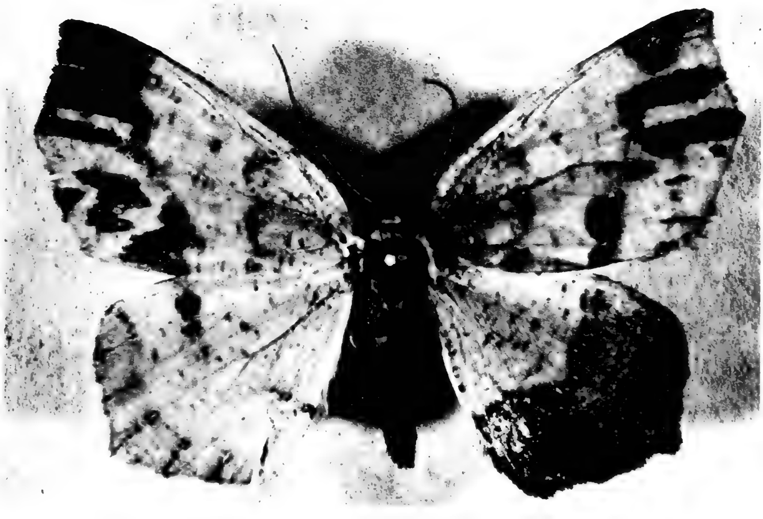

FIG. 1. Bilateral gynandromorph of *Antepione thisoaria* (Guenée).

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BOOK REVIEWS

Systematische Untersuchungen am *Pieris napi-bryoniae*-Komplex (Lepidoptera: Pieridae), by Ulf Eitschberger. 1983. *Herbipoliana 1*(1), 504 pp.; *1*(2), 601 pp. Published by the author and Hartmut Steiniger. Available from the author at Humboldtstrasse 13, D-8671 Marktleuthen, West Germany, and from entomological book dealers. (Due to fluctuations of the Mark against the Dollar, current prices are not available. Early in 1984 the price was 360.– DM + 15.– DM international postage.)

The biosystematics of the *Pieris napi* group remains one of the great intractable problems in the Holarctic butterflies. This is despite the massive and valiant revisionary effort represented by this lavishly-produced monograph, which has truly been a labor of love for its author.

Systematische Untersuchungen ("Systematic Investigations"), hereafter referred to as *S.U.*, brings together in one place more morphological and distributional data on the *napi* group than have ever been assembled before. Eitschberger did an incredible amount of finely detailed morphological work, which is reflected in extraordinary series of photographs (optical and SEM) and drawings of characters of both adults and immatures. The entire second volume is made up of illustrations, among them 218 color plates averaging over 30 specimens/plate. The photographs are meticulously produced and the colors by and large very true. Within each taxon a range of variability is usually represented, including seasonal forms and sexual differences; for *napi* and *bryoniae* numerous aberrations, rare genetic morphs, and sexual mosaics are also presented. The same specimens are usually shown in upper and lower surfaces on the same plates. For some reason the ventral surfaces are printed slightly smaller than the corresponding dorsals, which is confusing. There is no back-referencing system from the plates to the text, and the forward-referencing system is somewhat clumsy.

The first volume of *S.U.* contains all the text, plus numerous distributional maps. Except for long quotes from the primary literature, which are reproduced from the originals by photo-offset and are thus in their original languages, the text is in German and will not be easy going for readers unskilled in that language. (The most important previous work on the group, the monograph on *napi* and *bryoniae* by Müller and Kautz, is also in German and is even more strenuous reading. Moral: If you want to work on the *napi* group, learn German.)

Volume 1 is divided into a fairly brief overview of previous taxonomic work in the group and of the morphological characters deemed to be of value in such work, and a very lengthy taxon-by-taxon treatment which does include "biological," live-bug information when available. Twenty-five species are recognized, with a total of 48 subspecies in addition to the nominate ones. The species are grouped into four sets: a Eurasiatic complex of 11 species, including true *napi* and *bryoniae*; a North American group of six (to be discussed below); and two Asiatic groups of four species each. There is a tabular summary of character states for the taxa of the first group (pp. 46–51).

Even a casual inspection of volume 1 reveals a number of potential problems. (1) Geographic coverage is extremely uneven. This is presumably no fault of the author, who in fact has been remarkably successful in assembling material from odd places. But as one might expect, distributions are mapped in almost infinitesimal detail in western Europe (diminishing rapidly to the east!), moderate (and to this reviewer, rather unsatisfactory) detail in North America, and poorly indeed in Asia—where, except for Japan, most taxa are represented by a handful of widely separated, random-looking dots on the map. The inevitable result is that taxonomy is much coarser in some areas than in others. (2) The author is not an ideologue, and does not attempt to force the taxa into the formalisms of cladistics or the quantitative definitional modes of phenetics. He is, however, apparently not much of an evolutionist or biogeographer either, and he has an old-fashioned, implicitly typological and explicitly morphological species concept. His work thus most resembles the alpha-taxonomy done on poorly-known groups of bark beetles from Java, and is not at all like what one has come to hope for in the Holarctic butterflies in these sophisticated times. (3) The naming of new taxa has been promiscuous and based on the sort of species concept just described. Many of the new taxa are unlikely to sit well with regional specialists, and many are apt to be ignored or to be treated as junior synonyms of more familiar names, at least until more information about the biology of the animals is available. All these points are relevant to the handling of the Nearctic fauna.

Eitschberger recognizes 18 taxa in the Nearctic, of which nine, or 50%, are new. They are (* = Eitschberger name): *Pieris venosa venosa*; *P. oleracea oleracea*; *P. o. ekisi**; *P. marginalis marginalis*; *P. m. reicheli**; *P. m. pallidissima*; *P. m. mcdunnoughi*; *P. m. mogollon*; *P. m. hulda*; *P. m. meckyae**; *P. m. guppyi**; *P. m. tremblayi**; *P. m. shapiroi**; *P. m. browni**; *P. acadica acadica*; *P. angelika angelika**; *P. virginiensis virginiensis*; *P. v. hyatti**. He is not certain that all the *marginalis* subspecies are conspecific. There are also brief discussions of several additional *marginalis* populations he is unwilling to name for lack of good series. Most of the new taxa occur in northwestern North America, from Alaska to British Columbia. (*P. angelika,* named for Eitschberger's wife, was actually described in 1981 in a paper in the German journal *Atalanta,* which Eitschberger edits. It is generally unheard of in North American lepidopterological circles. The other new taxa are named and described in *S.U.* itself. *Angelika* is described at the species level for reasons which are not terribly clear. It is mostly allopatric with the various *marginalis*-taxa, but there is a suggestion of sympatry in a few places. Aside from the co-occurrence of *oleracea* and *virginiensis* in a few localities in the northeastern U.S. and perhaps adjacent Canada, this would be the only instance in which it is alleged that members of the *napi* complex occur sympatrically in the Nearctic.)

I have accused Eitschberger of being typological, and I should qualify this by saying that a summary of character-state distributions—raw data only—for selected wing characters is given for most taxa based on the series he examined; and, as noted already, the illustrations portray a good range of variation. Nonetheless, one is left unsatisfied as to the criteria used to recognize and rank taxa; basically, we are being asked to trust the author's judgment. I have discussed this with Eitschberger with specific reference to the northwestern Nearctic taxa, and it is quite plain to me that his weighting criteria are perfectly clear to **him**. But they are not to me. In fact, I do not consider my own patronymic, *shapiroi*—which I have never seen alive; oddly, I have apparently worked on the population Eitschberger named *angelika*—to be well-defined and find it a good candidate for sinking. (I won't miss it.)

North Americans tend to bristle at the idea of Europeans working on their fauna from a distance; after all, we are no longer colonials. Such jingoistic reactions should play no role in how we evaluate Eitschberger's treatment of the Nearctic *napi.* Most Nearctic workers who know our taxa by experience will, however, be properly suspicious of his weighting and grouping. Northern California workers, for example, know that a very complex situation exists in that region in which *venosa*, *marginalis*, and *pallidissima* are all involved; there is no hint of that here. Entities which are considered allospecific by Eitschberger may or may not be interbreeding in such zones. Such information must ultimately override inferences from morphology. Eitschberger's logical structure would fall apart if interbreeding cuts across his morphological criteria for species status. But does it?

The pitfalls, not only of Eitschberger's methods but of their application to this particular group, are shown by his contribution to the seemingly endless European *napi-bryoniae* problem. These two taxa are to European butterfly work what *Colias philodice* and *eurytheme* are in North America. Are they one species, or two, or something somehow inbetween? Given that they appear to interbreed in some places but not others, Z. Lorković proposed that they be treated as "semispecies," species *in statu nascendi*. But "semispecies" is not a taxonomic ranking, and one must decide what to call them. After much soliloquizing, Eitschberger opts to treat them as species and indeed to give *bryoniae* fifteen (!) subspecies of its own—extending the sense of the name to a large number of poorly-known, hitherto obscure, and very interesting Asiatic populations.

Meanwhile, at Bern, Switzerland, Hansjürg Geiger (1978, Entomol. Zeitschrift 88:229–235; 1981, J. Res. Lepid. 19:181–195; 1985, Experientia, 41:24–29) has shown that electrophoretically European *napi* and *bryoniae* are virtually identical (within-taxon variance sometimes exceeds between-taxon variance). This of course does not prove conspecificity (see below). It **is** entirely consistent with the hypothesis that the *napi-bryoniae* distinction is very recent (Holocene) as compared to many other taxic distinctions in *Pieris,* and it seems inconsistent with the schema developed by Eitschberger. Speaking from the gut, I am willing to bet that electrophoretic data will show Eitschberger's *bryoniae*-concept to be grossly polyphyletic. Again, time will tell.

Why is all this so unsatisfactory? Part of the problem is that Eitschberger's roots are in the German morphological tradition and not in Darwinism, so that we are not all speaking the same theoretical language. But that is only part of the problem; the other part derives from the animals themselves. The taxonomic characters in the *napi-bryoniae* group (if it **is** a monophyletic group) are mostly wing-color and -pattern things—things we know are commonly determined by a handful of loci. The correspondence between these characters and reproductive isolation is not good, as Lorković has shown us with his sibling species *balcana*. Most revisionary work in Lepidoptera involves morphological characters, especially genetalic ones. But in this group these characters are close to worthless. The differences are so slight—as the hundreds of drawings in vol. 2 show us—that Eitschberger is forced to seize on trivia and to weight them heavily in order to be able to define taxa at all. The results are, not unsurprisingly, not very satisfactory when we compare the *napi* complex to other groups in which nature has been kinder to the taxonomist.

And that is not all; such differences as exist are often overshadowed by phenotypic plasticity in the *napi* group. Most of the taxa are polyphenic; seasonal phenotypic differences within taxa are normally greater than differences in the corresponding seasonal brood between taxa; and pupal morphology varies depending on whether or not the individual is in diapause. All of this spells a mess of overwhelming proportions.

I maintain that in many cases, **only** reproductive-compatibility and/or electrophoretic data will permit proper species assignments in this group. Yet we can now see that **these two types of data may conflict with each other!** Geiger finds that, electrophoretically, *balcana* is no more different from *napi* than *bryoniae* is—but *balcana* and *napi* are highly intersterile (Lorković) while *bryoniae* and *napi* are more or less highly interfertile, with some exceptions. There is a hint in all of this of an infective or transposable genetic element responsible for sterility, something akin to the "hybrid dysgenesis" factors in *Drosophila.* If that should be the case, it kicks **all** conventional species concepts into a cocked hat.

Whatever the basis of sterility in hybrid crosses, it is certain that character reversals, parallelisms, and the like are lurking everywhere in the *napi* group. The European group of taxa clustering electrophoretically with *napi,* and probably the Nearctic ones grouped in *marginalis* and *angelika* by Eitschberger, seem to represent rapidly-evolving complexes consequent on Pleistocene and post-Pleistocene events. In northwestern North America there is reason to think one is dealing with two, perhaps three, invasions across Beringia—the oldest perhaps Tertiary, the youngest very recent. Preliminary electrophoretic data from Geiger, not available to Eitschberger, roughly support the latter's gross clustering of Nearctic taxa.

No grand synthesis is possible without genetics **or** without historical-biogeographical analysis **or** without cladistic reasoning (if not cladistic formalisms). If and when all this is done—and we intend to try it for the northwestern Nearctic—I suspect Eitschberger's judgments will be shown better than might have been forecast. But, I do not intend to start using his nomenclature until then.

Lionel Higgins has given this book a favorable review in the British journal *Entomologist's Gazette* (1984, 35:174–175). I cannot be so sanguine. (Higgins, by the way, seems to have gotten lost in this Teutonic tome; he asks what the structures shown in vol. 2, pp. 317–321, might be. They are the distal ends of the tongue-cases and antennae of pupae, as should be self-evident to anyone who has seen pierine pupae but at any rate is explained in vol. 1, p. 15.) Eitschberger, who is by profession a pharmacist, has gone to incredible trouble and almost unimaginable personal expense to provide us with this huge work. As I noted at the beginning, it is the biggest compilation of data on these animals ever assembled, and therein lies its primary value. The data cry out for other sorts of interpretation than Eitschberger has given them. Anyone interested in this most exasperating of groups, and who reads German, **must** have access to this book. If you are not willing to buy it, have your institutional library do so. Otherwise, it will become another Müller and Kautz. Possibly the only academic library copy of Müller and Kautz in the United States is at Yale, which prohibits photocopying of interlibrary loan materials. The only way to get hold of the book is to go to New Haven or to buy one through an antiquarian. Will *S.U.* disappear in similar fashion?

Eitschberger told me over a stein of beer that he hopes other people will take up and expand his work. That is good, for it must—and will—be done. *Systematische Untersuchungen* . . . could be read superficially (and apparently was, by Higgins) as the definitive resolution of the *napi* problem. It isn't. It is a beginning.

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DEAR LORD ROTHSCHILD (BIRDS, BUTTERFLIES & HISTORY). Miriam Rothschild. 1983. Hutchinson Publishing Group, 17–21 Conway St., London, W1P5HL. Format 7″ × 9¾″ 398 pp., including index & appendices. 90 pp. of B/W photographs. 12 pp. of color plates. Cloth bound. 14.95 (British pounds.)

One usually thinks of Lord Rothschild in connection with Karl Jordan or Ernst Hartert, both of whom were among his co-authors. In contrast, few people know the history of the Tring Museum, nor the other aspects of his life which took place beyond the boundaries of Tring. This book, written by his niece, is a revelation. It is a story of one life, liberally embellished with ancestors and heavily endowed with wealth. It is the story of the workings of Parliament, the education of the young, of action on the high seas, and of wild creatures, both alive and dead, which previously had never been known to the world.

"It is not easy to be born. The average man is squeezed out into the world with blood to lubricate his passage and wild shrieks of anguish to speed him on his way."

So begins the biography of Lionel Walter Rothschild, 2nd Baron of Tring.

At the age of seven, at tea time in the nursery, Walter suddenly stood and made the following announcement: "Mama, Papa, I am going to make a museum, and Mr. Minal is going to help me look after it." This prophesy came true.

Walter was the classic example of a child who shows little scholastic promise, but at some point becomes fired with enthusiasm in one particular field of endeavor to the extent that he becomes expert in that field to the exclusion of all else. A psychologist might have altered this, if such a person had existed in England at that time. He was born to a mother who was strict and sensorious on one hand—overprotective and indulgent on the other. His father was never able to understand either his love for animals or his failure in finances. From the beginning he had a speech defect which resulted in crippling shyness. He was tutored at home and rarely played with boys of his own age. All of this, added to the astronomical wealth of his family, contributed to his enigmatic personality.

He began his collections at the age of seven with one butterfly. By the time he was 19 he had collected 5000 birds (2000 of which he had already mounted) and 38,000 Lepidoptera. Two years later, his family built him a museum as a 21st birthday present.

This book mirrors the life-long curiosity of one man to discover and collect all the exotic forms of life, many of which are now extinct, or nearly so, from immense animals such as the Galapagos tortoises and elephant seals to the smallest of insects, the "fleas and lice from bats, birds and mammals." Included in his final inventory were 13 Gorillas, 62 Birds of Paradise, 520 Hummingbirds, 144 Giant Tortoises, 300,000 bird skins, 200,000 birds eggs and 2,250,000 Lepidoptera. Obviously such carnage would not be tolerated today, but perhaps it was a necessary prelude to the conservation movement, of which Charles Rothschild is considered to be the founder. In any case, the variety of perfectly mounted animals and birds were, at that time, a revelation and a major contribution to the understanding of the animal kingdom.

In 1889 when he was 21, Walter entered the firm of N. M. Rothschild & Sons, at the insistance of his father. He resigned in 1908, having spent most of his tenure not in banking but in editing his museum's publication, "Novitates Zoologicae," writing monographs and, with his salary, hiring collectors, planning and financing expeditions to remote places and corresponding with his collectors and crews.

During this same period he became involved with two scheming women at the same time, and still worse, his antics with them were such that an unidentified (and financially deprived) peeress enjoyed a life-long income by periodically blackmailing him. The First World War depleted his fortune still further.

His last decisive act was to sell his cherished collection of birds to the American Museum of Natural History in New York. He never told his family what he had done, and they only found out through an article in the Times five months later. After this deeply traumatic sacrifice, his ardour diminished. He died five years later.

The author's obvious esteem for her uncle is felt throughout the book. She narrates the adventures and the misadventures of this enigmatic man without censure, without apology, but with sensitivity and candor. She seems to lift him out of her feelings and set him in a place in the sun where all of his many facets can glisten and come and go.

The illustrations are outstanding. They are nearly a biography in themselves. Walter is seen at all ages, from adorable to cute to beautiful, to handsome, to distinguished. His mother is pictured in her coronation robes, worn at the coronation of Edward VII. There are many pictures of Tring Palace, Tring Park, ancestors and relations, one of King George V at Tring, and one of Queen Victoria—autographed.

The Victorian era has never seemed more wondrous than in the two generations of Rothschilds which dominate this book—Nathan Mayer, First Baron Rothschild of Tring and his wife, Emma Louise von Rothschild and their two sons, Lionel, Second Baron Rothschild of Tring and Nathaniel Charles. Hon. Miriam Rothschild, the author, is a daughter of Charles. It is owing in large part to her sympathy that this extraordinary family is made so lovable. In the end one has not read the story of one man only but of a devoted family whose fabulous wealth was shared by the world in ways not always clear, nor even comprehensible, but certainly in this book, memorable.

JO BREWER, *257 Common Street, Dedham, Massachusetts 02026.*

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38(4), 1984, 329–332

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(New names in **boldface**)

Date of Issue (Vol. 38, No. 4): 10 July 1985

NOTICE TO CONTRIBUTORS

Contributions to the *Journal* may deal with any aspect of the collection and study of Lepidoptera. Contributors should prepare manuscripts according to the following instructions.

Abstract: A brief abstract should precede the text of all articles.

Text: Manuscripts should be submitted in *triplicate*, and must be typewritten, *entirely double-spaced*, employing wide margins, on one side only of white, 8½ × 11 inch paper. Titles should be explicit and descriptive of the article's content, including the family name of the subject, but must be kept as short as possible. The first mention of a plant or animal in the text should include the *full scientific name,* with *authors* of zoological names. Insect measurements should be given in *metric units*; times should be given in terms of the *24-hour clock* (e.g. 0930, not 9:30 AM). Underline only where *italics* are intended. References to footnotes should be numbered consecutively, and the footnotes typed on a separate sheet.

Literature Cited: References in the text of articles should be given as, Sheppard (1959) or (Sheppard 1959, 1961a, 1961b) and all must be listed alphabetically under the heading LITERATURE CITED, in the following format:

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In the case of general notes, references should be given in the text as, Sheppard (1961, Adv. Genet. 10: 165–216) or (Sheppard 1961, Sym. R. Entomol. Soc. London 1: 23–30).

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16 October 1985

THE LEPIDOPTERISTS' SOCIETY

EXECUTIVE COUNCIL

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Cover illustration: Micropylar end view (×130) of the egg of *Sericosema* sp. (probably *juturnaria*) (Geometridae). The scanning electronmicrograph was taken by Thomas D. Eichlin, Sacramento, of eggs furnished by Ron Robertson, Santa Rosa, California.

JOURNAL OF
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NEW U.S. RECORDS AND OTHER INTERESTING MOTHS FROM TEXAS

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ABSTRACT. Twenty-eight moths, most of which are recorded from the U.S.A. or Texas for the first time, are illustrated. The text includes a brief description and distributional records known to the authors.

This paper reports 28 species of moths collected in Texas by the authors. In most cases, these have not been illustrated previously or have been mentioned only in publications that are now long out of print and difficult to obtain. The species were selected because in some cases they represent new U.S. records and are not included in the new *Check List of the Lepidoptera of America North of Mexico* (Hodges et al., 1983); in other cases, the species were included in the new check list based on the records given here, the specimens having been previously examined by the authors of the check list. Certain species were included because they represent important new range extensions. Finally, some represent species that have not been adequately illustrated previously. The authors hope that this information on striking and easily recognized species will be useful and that perhaps it will encourage others to develop an interest in this field of lepidopterology.

Sphingidae

Xylophanes libya Druce (Fig. 1). Hidalgo Co., Bentsen Rio Grande Valley St. Pk., 11-X-75, 1 male, E. Knudson coll. **New U.S. record.** Det. R. Hodges and V. Brou. This species is common in Mexico and has been collected there by the junior author within 200 miles of the border. The forewings are several shades of olive brown; hindwings are banded with black and dull orange yellow.

Noctuidae

Acronicta funeralis (G. & R.) (Fig. 2). Washington Co., Brenham, 1-IV-79, 2 males (1 donated to USNM), 1 female, 1 last instar larva on Hickory (*Carya* sp.), producing a male, May 1980; Anderson Co., Engeling Wildlife Management Area, 15-III-83, 2 males, all E. Knudson coll. Det. R. Poole. These are apparently the first Texas records of this species. Forewings light gray marked with black; hindwings white.

Euxoa pimensis B. & McD. (Fig. 3). El Paso Co., Tom Mays Park, 24-V-81, 3 males (1 donated to CNC), 3 females; Culberson Co., Nickel Creek, 26-V-81, 1 male, all E. Knudson coll. Det. Lafontaine. Apparently a new Texas record. Forewing light gray with variable black shading between orbicular and reniform, black basal dash; hindwings pale fuscous.

Eriopyga iole Schaus (Fig. 4). Brewster Co., Big Bend Nat'l. Park, Green Gulch, 28-V-81, 1 male, E. Knudson coll. **New U.S. record.** Det. R. Poole. Head, thorax and forewings reddish brown; ordinary lines obscure, dark brown; reniform outlined with white; hindwings pale fuscous, fringe orange-brown.

Oncocnemis rosea Smith (Fig. 5). El Paso Co., Tom Mays Park, 30-III-83, 5 males, 6 females (1 pair donated to USNM), E. Knudson coll. Det. R. Poole. Apparently, first Texas record for this species, which, with the preceding *Euxoa pimensis,* is from the infrequently collected Franklin Mountains near El Paso. Forewings pinkish, shading to ochreous near base; strong black antemedial line; hindwings fuscous, lighter toward base.

Oncocnemis terminalis Smith (Fig. 6). Hemphill Co., Lake Marvin, 9-X-82, 1 male, E. Knudson coll. Det. R. Poole. Probable new Texas record. Forewings dark brown with blackish markings; hindwings white, with broad black terminal band, fringe white.

Miracavira brillians Barnes (Fig. 7). Brewster Co., Big Bend Nat'l. Park, Green Gulch, 27-VI-65, 2 males; Chisos Basin, 25-VIII-65, 5 males, A. & M. E. Blanchard coll.; Chisos Basin, 10-VIII-83, 2 males, E. Knudson coll. Det. J. G. Franclemont. Forewing white and different shades of foliage-green, with darker pattern of deep brownish black; reddish brown tornal spot; hindwings white.

Letis xylia (Guenée) (Fig. 8). Calhoun Co., Port Alto, 16-X-60, 1 male; Kleberg Co., Padre Island Nat'l. Seashore, 19-VII-76, 1 female, A. & M. E. Blanchard coll. **New U.S. record.** Det. E. Todd. The illustrated female is definitely paler than the male. Color is brown varying in saturation from very light to very dark.

Cropia ruthaea Dyar (Fig. 9). Brewster Co., Big Bend Nat'l. Park, Green Gulch, 28-V-81, 1 male, E. Knudson coll. **New U.S. record.** Det. R. Poole. Forewings dark brown with black antemedial and postmedial lines; subterminal line, orbicular, and reniform contrasting light brown; hindwings light brown, paler toward base. Similar to *Cropia connecta* Smith, which also occurs in western Texas. *Connecta* is larger; has a contrastingly dark shaded inner margin of forewing; orbicular and reniform concolorous with ground; subterminal line indistinct; hindwing darker.

Hemispragueia idella Barnes (Fig. 10). Presidio Co., Ruidosa Hot Spring, 8-VII-69, 1 male, A. & M. E. Blanchard coll. Forewings ivory-white with black markings; hindwing bright yellow.

Lesmone fufius (Schaus) (Fig. 11). Hidalgo Co., Santa Ana Refuge, 13-IX-80, 3 males; Bentsen Rio Grande Valley St. Pk., 27-V-82, 1 female. Det. R. Poole. Forewings grayish brown with blackish orbicular, reniform, and costal wedge near apex; hindwings concolorous. Sexes similar.

Lesmone formularis (Geyer) (Fig. 12). Hidalgo Co., Santa Ana Refuge, 28-XI-75, 1 female, A. & M. E. Blanchard coll.; Kleberg Co., Kingsville, 1-XI-75, 1 female, Shu Wong coll. (submitted by J. Gillaspy). Wings grayish brown varying in saturation from medium to dark; straight line from inner angle to apex in hindwing is orange, bordered internally by blackish. Sexually dimorphic. Males collected by junior author in Mexico have a strong

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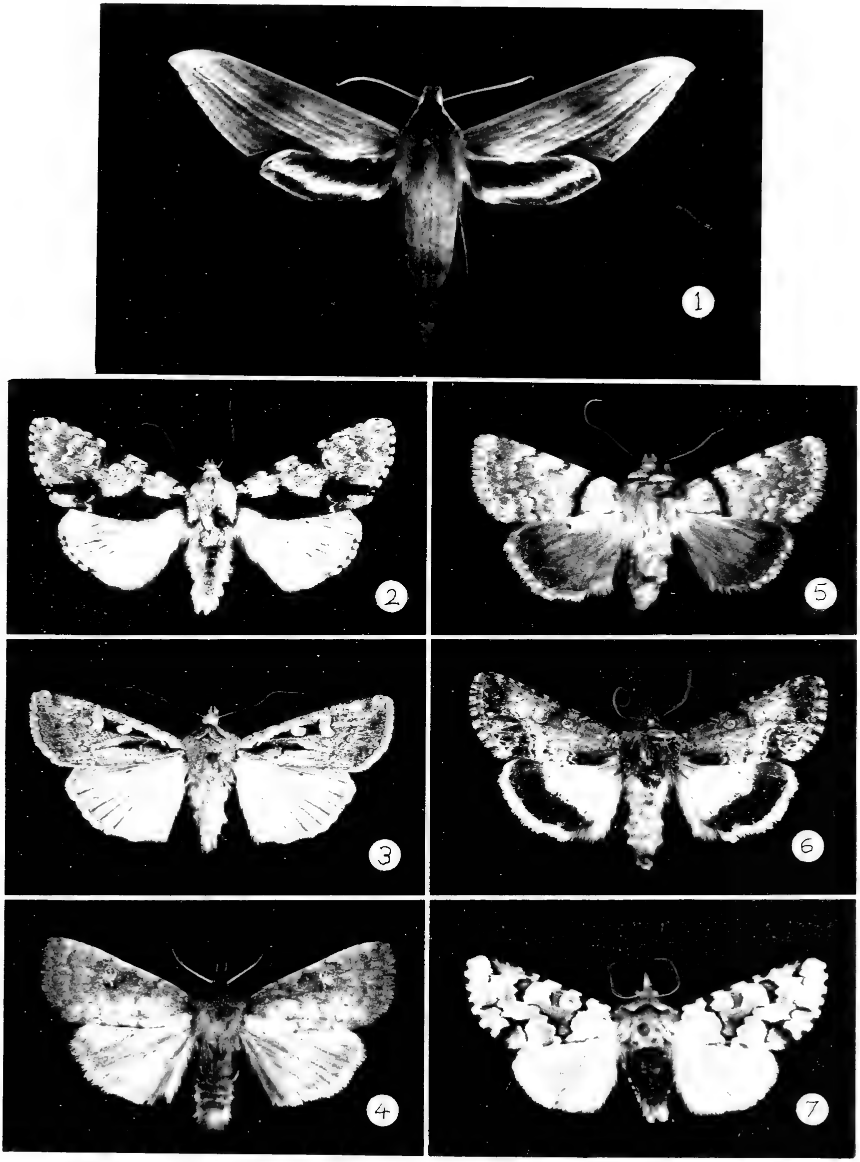
FIGS. 1–7. **1,** *Xylophanes libya* Druce, Hidalgo Co., Bentsen Rio Grande Valley St. Pk., 11-X-75, wing expanse 71 mm. **2,** *Acronicta funeralis* (G. & R.), Washington Co.,



Brenham, 1-IV-79, wing expanse 34.1 mm. **3,** *Euxoa pimensis* B. & McD., El Paso Co., Tom Mays Park, 24-V-81, wing expanse 41.2 mm. **4,** *Eriopyga iole* Schaus, Brewster Co., Big Bend Nat'l. Park, Green Gulch, 28-V-81, wing expanse 28.3 mm. **5,** *Oncocnemis rosea* Smith, El Paso Co., Tom Mays Park, 30-III-83, wing expanse 28.8 mm. **6,** *Oncocnemis terminalis* Smith, Hemphill Co., Lake Marvin, 9-X-82, wing expanse 35 mm. **7,** *Miracavira brillians* Barnes, Brewster Co., Big Bend Nat'l. Park, Chisos Basin, 27-VI-65, wing expanse 35.8 mm. (Figures not at same scale. Full wing expanse given for each specimen.)

blackish diagonal line from near base to apex in forewings; the diagonal line of the hindwings is blackish, without any orange shading.

Eulepidotis addens (Walker) (Fig. 13). Hidalgo Co., Bentsen Rio Grande Valley St. Pk., 11-X-80, 1 female, E. Knudson coll.; Cameron Co., Brownsville, 9-XI-69, 1 male, A. & M. E. Blanchard coll. **New U.S. record.** Det. J. G. Franclemont and R. Poole. Forewings with dull yellow ground over basal ⅔, interrupted by dark violet-brown semimetallic bars; apical ⅓ dull violet-brown; hindwings brownish with blue "eyespot" near tornus. Male less colorful, with the yellow ground of forewing replaced by medium violet-brown.

Goniocarsia electrica Schaus (Fig. 14). Brewster Co., Big Bend Nat'l. Park, Green Gulch, 7-X-66, 1 female, A. & M. E. Blanchard coll. Det. E. Todd with the remark "extremely variable" (pers. comm.). Medium brown with violaceous tinge; postmedial line whitish.

Notodontidae

Nystalea collaris (Schaus) (Fig. 15). Cameron Co., Brownsville, 8-XI-69, 1 female; 17-XI-69, 1 female, ex pupa, found on Guava (*Psidium guajava* L.), A. & M. E. Blanchard coll. Same locality, 3 larvae, 2 pupae collected on Guava by R. O. Kendall, producing the following adults: 24-XI-69, 3 females; 23-XII-69, 1 female. 1 larva preserved. Det. E. Todd and also recorded from Texas by him as follows: Brownsville, Oct. 1953, J. M. McGough coll.; Mercedes, July 1957, P. T. Riherd coll. Ground color light gray; postmedial line bordered inwardly with orange, outwardly with blackish triangular spots; pattern otherwise black.

Geometridae

Scopula eburneata Guenée (Fig. 17). All from North Padre Island, either Kleberg or Nueces Co., 17-V-76, 2 females; 24-VI-76, 1 male; 19-VII-76, 1 male; 19-VI-77, 1 male; 21-VI-77, 1 female; 6-IV-78, 2 females; 8–11-VI-78, 1 male, 3 females, all A. & M. E. Blanchard coll.; 1-X-77, 2 males, E. Knudson coll. Det. D. S. Fletcher (BM). Ground color creamy white with blackish markings.

Pyralidae

Araschnopsis subulalis (Guenée) (Fig. 18). Hidalgo Co., Bentsen Rio Grande Valley St. Pk., 20-X-74, 1 female, E. Knudson coll.; Santa Ana Refuge, 28-XI-75, 1 female, A. & M. E. Blanchard coll. **New U.S. record.** Det. E. G. Munroe and D. C. Ferguson. Creamy white reticulated with medium brown; brown patches on outer margins of both wings.

Lamprosema baracoalis Schaus (Fig. 19). Hidalgo Co., Santa Ana Refuge, 5-III-73, 1 female; 28-XI-75, 1 female, A. & M. E. Blanchard coll.; same locality, 20-X-74, 1 female, E. Knudson coll. Det. D. C. Ferguson. Chocolate-brown with hyaline spots on forewing (basal area in figure partially denuded of scales by wear); hindwing with narrow white antemedial line, bordered inwardly with black.

Bocchoropsis pharaxalis Druce (Fig. 20). Hidalgo Co., Santa Ana Refuge, 25-XI-73, 1 female, A. & M. E. Blanchard coll. **New U.S. record.** Det. D. C. Ferguson. Shiny yellowish white marked with light brown.

Stemhorrhages costata (Fab.) (Fig. 21). Harris Co., Bellaire, 15-IX-80, 1 male; 25-IX-83, 1 male; Kerr Co., Hunt, 23-VIII-81, 1 female, E. Knudson coll.; Dallas Co., Garland, 14-IX-83, 1 female, H. A. Freeman coll. Det. D. C. Ferguson. This species is also reported

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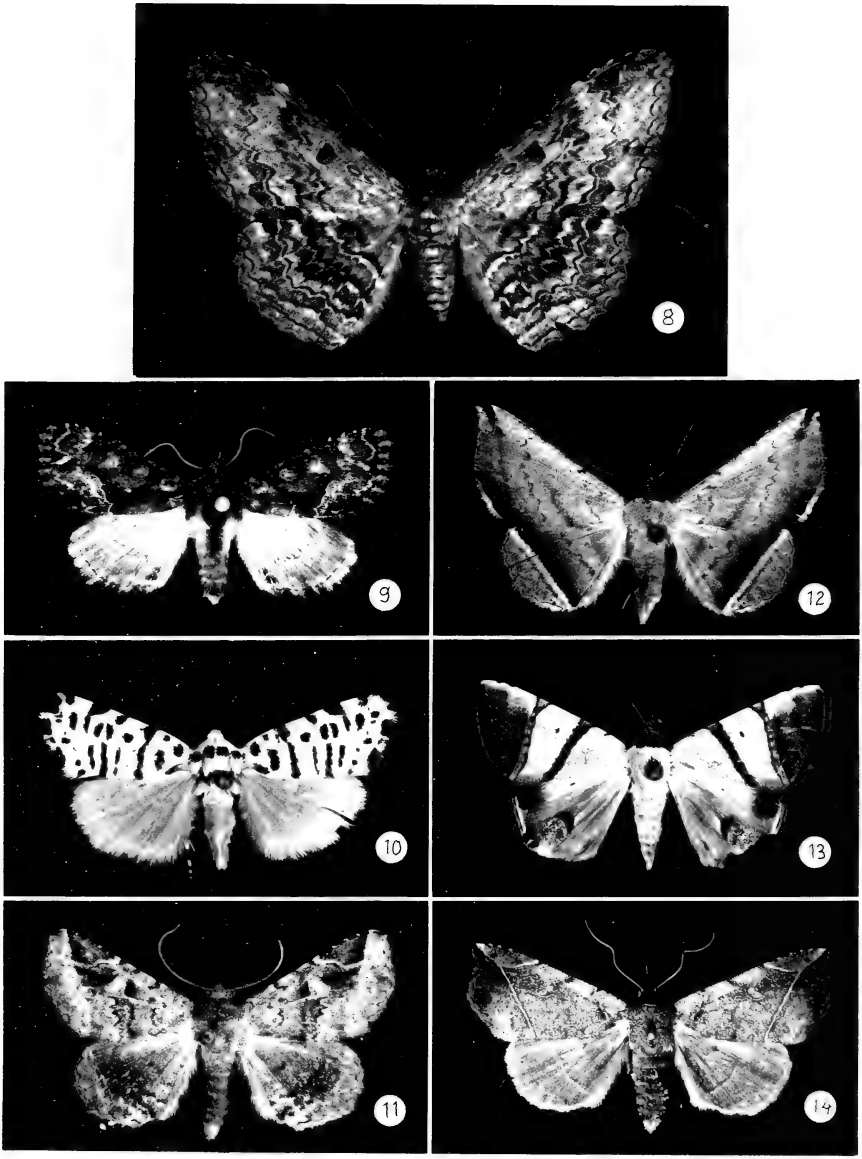
FIGS. 8–14. **8,** *Letis xylia* (Guenée), Padre Island Nat'l. Seashore, 19-VII-76, wing expanse 82 mm. **9,** *Cropia ruthaea* Dyar, Brewster Co., Big Bend Nat'l. Park, Green



Gulch, 28-V-81, wing expanse 35.9 mm. **10,** *Hemispragueia idella* Barnes, Presidio Co., Ruidosa Hot Springs, 8-VII-69, wing expanse 23.5 mm. **11,** *Lesmone fufius* (Schaus), Hidalgo Co., Santa Ana Refuge, 13-IX-80, wing expanse 26.2 mm. **12,** *Lesmone formularis* (Geyer), Hidalgo Co., Santa Ana Refuge, 28-XI-75, wing expanse 30.8 mm. **13,** *Eulepidotis addens* (Walker), Hidalgo Co., Bentsen Rio Grande Valley St. Pk., 11-X-80, wing expanse 26.8 mm. **14,** *Gonocarsia electrica* Schaus, Brewster Co., Big Bend Nat'l. Park, Green Gulch, 7-X-66, wing expanse 40.5 mm. (Figures not at same scale. Full wing expanse given for each specimen.)

from Louisiana for the first time by V. A. Brou as follows: West Feliciana Par., Weyanoke, 30-IX-79, 1 female; St. John Par., Edgard, 12-V-82, 1 male; 6-IX-82, 1 female, V. A. Brou coll. Glossy white with yellow-brown costa and small black discal spot on forewing; male with prominent black anal tuft.

Daulia arizonensis Munroe (Fig. 22). Brewster Co., Big Bend Nat'l. Park, Chihuahuan desert near Nugent Mt., 21-IX-71, 2 males; Gov't. Spring, 29-IX-65, 1 female; 11-X-69, 1 male, A. & M. E. Blanchard coll. Big Bend Nat'l. Park, Gov't. Spring, 28-IX-81, 1 male; K-Bar Research Station, 28-III-83, 1 male; Study Butte, 4-XI-81, 2 males, 1 female; El Paso Co., Tom Mays Park, 24-V-81, 1 male, 1 female, E. Knudson coll. Det. E. G. Munroe. Forewing golden yellow with silvery markings, margined with black scales; hindwing whitish.

Microthyris prolongalis Guenée (Fig. 23). Hidalgo Co., Santa Ana Refuge, 28-XI-75, 1 male, A. & M. E. Blanchard coll. Det. D. C. Ferguson. Medium brown with obscure hyaline spots on forewing; hindwing with dark brown antemedial line.

Salobrena sincera (Zeller) (Fig. 24). A common and widely distributed species in southwestern Texas, from San Antonio south to Brownsville and west to the trans-Pecos region. Varying shades of brown tinted with reddish orange; forewing of male with huge funnel-shaped costal process; female with much smaller costal process. This common Texas species is included to illustrate the peculiar wing shape of the male.

Hemiplatytes parallela (Kft.) (Fig. 25). Randall Co., Palo Duro Canyon, 11-IX-66, 1 male, A. & M. E. Blanchard coll.; same locality, 9-V-81, 2 females; Brewster Co., Alpine, 5-V-78, 1 male, E. Knudson coll. Det. D. C. Ferguson. Forewing light yellowish brown with broad, continuous silvery streak from base to apex, and narrow silvery streak on fold; hindwing white.

Diviana eudoreella Ragonot (Fig. 26). Kimble Co., Junction, 16-IV-74, 1 male, A. & M. E. Blanchard coll.; Jeff Davis Co., Davis Mountains St. Pk., 28-V-79, 1 female; Mt. Locke, 8-VIII-83, 1 female; Kerr Co., Hunt, 4-X-80, 1 male (donated to USNM), 1 female; 25-VII-81, 1 male; 6-IX-81, 1 male, all E. Knudson coll. Det. D. C. Ferguson. Forewing light gray with blackish gray markings; hindwing pale fuscous.

Sosipatra nonparilella Dyar (Fig. 27). Jeff Davis Co., Ft. Davis, 13-X-66, 1 female; Brewster Co., Big Bend Nat'l. Park, Chihuahuan desert near Nugent Mt., 1-V-72, 1 male, A. & M. E. Blanchard coll. Forewings whitish gray, evenly speckled with black scales; lines white, nearly straight, bordered with black; hindwing pale fuscous. This rare species is similar in appearance to several other phycitines, but may be separated by genitalic characters.

Tortricidae

Sparganothis cana Rob. (Fig. 28). Walker Co., Huntsville St. Pk., 20-V-69, 5 males, 1 female, A. & M. E. Blanchard coll. Det. J. Powell. Forewings light gray, reticulated with black; the two costal and one dorsal patches are medium gray; hindwing fuscous.

Cossidae

Hypopta palmata B. & McD. (Fig. 16). Brewster Co., Big Bend Nat'l. Park, Green Gulch, 29-IX-81, 1 male; Dugout Wells, 9-VIII-83, 1 male, E. Knudson coll. Forewing

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FIGS. 15–28. **15,** *Nystalea collaris* (Schaus), Cameron Co., Brownsville, 8-XI-69, wing expanse 51 mm. **16,** *Hypopta palmata* B. & McD., Brewster Co., Big Bend Nat'l. Park, Green Gulch, 29-IX-81, wing expanse 30 mm. **17,** *Scopula eburneata* Guenée, North Padre Island, 19-VI-77, wing expanse 13 mm. **18,** *Araschnopsis subulalis* (Guenée), Hidalgo Co., Santa Ana Refuge, 28-XI-75, wing expanse 20 mm. **19,** *Lamprosema baracoalis* Schaus, Hidalgo Co., Santa Ana Refuge, 28-XI-75, wing expanse 22.3 mm. **20,** *Bocchoropsis pharaxalis* Druce, Hidalgo Co., Santa Ana Refuge, 25-XI-73, wing


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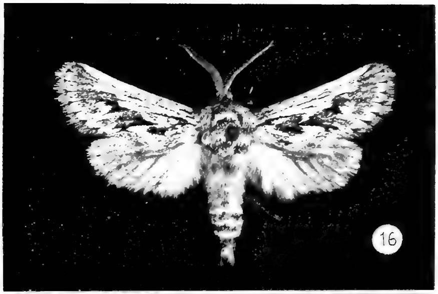
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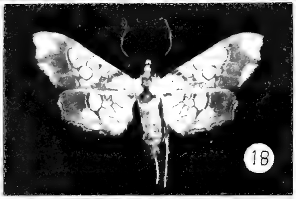
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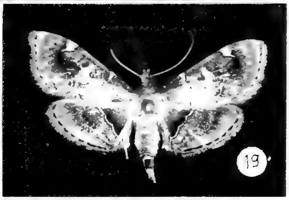
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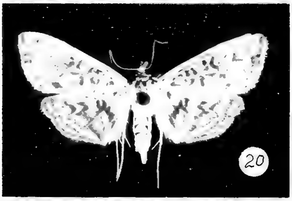
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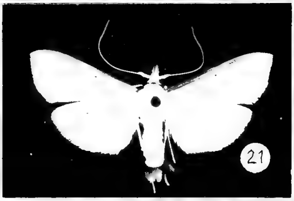
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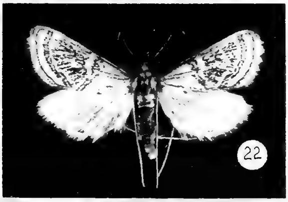
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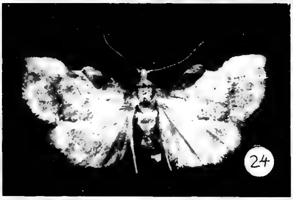
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expanse 20.3 mm. **21,** *Stemhorrhages costata* (Fab.), Harris Co., Bellaire, 15-IX-80, wing expanse 29.6 mm. **22,** *Daulia arizonensis* Munroe, Brewster Co., Big Bend Nat'l. Park, Chihuahuan desert near Nugent Mt., 21-IX-71, wing expanse 29.6 mm. **23,** *Microthyris prolongalis* Guenée, Hidalgo Co., Santa Ana Refuge, 28-XI-75, wing expanse 29.6 mm. **24,** *Salobrena sincera* (Zeller), Cameron Co., Brownsville, 12-IV-66, male, wing expanse 13.6 mm. **25,** *Hemiplatytes parallela* (Kearfott), Randall Co., Palo Duro Canyon, 11-IX-66, wing expanse 25.1 mm. **26,** *Diviana eudoreella* Ragonot, Kimble Co., Junction, 16-IV-74, wing expanse 15.8 mm. **27,** *Sosipatra nonparilella* Dyar, Jeff Davis Co., Ft. Davis, 13-X-66, wing expanse 20.1 mm. **28,** *Sparganothis cana* Robinson, Walker Co., Huntsville St. Pk., 20-V-69, wing expanse 18.7 mm. (Figures not at same scale. Full wing expanse given for each specimen.)

whitish, irrorated with black scales; veins black; dark gray patches on fold and subterminal area; hindwing fuscous.

ACKNOWLEDGMENTS

The authors are extremely grateful for the assistance of Drs. D. C. Ferguson, D. S. Fletcher, J. G. Franclemont, R. W. Hodges, J. D. Lafontaine, E. G. Munroe, R. B. Poole, J. A. Powell, and E. L. Todd for determinations and especially to Drs. Ferguson and Poole for reviewing the manuscript. We are also grateful to R. O. Kendall, V. A. Brou, and Dr. E. L. Todd for providing additional records. We also wish to express thanks to the Texas Parks and Wildlife Dept. and U.S. National Park Service for their assistance.

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NOTES ON THE LARVA AND BIOLOGY OF *MOODNA BISINUELLA* HAMPSON (PYRALIDAE: PHYCITINAE)[1]

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ABSTRACT. The last stage larva of *Moodna bisinuella* Hampson is described, and the biology of this phycitine with reference to gama grass (*Tripsacum*) in North Carolina is briefly outlined.

Recently, gama grass (*Tripsacum* sp.) was brought to Raleigh, North Carolina from Mexico and planted on a research farm as part of a plant breeding program. Inadvertently, phycitine larvae were introduced with the plants. Injury to the plants eventually prompted the collection of larvae and rearing of adults. Adults were identified as *Moodna bisinuella* Hampson, a species of economic importance in Central America. Although the phycitines were eradicated from the grass in North Carolina after the insects were identified, notes taken and larval specimens obtained during the rearing procedures provided worthwhile information relative to this pest. Little has been published regarding the appearance of the immature stages and biology of *M. bisinuella*. Previous authors have only mentioned a few morphological features of the larva (Capps, 1963) and merely stated that the species feeds as a larva in the ears of soft or "green" corn (*Zea mays* L.) (Capps, 1963; Heinrich, 1956). In this paper, I describe the last stage larva in detail and briefly discuss the biology of *M. bisinuella* in association with its previously unreported host, gama grass.

Description of Last Stage Larva

General. Length 10.2–16.0 mm, avg. 13.5 mm.

Color. Head yellowish brown (at times with green undertones in living larva); tonofibrillary platelets pale brown, indistinct; usually, a pale brown to brown patch within arc of stemmata and pale brown to brown streaks near notch of postgenal region (these 2 pigmented areas sometimes coalescing); hypostoma with brown to black markings; mandibles yellowish brown between articulations becoming dark brown along lateral margins and distally.

Prothoracic shield pale yellow to pale brown with lateral and posterior margins darker (green undertones in living larva). Prespiracular plate yellowish brown to dark brown. Remainder of prothorax white to yellowish white overlaid with brown to gray integu-

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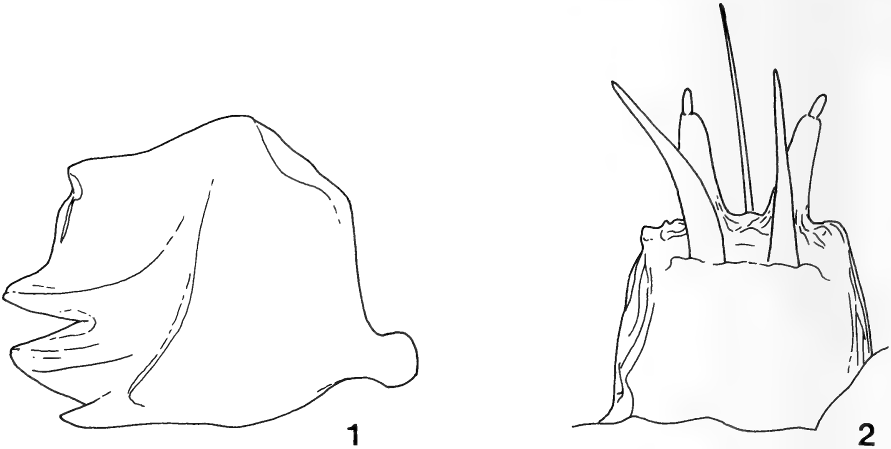


FIGS. 1, 2. *Moodna bisinuella* Hampson. **1,** mesal aspect of right mandible of last stage larva. **2,** dorsal aspect of part of right maxilla of last stage larva.

mental granules (living larva with remainder of prothorax pale red to red with brown to gray granules and scattered blue undertones; red pigmentation usually more intense on mesothorax and metathorax, and blue more pronounced laterally and ventrally); mesothoracic pinaculum ring pale brown to dark brown, white within ring; thoracic legs mostly pale brown to brown.

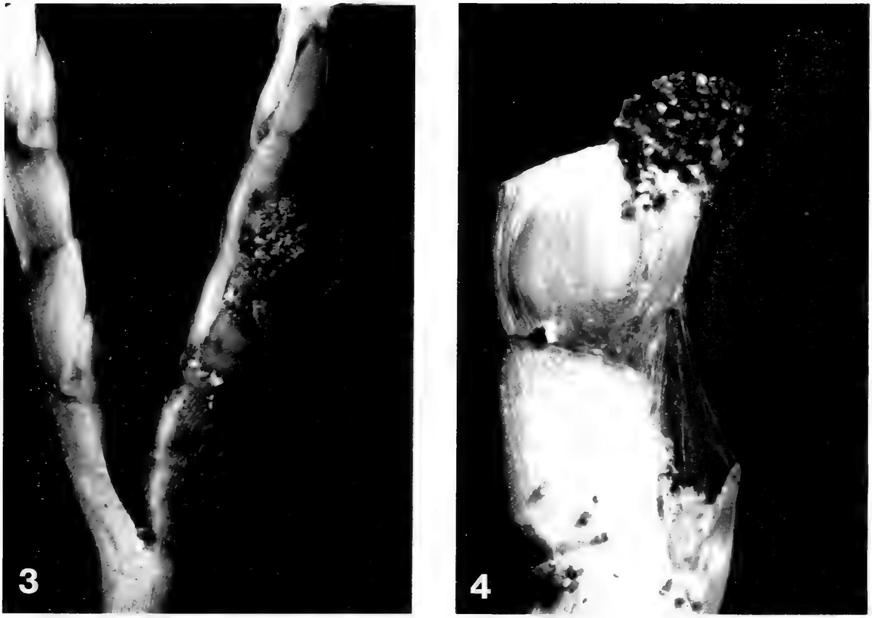
Abdomen similar to mesothorax and metathorax; eighth abdominal segment pinaculum ring pale brown to brown; anal shield pale yellow to yellowish brown with slightly darker margins.

Morphological features: Head. Width 0.83–0.93 mm, avg. 0.90 mm; surface slightly uneven; adfrontals reach ca. ⅚ distance to epicranial notch; AF2 setae usually slightly ventrad of level at which epicranial suture forks; AF2 setae slightly above imaginary line between P1 setae; P1 setae further apart than P2 setae; labrum shallowly notched; mandibles simple, distal teeth distinct (Fig. 1); sensilla trichodea of maxillae simple (Fig. 2). Spinneret moderately long.

Prothorax. On shield, distance between D1 setae less than distance between XD1 setae; on each side of shield, distance between SD1 and SD2 greater than distance between SD1 and XD2, distance between D1 and D2 greater than distance between D1 and XD1, and XD2, SD1 and SD2 form an acute angle; L setae of each side in a nearly vertical configuration.

Mesothorax and metathorax. SD1 pinaculum rings of mesothorax well developed; SD1 setae of mesothorax ca. 2 times as long as SD1 setae of metathorax; SD1 and SD2 pinacula of metathorax fused; D1 and D2 pinacula of metathorax fused.

Abdomen. D2 setae of anterior segments ca. 0.4 mm long; D1 setae of anterior segments ca. as long as D2 setae; distance between D2 setae on segments 1–7 slightly greater than distance between D1 setae; distance between D1 and D2 on each side of segments 3–6 about same as distance between D1 and SD1; SD1 setae of segments 1–7 without pinaculum rings; crochets in a biordinal ellipse, avg. number on prolegs of segments 3, 4, 5, 6, and anal segment, 50, 56, 57, 58, and 49, respectively; vertical diam. of spiracles on segment 8 ca. ⅓ larger than same diam. of spiracles on segment 7; horizontal diameter of spiracle of each side of segment 8 slightly less than distance between L1 and L2; SD1 pinaculum rings of segment 8 relatively broad but appearing incomplete; SD1 setae of segment 8 ca. 1.9 times longer than SD1 setae of segment 7; 2 SV setae on each side of segment 8; distance between D1 and D2 on each side of segment 9 ca. 3 times distance between D1 and SD1; 2 SV setae on each side of segment 9.



FIGS. 3, 4. Seeds of gama grass infested with last stage larvae of *Moodna bisinuella* Hampson.

Material Examined

North Carolina: Raleigh; 5 larvae, *Tripsacum* sp. seed, 19-IX-80, Coll. H. H. Neunzig; 11 larvae, *Tripsacum* sp. seed, 30-IX-80, Coll. H. H. Neunzig. These specimens have been deposited in the NCSU Insect Collection.

Biology and Discussion

In North Carolina, *M. bisinuella* overwintered as diapausing larvae within silk enclosures constructed at the inner base of gama grass. Pupation occurred in the spring, and adults emerged in April and May. Oviposition and larval feeding sites for the spring generation could not be determined. Larvae of the summer generation (July–September) were all found associated with the seeds of gama grass. These larvae fed on the well-developed, but more or less soft, seeds. Usually this occurred while the seeds were still attached to the plant, but seeds that had fallen from the plant were also eaten. The seeds were bored into and frass and silk extruded from the entrance hole (Figs. 3 & 4). Several seeds were eaten by each larva as it developed. Ergot (*Claviceps* sp.), which was at times associated with gama grass seed, was also sometimes ingested by the larvae.

The fact that *M. bisinuella* feeds on gama grass as well as corn supports the botanical view that the two plant genera (*Tripsacum* and *Zea*) are closely related (they are considered by most botanists to be the only members of the New World tribe Maydeae). In Central America, where the two plants sometimes grow in close proximity, wild communities of gama grass are in all likelihood providing a reservoir of *M. bisinuella* that periodically infest fields of corn.

ACKNOWLEDGMENTS

D. L. Stephan of the Plant Disease and Insect Clinic of North Carolina State University made available to the author the initial series of larvae of *M. bisinuella* collected in North Carolina.

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BIOLOGY AND DESCRIPTION OF THE LARVA OF *DICYMOLOMIA METALLIFERALIS*: A CASE-BEARING GLAPHYRIINE (PYRALIDAE)

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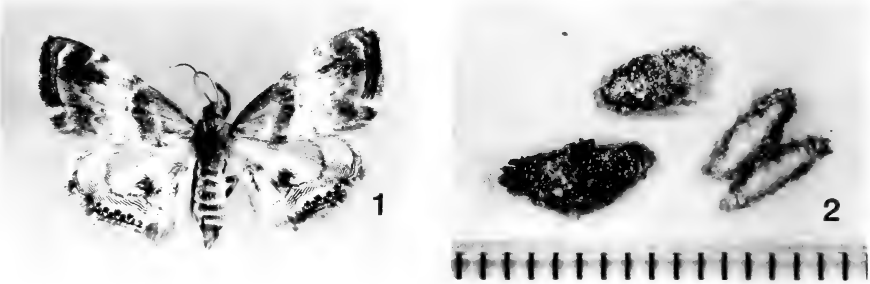
ABSTRACT. The larval biology of *Dicymolomia metalliferalis* (Packard) is described. Larvae were collected from partially opened, necrotic seed pods of two *Lupinus* L. species and reared to adults. Larvae fed from within purse-like cases constructed of silk and detrital tissues. This constitutes the first record of the case-bearing habit for the glaphyriine genus, *Dicymolomia* Zeller. The larva is described and compared with that of *D. julianalis* (Walker).

Dicymolomia metalliferalis (Packard) is a day-flying pyralid found from southern Vancouver Island south to San Diego (Munroe, 1972). Although adults (Fig. 1) may be locally common, the early stages of this moth were previously unknown. During the course of a faunal survey of the Lepidoptera associated with *Lupinus* L. species, I reared *D. metalliferalis* from partially opened, decaying seed pods of two perennial *Lupinus* species.

Larvae were recovered from the seed pods of the previous spring's seed set. In most of the inflorescences surveyed, greater than 95% of the seed pods had fully dehisced, releasing all their seeds. However, a fraction of the seed pods had failed to open completely; these partially intact pods were split open and examined for lepidopteran larvae. Over 400 seed pods of *Lupinus arboreus* Sims (ca. 150), *L. chamissonis* Eschs. (ca. 80), *L. albifrons* Benth. (ca. 150), and *L. latifolius* J. G. Agardh (ca. 20) were examined; *D. metalliferalis* larvae were recovered from the latter two species: CA, Marin Co., Nicasio Reservoir, 26-I-1980, ex *L. albifrons*; Contra Costa Co., Tilden Park, nr. Inspiration Point, 2-II-1980, ex *L. latifolius*; and Contra Costa Co., Briones Reservoir, 17-I-1982 and 12-II-1983, ex *L. albifrons*.

The partially intact seed pods from which larvae were recovered invariably showed signs of insect feeding damage. Many of the occupied pods were partially held together by the silk of braconid cocoons which presumably resulted from the parasitism of seed-feeding Lepidoptera. Other seed pods hosting *Dicymolomia* larvae had been attacked by *Apion* Herbst, a common seed-feeding curculionid that occurred in all *Lupinus* species studied. No larvae were collected from intact seed pods; presumably, *Dicymolomia* larvae entered damaged seed pods secondarily.

Most of the larvae were collected in purse-like cases (Fig. 2), but several larvae were recovered from chambers of sparse silk formed in



FIGS. 1 & 2. **1,** *Dicymolomia metalliferalis,* Briones Reservoir, Contra Costa Co., CA. **2,** early instar cases, lower right case opened. Scale in mm.

cavities of the partially intact fruits. However, soon after being brought indoors, these larvae constructed cases. After one week all larvae were observed feeding from within cases where they remained to maturity. Larvae were reared on necrotic seed pod tissues or on a combination of pod fragments and wheat germ.

Cases were constructed of silk with miscellaneous inclusions. One field-collected, overwintering case (length: 0.48 mm) contained portions of a seed coat, seed pod tomentum, larval frass, and an earlier instar head capsule. The case of a mature laboratory-reared larva (length: 1.3 cm) included numerous leaf fragments and wheat germ. Several of the field-collected cases had at least two species of fungi growing on them, and associated mites which presumably were feeding on the fungi. Neither the fungi nor the mites appeared to have had a detrimental effect on the larvae. Larval cases were constructed with an opening at each end.

Pupation occurred within the larval cases. Laboratory-reared adults emerged between 15 May and 25 June (N = 3). However, most of the records for field-collected adults occur later in the summer: CA, Berkeley, 23-VI to 10-IX (12 records, CIS collection).

The larval description is based on six late instar larvae collected at Briones Reservoir, Contra Costa Co., CA, on 17-I-1982 (1) and 12-II-1983 (5). Larvae were distended in hot water and then transferred to 70% EtOH. One larva was cleared in 10% KOH and stained with chlorosol black to facilitate the examination of smaller setae. Measurements refer to a mature fully distended larva. Setal nomenclature follows Hinton (1946).

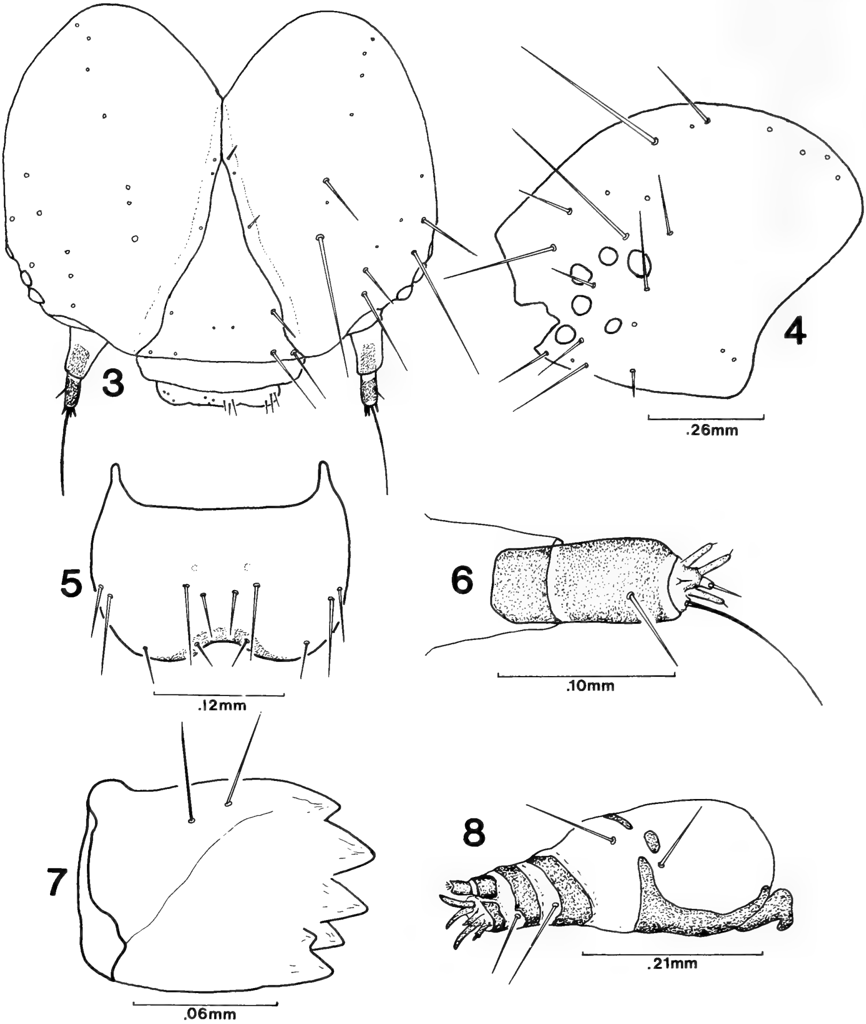
DISCUSSION

Six species of *Dicymolomia* are reported for North America north of Mexico (Munroe, 1972). Larvae of the genus have not been described or figured in detail. However, Forbes (1932) included a setal map of *D. julianalis* (Walker) for segments T1, T2, A2, and A7–9. Larvae of *D. metalliferalis* are readily separable from those of *D. julianalis*. The mesothorax of *D. julianalis* has a large sclerotized shield extending from just anterodorsad of D1 to the dorsal midline, which is absent in *D. metalliferalis*. In *D. metalliferalis* L1 and L2 on T2-A8 and the SV setae on A2–7 are not included on the same pinaculum as in *D. julianalis*. Forbes did not illustrate an SD2 seta in *D. julianalis*, which is present but minute in *D. metalliferalis*.

D. julianalis exhibits a diverse range of larval substrates: larvae are recorded from *Astragalus canadensis* L. and *Cirsium lecontei* Torrey and Gray; as internal feeders in cat-tails (*Typhus*) and cactus stems (*Opuntia*); from senescent cotton bolls (*Gossypium*); and as predators on the eggs and larvae of bagworms, *Thyridopteryx ephemeraeformis* (Haworth) (Munroe, 1972). Although *D. metalliferalis* larvae have been reared from only two lupine species, circumstantial evidence suggests that this moth may utilize an array of larval substrates. Larvae were recovered in rather low densities relative to numbers of adults flying at the collection sites. Furthermore, *D. metalliferalis* adults may be collected in localities with little or no lupine. The decomposed nature of the occupied pods suggests that larvae feed generally on detrital tissues. Lastly, one overwintering larva was reared to maturity on a mixture of seed pod fragments and wheat germ.

Two other species of microlepidoptera were commonly associated with partially intact, necrotic *Lupinus* seed pods. Several fully grown overwintering larvae of *Argyrotaenia citrana* (Fern.) (Tortricidae) were collected inside seed pods; larvae pupated soon after their collection with no indication as to having fed on the seed pods. A member of an undetermined gelechiine genus was frequently collected in the seed pods of *L. arboreus*, *L. albifrons*, and *L. latifolius*. Laboratory-reared larvae were observed to feed on the necrotic tissues of the fruit pericarp beneath sheets of silk. The larvae were smokey-red in color with pale longitudinal stripes.

The case-bearing habit is of general occurrence in several primitive lepidopteran taxa: in the later instars of Incurvarioidea, e.g., Adelinae and Incurvariinae; in the Tinoidea, e.g., Tineidae and Psychidae; and in the Gelechioidea, e.g., Coleophoridae and some Oecophoridae (Common, 1970). Case-bearing is of sporadic occurrence in the Tortricoidea, e.g., *Clysiana acrographa* (Turn.) (Common, 1970) and Pyraloidea, e.g., Nymphulinae and Glaphyriinae. Within the Glaphyriinae, case-bearing has been reported for two genera: *Stegea* Munroe and *Lipocosma* Lederer (Forbes, 1932; Munroe, 1972). Hence, *Dicymolomia* is the third of 15 North American glaphyriine genera for

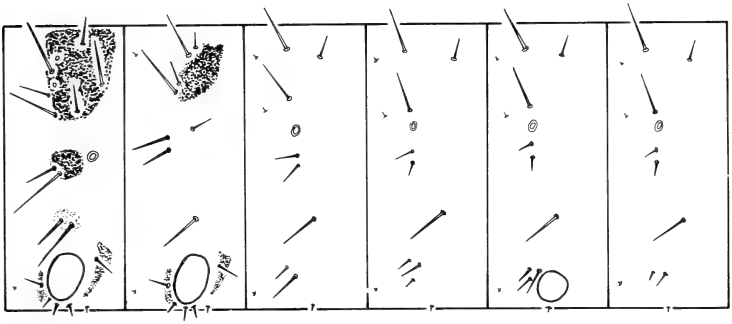


FIGS. 3–8. Head of *D. metalliferalis*. **3,** head capsule, dorsal view, width 0.93 mm. **4,** head capsule, lateral view. **5,** labrum. **6,** antenna. **7,** mandible, mesal view. **8,** maxilla.

which case-bearing is known. Detrivory appears to be especially common among case-bearing taxa relative to other Lepidoptera, e.g., at least some Adelinae, Tineidae, Oecophoridae, and *Dicymolomia*.

DESCRIPTION OF MATURE LARVA

General. Overall length 10.2 mm. Body salmon-orange, intersegmental regions unpigmented in living larvae, color fading to white in preserved material. Setulae indistinct,



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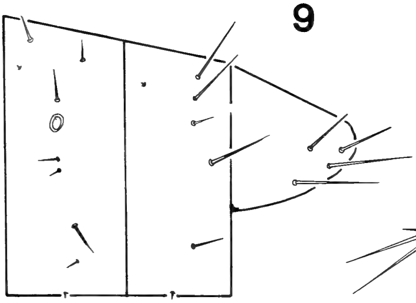

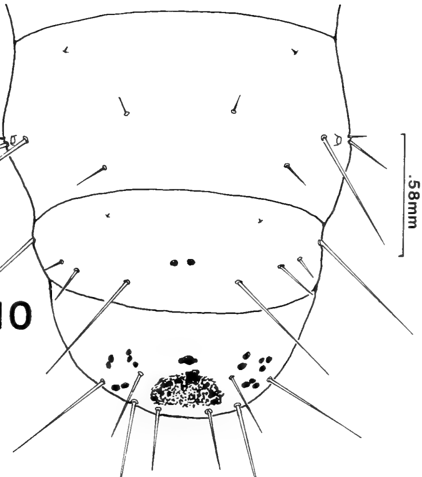

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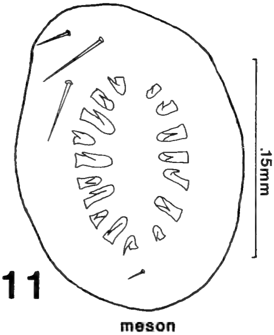

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FIGS. 9–11. Thorax and abdomen of *D. metalliferalis*. **9,** setal map of segments T1–2, A1–3, & A7–10. **10,** dorsal view of A8–10. **11,** crochets on A6.

visible at 100×. Pinacula indistinct. Spiracles flat, lightly pigmented; spiracles on T1 and A8 twice the diameter of those on A1–7.

Head. (Figs. 3, 4) 0.93 mm wide; frons extending ⅘ of the way to occipital foramen. Head capsule yellow-brown to red-brown. Six stemmata; S1, S2, S3, S4 and S6 equidistant, forming a semicircle; S5 below antennae; S1 almost twice the diameter of other stemmata. Labrum (Fig. 5) 1.25× as broad as long; anterior margin emarginate and heavily pigmented. Antenna (Fig. 6) 0.15 mm; scape lightly pigmented; scape and pedicel subequal in length. Mandible (Fig. 7) with five teeth, ventral tooth notched; molar process moderately developed. Maxilla (Fig. 8) 0.42 mm; stipes with an elongate sclerite along mesal margin and small free sclerite at level of the spinneret; palpiger and palpus lightly sclerotized. Labium with a hook-like sclerite on either side of spinneret.

Thorax. Prothoracic shield brown; L1 and L2 on a darkened pinaculum; SV setae on lightly sclerotized pinaculum; 5 coxal setae. Meso- and metathorax with sclerite posteriorad of D and SD setae, smaller and paler on metathorax.

Abdomen. (Figs. 9, 10) D1 twice the length of D2 on A1–7; subequal on A8–9. SD1 large, directly above spiracle; SD2 minute. L1 and L2 approximate and in vertical row. A1 with two and A2 with three SV setae. A9 with a pair of subcuticular pigment spots near dorsal midline. A10 with 13 pairs of setae; anal plate irregular with numerous subcuticular pigment spots laterad of anal plate (Fig. 10). Crochets 16–28 in biordinal penellipse on A3–6 (Fig. 11), anterior crochets slightly larger; crochets 15–26 in a biordinal transverse band on A10.

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FIELD SURVEY OF THE TRUE BUTTERFLIES (PAPILIONOIDEA) OF RHODE ISLAND

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ABSTRACT. The survey was undertaken to establish a better understanding of butterfly occurrences in an area previously lacking in published records for many species of the Papilionoidea. All species observed in the field are indigenous to the entire New England region, although some are very selective in choosing their particular habitats. It is interesting to note that many of the species listed are technically records for the state.

Following are the results of my 1983 field studies of the butterflies of Rhode Island. Most occurrences were confirmed by several captures at that particular location (usually followed by release of the specimen), but many sightings were logged on the basis of behavioral characteristics. This task was especially easy in the case of the most common species, while the rarer species were recorded only after a documented capture. Doubtful or questionable sightings were not recorded.

Most sightings were recorded from five primary study areas (Fig. 1) which were visited several times per week on a regular basis throughout the collecting season:

1. Trestle Trail, Coventry town: A dismantled railroad bed offering an excellent cross-section of the region's predominant oak forest with several areas of woodland swamp. This proved to be a poor area for butterflies, containing a fair variety of species but generally in very low numbers, totalling 17. Several oak tree species and an undergrowth of various blueberries predominate here, with wildflowers generally lacking.

2. West Warwick and eastern Coventry towns: Old established residential/commercial/industrial area interspersed with urban lots, abandoned areas, disturbed fields, and neglected weedy areas. Wildflowers such as asters, daisies, goldenrod, milkweed, parsnip, sunflowers, and loosestrife (in wet areas) abound in these open places and attract an abundance of the more typical weed-field butterfly species, totalling 23.

3. Arcadia Wildlife Management Area, Exeter: Extensive areas of oak and pitch pine forest traversed by a network of dirt roads. The area contains several large weed fields. A fair variety of species occurs here, totalling 16; but again, numbers are very low.

4. Great Swamp Wildlife Management Area, South Kingstown: Mostly oak forest with areas of mixed forest, extensive freshwater wetland, and several large weed fields. Other unique features such as

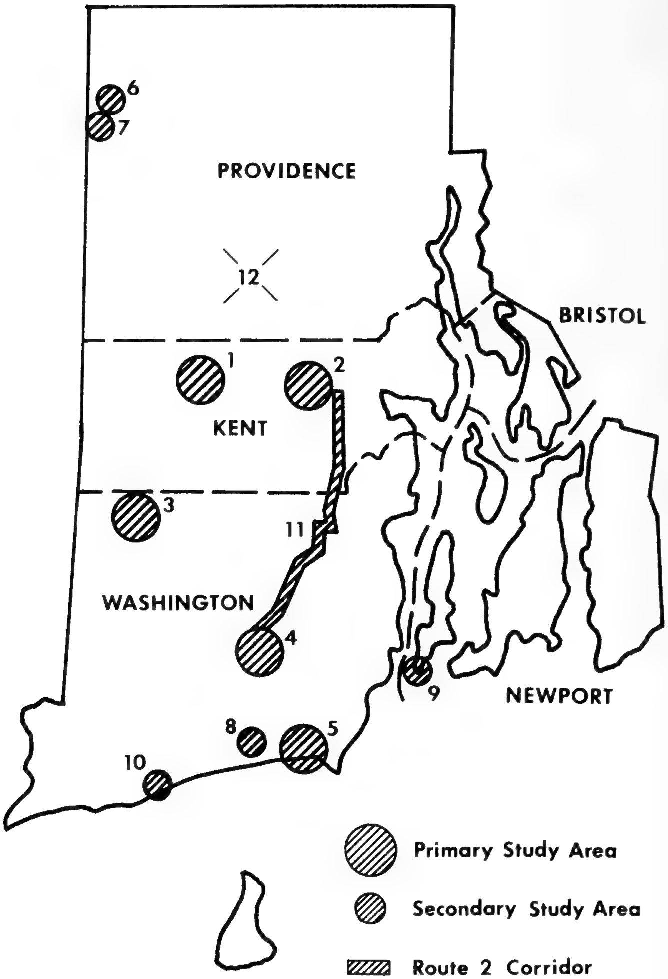

FIG. 1. Study areas for field survey of butterflies of Rhode Island.

sphagnum and cranberry bogs, maple swamp, and at least two stands of Atlantic white cedar are found here. This is perhaps the richest ecological area of the state, containing the largest variety of wildflowers and butterflies, which total 26 species. Many species reach their greatest abundance here.

5. East Matunuck State Beach, South Kingstown: A typical east coast beach, with predominant dune grass, rugosa rose thickets, and late-season goldenrods. Not a very rich area for butterflies, except toward the season's end, at which time butterfly numbers seem to increase remarkably. Probably due to the ocean's moderating effect on early frosts experienced inland, one will find butterflies here weeks after they have disappeared in all other locations. Only 10 species were recorded here.

Several secondary study areas were also included in this survey (Fig. 1). These were each visited on an irregular basis although a very thorough count was made on each occasion:

6. George Washington Wildlife Management Area, Burrillville: Mixed transition zone forest interspersed with wooded swamps and lakes. A surprisingly poor area for butterflies, with only 3 species sighted. Visited in early August.

7. Durfee Hill Wildlife Management Area, Glocester: An open wetland bordered by mixed forest and a field of goldenrod and joe-pye weed. *Colias* species abundant but few others are present. Only 5 species were sighted in late August.

8. Trustom Pond Wildlife Refuge, South Kingstown: Characterized by coastal mixed forest with abundant scrub oak. There are several large weed fields here. 15 species of butterflies were recorded here in late July.

9. Beavertail State Park, Conanicut Island, Jamestown: The weed fields above this rocky coastal hillside are characterized by thorny scrub and an abundance of goldenrods and other wildflowers. Pierids abundant with some noticeable gathering of fall migratory species, totalling 19. Visited throughout September.

10. Ninigret Conservation Area, Charlestown: Typical east coast barrier beach. Same plants and conditions as in area 5. However, only 6 species were sighted here from late September to early October.

Finally, sightings were recorded along local roads, and generally anywhere, when possible, during my various treks throughout the state:

11. State Route 2, Warwick City to South Kingstown: Cutting a cross-sectional corridor through the state's heartland, this was the most thoroughly logged road in my study. Observations were made at various roadside stops and at random locations off the route. This road bisects a variety of environments, from suburban development to woodlands, weedy fields, and agriculture. Observations indicate that butterflies are generally scarce except common pierids. Only 6 species were recorded throughout the year.

12. Various other places throughout the state, wherever I travelled, were subject to investigation. None were ever investigated to any degree beyond, perhaps, a one hour collecting stop. A total of 13 species was recorded outside the 11 study areas.

1983 was characterized by abnormal weather patterns. Although blessed by one of the mildest winters on record, the spring was unusually cool, cloudy, and brought record rainfalls to New England. This had detrimental effects on spring broods, keeping numbers low. The summer was characterized by an extended period of drought and excessive heat, lasting well into September. This probably also spelled ill for summer broods, keeping numbers low except in the case of the common weed-field species which seemed to flourish. The fall started off mildly, but cold weather set in suddenly in mid-October, with some frosts inland.

In general, collecting was very poor in 1983 in Rhode Island, and apparently much of New England as a whole. The most common species appeared in healthy numbers, but less common species and "exotics" were found to be either very low in numbers, rare, or absent altogether.

RESULTS

Following each description, numbers refer to all study areas (Fig. 1) in which sightings were made, and in parentheses are county listings, abbreviated as follows: **B** = Bristol, **K** = Kent, **N** = Newport, **P** = Providence, **W** = Washington. New county records are in italics. State records are denoted by an asterisk (*).

Danaus plexippus plexippus Linnaeus: Northward migrants first appeared in moderate numbers in mid-vii but became scarce thereafter. Fresh adults appeared in small numbers in milkweed fields during late-viii, but dispersed widely by 1-ix. Population swelled in the southern part of the state from mid-ix to early-x, with gathering along the coast but no obvious migratory movement. Areas 1, 2, 4, 5, 7, 8, 9, 10, 11, 12. (**KNPW**).

Celastrina laden ladon Cramer: Appeared in great abundance in most localities in iv. Usually found along dirt roads in wooded areas. Form *lucia* dominant early, *marginata* later, and *violacea* dominant toward end of brood in v, with all degrees of intergrades present throughout. I have assembled a complete series of these intergrades, ranging from very heavily-marked *lucia*, through *marginata*, to very light, sharply-marked *violacea*. In contrast, summer form *neglecta* was represented by only a few isolated sightings in vii. I suspect a possible sibling species relationship here. Spring forms *lucia, marginata, violacea* in areas 1, 2, 3, 4, 11, 12. (**KW**).* Summer form *neglecta* in areas 1, 2, 12. (**KP**).*

Celastrina neglecta-major Tutt (?): Found mainly at Great Swamp. Originally thought to be a partial second brood of *C. ladon*, but evidence suggests that this butterfly is, very likely, a sibling species. Appears toward the end of *C. ladon* spring brood in v, when large, bright blue, freshly-emerged males of *neglecta-major* mingle with worn stragglers of *C. ladon* form *violacea*. The *neglecta-major* males seemed to disregard *C. ladon* females with which they flew, apparently seeking their own kind. The females are very elusive, keeping to the woods and avoiding open spaces. One female was observed flying about a dogwood tree at Great Swamp. Areas 4, 12. (**KW**).*

Everes comyntas comyntas Godart: Three broods. A small brood in early-vi, as the spring form, again appearing in small numbers in early-vii as the summer form. Common only in viii as a full summer brood, with late emergers into early-x. Found mostly in weed fields. Areas 2, 3, 4, 7, 12. (**KPN**).*

Incisalia henrici henrici Grote & Robinson: Appearing in small numbers in early-v in the vicinity of Great Swamp. Found only in association with American holly, never straying far from this plant, although another reported foodplant, highbush blueberry, is abundant here. Area 4. (**W**).*

Incisalia niphon clarki Freeman: Represented by one individual captured in early-v in the vicinity of Great Swamp. Found in close proximity to a stand of pitch pine, the reported foodplant. Area 4. (**W**).*

Lycaena phlaeas americana Harris: Three broods. Spring form common from late-v to early-vi. Summer form in two broods of moderate numbers, throughout July and again in late-viii through ix. Found mostly in weed fields. Areas 1, 2, 3, 4, 8, 9. (**KWN**).*

Satyrium acadica acadica Edwards: Represented by one individual taken in mid-vii in West Warwick. This butterfly was sighted near a pond ringed with willows, the reported foodplant. Area 2. (**K**).*

Satyrium edwardsii Grote & Robinson: Very few of these butterflies were taken in oak woods in mid-vii. One sighting near the coast in a scrub oak thicket. Areas 1, 8. (**KW**).

Satyrium liparops strigosus Harris: Very few captures in oak woods, from late-vii to early-viii. Areas 1, 2, 3. (**KW**).

Strymon melinus humuli Harris: Surprisingly only one sighting of this butterfly, which is normally common in the northeast. Captured in West Warwick, late-vii. Area 2. (**K**).

Strymon titus titus Fabricius: Very few captures in oak woods throughout vii. Areas 1, 2, 4. (**KW**).

Boloria selene myrinna Cramer: Only two individuals of this reputedly common species were sighted at Great Swamp in mid-vii. Area 4. (**W**).

Limenitis archippus archippus Cramer: The first brood in v produced very few individuals. An extended summer brood produced individuals in two overlapping cycles, possibly a "split" second brood. Males appeared in moderate numbers at most localities in mid-vii, with females first becoming evident only one week later. Most individuals were well-worn by late-viii, at which time many fresh butterflies appeared. It is with this late emergence that many very dark brownish red individuals appeared at Great Swamp. Worn individuals flew until late-ix. A large number of aberrant forms were sighted throughout the state in 1983. Of the approximately 50 sightings of *archippus* recorded throughout the year, about 34 can be considered within the normal range of variation, with the remainder all of some aberrant nature. Form *lanthanis* was the most common, with 8 sighted or captured. *Lanthanis* varied considerably as well, from very light orange to darker than average ground color. A few specimens have remnant traces of the hindwing band. Five of the dark brownish red variety were observed at Great Swamp. Two specimens were taken which resemble individuals of the southern subspecies *watsonii*, with dark brownish red forewings and pale orange hindwings. Also, one dwarf was sighted in West Warwick, but with normal coloration. Areas 1, 2, 3, 4, 6, 8, 11, 12. (**PKW**).*

Limenitis arthemis astyanax Fabricius: Generally uncommon, from mid-vi through viii. However, many were observed at Arcadia Wildlife Management Area in mid-viii, where one individual of form *proserpina* was sighted. Another *proserpina*, with the hindwing band greenish, and with a trace white band on the upper forewings, was found in central Coventry. One giant female was spotted, perhaps as large as a swallowtail, for which it was first mistaken. Areas 1, 2, 3, 4, 8, 12. (**KW**).

Nymphalis antiopa Linnaeus: Worn hibernators of the previous fall brood emerged in mass-numbers at Great Swamp in early-iv. These were dark, with the marginal bands appearing whitish and narrow. Numbers decreased sharply by 1-v, with stragglers on the wing until vi. A very small summer brood of 6 was observed elsewhere in the state throughout vii. These were very brightly colored, with wide ochreous marginal bands. No sightings of the fall brood were made anywhere in the state in 1984. Areas 1, 2, 4, 8, 11. (**KW**).*

Phyciodes tharos tharos Drury: First brood in large numbers throughout vi. Most were typical summer form *morpheus*. While no distinct *marcia* individuals were identified out of hundreds, many *morpheus/marcia* intermediates were evident. *Morpheus* was abundant in the summer brood from mid-vii through viii. A partial third brood of small numbers appeared in mid-ix. These were all *morpheus/marcia* intermediates much like spring specimens. This species was found generally everywhere in weed fields. Areas 1, 2, 3, 4, 6, 8. (**PKW**).*

Polygonia comma Harris: Only three sightings of form *harrissi* in widely separated locations in late-viii and early-ix. Found in woodlands near water. Areas 3, 4, 12. (**W**).*

Polygonia interrogationis Fabricius: Surprisingly, only two sightings were made, both of form *umbrosa*. Found along railroad tracks in West Warwick. Late-vi and early-vii. Area 2. (**K**).*

Junonia coenia Hübner: A latecomer in late-ix and early-x. Found in small numbers only along the coast. None were of any distinct form, but rather, were intermediate between wet and dry forms. Areas 9, 10. (**WN**).*

Speyeria cybele cybele Fabricius: Surprisingly few sightings, and only at Great Swamp. Late-vii. Area 4. (**W**).

Vanessa atalanta Linnaeus: Few sightings, most occurring along the coast, but one sighting inland at West Warwick. Two broods, first in vii, again in late-ix. Areas 2, 5, 8, 9. (**KNW**).*

Vanessa cardui Linnaeus: Northward migrants and/or local hibernators in late-iv, lingering into vi. Summer brood was abundant at inland locations in vii, disappearing by viii. Small numbers reappeared briefly in late-viii, with the final brood appearing in late-ix to early-x, mostly along the coast. Another common weed-field species. Areas 2, 4, 5, 8, 9, 10. (**KNW**).*

Vanessa virginiensis Drury: An erratic brood sequence was recorded. Small numbers appeared in scattered locations during the first week in v, and again during the second week in vi. Found throughout vii in small numbers but common only during the third week. Small numbers reappeared briefly in late-viii. The final brood appeared during late-ix, when this species became fairly common. Generally found in weed fields. Areas 1, 2, 3, 4, 5, 8, 9, 12. (**KNW**).*

Papilio glaucus glaucus Linnaeus: Spring "form" *canadensis* was found in very small numbers in the center of the state, in late-iv and early-v. The summer form was recorded as occasional sightings in widely scattered locations, throughout vi to viii. I suspect *canadensis* is possibly a univoltine sibling species, but more research is needed. *Canadensis* in areas 1, 2. (**K**).* Summer form in areas 1, 2, 4, 5, 8, 11, 12. (**KNW**).*

Papilio polyxenes asterius Stoll: Only two spring brood sightings in early-vi. Summer brood appeared in small numbers at Great Swamp in late-viii. Areas 2, 4, 5. (**KW**).*

Papilio troilus troilus Linnaeus: Spring brood indicated by only one observation in early-vi. Summer form sighted at widely scattered locations from mid-vi through viii, but only common at Great Swamp in early-viii. Areas 1, 2, 3, 4, 12. (**KW**).*

Colias eurytheme Boisduval: Spring form *ariadne* appeared in small numbers throughout v. Summer form *amphidusa* appeared in small numbers in early-vi. *Amphidusa* was widespread, and common in many areas, throughout vii, but very few were evident in viii. The final brood of *amphidusa* was widespread also from early-ix through x. Several different forms of possible *eurytheme/philodice* hybrids were captured throughout the season. One aberrant yellow female was taken at East Matunuck Beach in mid-vi. This species can almost always be expected in weed fields. Areas 2, 3, 4, 5, 7, 8, 9, 10, 11, 12. (**BKNPW**).*

Colias philodice Latreille: Possibly the most persistently abundant species in many areas of the state, with three distinct broods of the summer form. Spring form *anthyale* was evident in small numbers only at the onset of the first brood. Common throughout v and early-vi, again throughout vii, with an extended final brood from early-viii through x. Areas 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12. (**BKNPW**).*

Pieris rapae Linnaeus: The most widespread species in the state, common in almost all open areas but never as abundant as *Colias philodice* in any area. Spring form *metra* in late-iv. The typical form appeared in 4 broods from vi through x, with the final brood being the most common. Areas 1, 2, 3, 4, 5, 7, 9, 10, 11, 12. (**BKNPW**).*

Cercyonis pegala alope Fabricius: Very few of these were taken in two locations at the western edge of the state in early-viii, with main colonies not being found. The distinctive forewing patch is yellow in this subspecies. Areas 3, 6. (**PW**).*

Cercyonis pegala maritima Edwards: Abundant in widely scattered colonies from mid-vii through viii. Never before have I observed any butterfly in such large numbers as this, at Trustom Pond in South Kingstown, where approximately over one hundred individuals were observed along a 30-meter length of trail through a scrub oak thicket. The distinctive forewing patch is orange in this subspecies. *Maritima* also differs from subspecies *alope* by its slightly darker ground color. Differences between these two subspecies can only be safely concluded through large series of specimens. Found in grassy/shrubby areas. Areas 1, 2, 4, 8. (**KW**).*

Megisto cymela cymela Cramer: Usually found in small numbers in scattered locations, preferring grassy open woods. The first appearance was in early-vi, only at Great Swamp. Absent in late-vi but reappearing elsewhere in moderate numbers during the first week in vii and then in small numbers until early-viii. Areas 1, 2, 3, 4, 5, 8. (**KW**).*

Satyrodes appalachia Chermock: Two sightings only at Great Swamp in mid-vii. Sighted in woods. Area 4. (**W**).*

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FOREST TORTRICIDS TRAPPED USING *EUCOSMA* AND *RHYACIONIA* SYNTHETIC SEX ATTRACTANTS

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ABSTRACT. Moths of 31 non-target species of Tortricidae (30 Olethreutinae, 1 Tortricinae) were lured to synthetic *Eucosma* and *Rhyacionia* sex attractants deployed in pine forests throughout 12 states in the western U.S. Genera represented include *Petrova, Barbara, Phaneta, Eucosma, Epiblema, Epinotia, Ancylis, Dichrorampha, Sereda, Grapholita, Cydia,* and *Decodes,* as well as a new genus near *Rhyacionia.*

In 1977 and 1978 we conducted an extensive trapping survey in pine forests in the western United States, using synthetic sex attractants. The primary objective was to learn more about geographical distribution and host relationships of *Eucosma sonomana* Kearfott and species of *Rhyacionia.* While the major results have been published (Sartwell et al., 1980; Stevens et al., 1980), a variety of other moths, largely olethreutines, also responded to the lures. These were saved and identified when their numbers indicated more than chance captures. Generally, a minimum of 4–6 similar moths at a trapping location was considered sufficient to indicate attraction was not incidental, although in some instances we recovered fewer. The catches reported here provide clues regarding pheromone chemistry of and possible taxonomic relationships among certain species. The information may be useful for future studies on these and related species. It also provides range extensions for some of the species captured.

METHODS

Details of the methods, including trapping periods and precise trap locations for most collections, are presented in the previously cited works (Sartwell et al., 1980; Stevens et al., 1980). In cases in which these are not cited, we provide precise trap locations in Table 1. Trapping periods were similar to those at nearby localities. Briefly, we deployed attractant-baited traps in pine forests in most of the western United States in spring and early summer 1977 and 1978. Four baits were used: (E)-9 dodecenyl acetate (referred to hereafter as (E-9)); (Z)-9 dodecenyl acetate (Z-9); a 1:1 mixture of E-9 and Z-9 (50-50); and (E,E)-8,10 dodecadienyl acetate (E,E-8,10).

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The baits were formulated in 3 × 5 mm cylindrical polyvinyl chloride pellets containing 4% attractant by weight (Daterman, 1974). Baits were mounted on insect pins inserted centrally within Pherocon-II® traps. Traps were hung on tree limbs 1.5–2 m above ground.

Traps were set out at each location in 3 clusters of 5 traps each (4 baited, 1 unbaited), with no trap nearer than ca. 20 m to another. Thus, at each location, each attractant material was presented in 3 traps, along with 3 unbaited traps used as checks. Trapping periods ranged from overnight to more than a month (Stevens et al., 1980). In general, traps were deployed 2 to 8 weeks.

Recovered traps were stored in freezers. Moths were separated by presumed species. Representative individuals were removed with forceps, rinsed in xylene and then hexane or ether to remove the trapping adhesive, and finally relaxed and prepared for identification. In some instances small parts of traps holding specimens or entire traps were immersed in solvent to free specimens.

Representative specimens are kept in the insect museum at Colorado State University, Fort Collins, and at the Essig Museum of Entomology, University of California, Berkeley.

RESULTS AND DISCUSSION

The species trapped, lures responded to, and localities are presented in Table 1. The equivocal nature of a few of the species determinations reflects the difficult taxonomic situation in some Olethreutinae. The unbaited traps captured only occasional stray moths and were not considered attractive.

Altogether, 31 taxa, all but one being Olethreutinae, are represented in the trapped material. Comparing our material with information summarized by Inscoe (1982) and Roelofs and Brown (1982), five genera, *Decodes, Ancylis, Phaneta,* and *Sereda,* and a new eucosmine near *Rhyacionia,* are not reported to have been previously captured using synthetic attractants.

Most of the trapped Eucosmini responded to Z-9, E-9, and the 1:1 mixture of the two (50:50). *Phaneta columbiana* (Walsingham) was an exception, responding almost exclusively to E,E-8,10. Moths of the new genus near *Rhyacionia* responded to E-9, Z-9, and 50-50 except at Kingman, Ariz., where all 17 specimens were lured to E,E-8,10. This anomaly seems to justify further attention.

In general, members of the Grapholitini were attracted to E,E-8,10. The species of *Cydia* showed some variability in their responses to the preferred materials, reflecting the difficulties in their perceived taxonomic relationships. *C. tana* (Kft.) responded to 50-50, but since a total of only four specimens were collected this may not be meaningful.

However moths of the *C. piperana* complex were lured in large numbers to 50-50, as well as to E-9 and Z-9 (none to E,E-8,10); this may imply some divergence between this complex and other elements of the genus.

The two species of *Grapholita* we collected responded solely to E,E-8,10; more *G. conversana* Walsingham moths were trapped than any other species aside from the target *Rhyacionia*. By contrast, the much-studied oriental fruit moth, *G. molesta* (Busck) appears to respond primarily to compounds unsaturated only at the 8th position in the 12-carbon chain (Inscoe, 1982).

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TABLE 1. Tortricidae other than *Eucosma sonomana* and *Rhyacionia* spp. trapped with synthetic sex attractants, western United States, 1977 and 1978.

Species	Attractant(s) and number moths trapped	Localities collected[1]
Olethreutinae		
Eucosmini—new genus near *Rhyacionia*	E-9 (338) Z-9 (3) 50-50 (32) E,E-8,10 (17)[2]	*Arizona:* Kingman A, Portal *New Mexico:* Reserve, Ruidoso, Santa Fe, Silver City
Petrova metallica (Busck)	E-9 (96) Z-9 (16) 50-50 (45) E,E-8,10 (6)	*California:* Scott Valley (4 km W), Tuolumne Mdws., Yosemite Village (12 km NW) *Nebraska:* Alliance *Oregon:* Burns, Crescent Lake, Grants Pass, Keno, Sisters *Washington:* Entiat *Wyoming:* Kemmerer
Petrova picicolana (Dyar)	E-9 (27) Z-9 (5) 50-50 (255) E,E-8,10 (1)	*California:* Old Station (10 km SE), Sierra City (12 km N), Truckee A, Tuolumne Mdws., Yosemite Village (12 km NW) *Colorado:* Fraser *Idaho:* Coeur d'Alene, Headquarters *Montana:* East Glacier *Oregon:* Baker, Crater Lake, Crescent Lake, Idanha, Tiller, Sisters, Ashland *Utah:* Vernal *Washington:* Leavenworth *Wyoming:* Afton
Barbara colfaxiana (Kearfott)	Z-9 (24)	*Idaho:* Headquarters, Coeur d'Alene *Nevada:* Las Vegas A *Oregon:* Idanha *Washington:* Kettle Falls *Wyoming:* Afton
Phaneta columbiana (Walsingham)	Z-9 (1) E,E-8,10 (43)	*Idaho:* Arco *Nevada:* Austin *Oregon:* Lakeview *Utah:* Dutch John
Eucosma bobana Kearfott	E-9 (1) Z-9 (343) 50-50 (168) E,E-8,10 (5)	*Arizona:* Kingman B *California:* Big Bear City B, Lee Vining (4 km SW) *Colorado:* Ft. Collins C, Woodland Park *Idaho:* Arco *Montana:* Wolf Creek *Nevada:* Austin, Las Vegas A *Utah:* Dutch John *Wyoming:* Kemmerer
Eucosma ponderosa Powell	Z-9 (14) 50-50 (8)	*Oregon:* Bly, Chiloquin, Bend, Lakeview, Gold Beach, Sisters,

TABLE 1. Continued.

Species	Attractant(s) and number moths trapped	Localities collected[1]
	E,E-8,10 (2)	O'Brien *Washington:* Entiat, Goldendale
Eucosma recissoriana complex	Z-9 (256) 50-50 (127)	*California:* Tioga Pass, Tuolumne Mdws., Yosemite Village (12 km NW) *Montana:* Boulder *Oregon:* Chiloquin, O'Brien *Utah:* Manila *Wyoming:* Buffalo
Epiblema resumptana Walker	50-50 (8)	*Montana:* Havre, Wolf Creek
Epinotia emarginana (Walsingham)	E-9 (1)[3]	*California:* Monterey
Epinotia miscana (Kearfott)	E-9 (3) 50-50 (1)	*Oregon:* Crescent Lake
Epinotia columbia (Kearfott)	Z-9 (4) E-9 (2) 50-50 (5) E,E-8,10 (1)	*Idaho:* Headquarters *Montana:* East Glacier
Epinotia n. sp.	E,E-8,10 (32)	*Arizona:* Kingman B
Ancylis columbiana McDunnough	Z-9 (792) 50-50 (70)	*California:* Camino, Descanso (14 km NE), Emigrant Gap, Fall River Mills (4 km NW), Julian (3 km SW), Lake Arrowhead (3 km NE), Monterey, Sierra City (12 km N), Upper Lake (20 km N) *Oregon:* Bly, Ashland, Cave Jct., Crater Lake, Crescent Lake, Keno, Idanha, Tiller, Oakridge, Sisters, Grants Pass, O'Brien *Washington:* Goldendale, Kettle Falls, Leavenworth
Ancylis simuloides McDunnough	Z-9 (191)	*California:* Lake Arrowhead, Old Station (10 km SE)
Ancylis albafascia Heinrich	Z-9 (7)	*Oregon:* Crescent Lake
Ancylis pacificana (Walsingham)	Z-9 (6)	*Oregon:* Bend
Ancylis mediofasciana (Clemens)	E-9 (1714)	*California:* Big Bear City A, Crestline (1 km NE), Descanso (14 km NE), Emigrant Gap, Fall River Mills (4 km NW), Hat Creek, Julian (3 km SW), June Lake (6 km E), Lake Arrowhead (3 km E), Mt. Shasta City, Old Station (10 km SE), Placerville, Scott Valley (4 km NW), Truckee A, Upper Lake (20 km N)

TABLE 1. Continued.

Species	Attractant(s) and number moths trapped	Localities collected[1]
		Colorado: Ft. Collins *Idaho:* Arco, Boise, Coeur d'Alene *Montana:* Boulder, East Glacier, Superior, Wolf Creek *Oregon:* Ashland, Baker, Bookings, Burns, Cave Jct., Crater Lake, Crescent Lake, Gold Beach, Grants Pass, Idanha, Keno, Lakeview, Oakridge, O'Brien, Sisters, Tiller *Utah:* Dutch John, Manila *Washington:* Goldendale, Kettle Falls, Okanogan, Pomeroy, Shelton *Wyoming:* Afton, Kemmerer
Laspeyresiini		
Dichrorampha sedatana (Busck)	50-50 (6) E,E-8,10 (28)	*Montana:* Wolf Creek *South Dakota:* Deadwood
Sereda tautana (Clemens)	E,E-8,10 (89)	*New Mexico:* Ruidoso, Silver City
Grapholita caeruleana Walsingham	E,E-8,10 (44)	*Idaho:* Arco
Grapholita conversana Walsingham	E,E-8,10 (ca. 2900)	*Arizona:* Williams (20 km S) *California:* Clear Lake (20 km N), Crestline (1 km NE), Descanso (14 km NE), Emigrant Gap, Hat Creek, Julian (3 km SW), Lake Arrowhead (3 km NE), Monterey, Old Station, Sierra City (12 km N) *Colorado:* Pagosa Springs *Idaho:* Boise, Headquarters *Montana:* Conner, Havre *Oregon:* Baker, Burns, Cave Jct., Crater Lake, Keno, Lakeview, Tiller *South Dakota:* Deadwood *Utah:* Cedar City, Vernal *Washington:* Entiat, Goldendale, Kettle Falls, Leavenworth, Pomeroy, Tacoma *Wyoming:* Afton, Buffalo
Cydia populana (Busck)	E,E-8,10 (25)	*Colorado:* Redfeather Lakes *Utah:* Dutch John, Manila
Cydia n. sp. nr. *strobilella* (L.)	E,E-8,10 (13)	*Idaho:* Boise
Cydia ?tana (Kearfott)	50-50 (4)	*Oregon:* Ashland
Cydia nr. *leucobasis* (Busck)	E,E-8,10 (10)	*Oregon:* Idanha
Cydia americana (Walsingham)	E,E-8,10 (61)	*California:* Julian (3 km SW), Lake Arrowhead (3 km NE)

TABLE 1. Continued.

Species	Attractant(s) and number moths trapped	Localities collected[1]
		Idaho: Boise *Oregon:* Burns, Eugene, Tiller *Washington:* Entiat, Goldendale
Cydia colorana Kearfott	E,E-8,10 (13)	*California:* Lee Vining (4 km SW) *Colorado:* Ft. Collins C
Cydia cupressana Kearfott	Z-9 (4)	*California:* Monterey
Cydia piperana complex	E-9 (62) Z-9 (14) 50-50 (210)	*California:* Old Station *Oregon:* Sisters *Montana:* Boulder, Conner, Havre, Wolf Creek *Washington:* Entiat, Goldendale, Kettle Falls, Pomeroy *Utah:* Manila, Vernal *Wyoming:* Afton, Kemmerer
Tortricinae		
Cnephasiini		
Decodes stevensi Powell	Z-9 (163)	*Colorado:* Fort Collins C

[1] See Stevens et al. (1980) for more detailed trapping locations, and trapping dates. Detailed locations given here only if not included in Stevens et al. (1980).

[2] E,E-8,10 only from Kingman, Ariz.

[3] Probably incidental. *E. emarginana* is a generally abundant species and should have been trapped in greater numbers if moths responded to the lures.

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NOTES ON THE LIFE CYCLE AND NATURAL HISTORY OF *OPSIPHANES QUITERIA QUIRINUS* GODMAN AND *ERYPHANIS AESACUS BUBOCULUS* BUTLER (BRASSOLIDAE)

ROLANDO CUBERO

C.4, Avs 2-4, Barva-Heredia, COSTA RICA

ABSTRACT. Details of the various life stages are presented for *Opsiphanes quiteria quirinus* Godman and *Eryphanis aesacus buboculus* Butler. These are two of the rarest Costa Rican brassolids, and this is probably the first photo-illustrated report on their life cycles.

This is the first article of a proposed series devoted to describing the early stages, larval host plants and adult behavior of the Brassolidae known to occur in Costa Rica. The object of these studies is to provide general information and a taxonomic guide to the eight genera (*Brassolis, Caligo, Catoblepia, Dynastor, Eryphanis, Narope, Opoptera* and *Opsiphanes*) of Brassolidae containing the 19 species reported from this country.

General Descriptions of Life Stages

Opsiphanes quiteria quirinus Godman

Egg (Fig. 1). Spherical, slightly flattened at base with numerous vertical ribs; diameter ca. 1.5 mm; light green when first laid, becoming dark green with three reddish brown concentrical circles when fertile; hatches in 12 days.

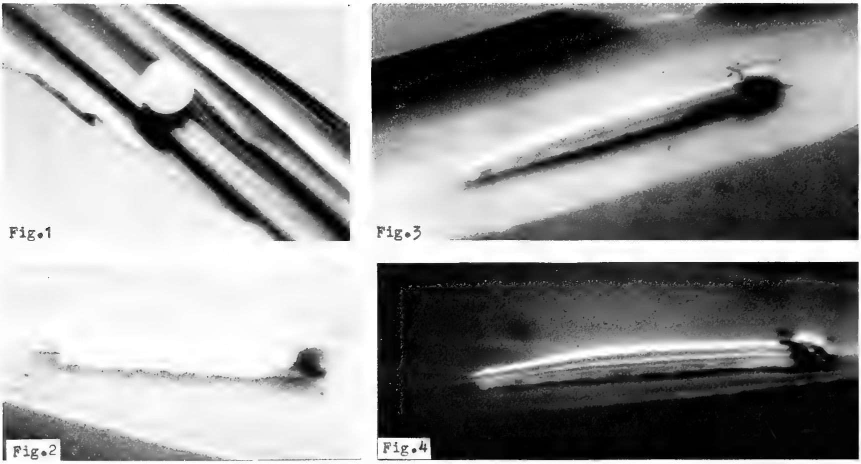
First instar larva (Fig. 2). Head capsule very dark brown, covered with small dark brown hairs and setae. Body cylindrical, cream-white in color with several longitudinal red bands and reddish brown forked tail. After feeding, color of body changes to light green with dark green longitudinal bands; forked tail turns to dark brown. Ca. 15 mm long. Moults in 10 days.

Second instar larva (Fig. 3). Head dark brown with yellow frontal patch on epicranial suture; bears four dark brown prominent projections or "horns" along superior and lateral borders; head also with whitish pubescence and pair of forward hair-tufts in blackish brown color appearing as conspicuous "mustache." Body with broad longitudinal lemon-yellow band on dorsum in quick succession with dark green and light green lateral stripes. Anal fork greenish gray. Ca. 24 mm long. Moults in 10 days.

Third instar larva (Fig. 4). Head with all four horns more developed, with vestigial horn at their bases. Yellow frontal patch now broader than in second instar and hair-tufts very conspicuous. Body retains dorsal yellow band, but other stripes turn to yellowish green and bluish gray. Ca. 39 mm long. Moults in 13 days.

Fourth instar larva (Fig. 5). Head capsule retains basically color pattern but now horns present light orange color with black tips. Dorsal yellow band of body divided by two fine light green stripes and rest of body retains same color of previous instar. Ca. 53 mm long. Moults in 18 days.

Fifth instar larva (Fig. 6). Shape of head, as in preceding three instars, basically rectangular, with broad pale yellow band along epicranial suture, in quick succession to very broad chestnut brown longitudinal band on each epicranium. Color pattern of body similar to previous instar; dorsal band now becoming lemon-yellow; spiracles orange-brown, and forked tail yellowish green. Ca. 104 mm long. Duration: 16 days.



FIGS. 1–4. *Opsiphanes quiteria quirinus*: **1,** egg, ca. 1.5 mm diameter; **2,** first instar larva, ca. 15 mm long; **3,** second instar larva, ca. 24 mm long; **4,** third instar larva, ca. 39 mm long.

Prepupa. Prepupal larva loses color pattern of body and changes to translucent green. Ca. 65 mm long. Duration: 2 days.

Pupa (Fig. 7). Pupa grass green; "boat shaped," laterally compressed at wing cases, with head slightly bifid; thin brownish green lines, one along dorsal angle, another lateral from cremaster to middle of wing case and another ventral line from cremaster to end of antennae; dorsal line gives rise to number of lateral lines in angle directed posteriorly to spiracular border; spiracles pale orange; each wing case ventrally with small dark brown spot and laterally with golden spot. Ca. 45 mm long. emergence in 22 days.

Adult. Male (Figs. 8, 9). Body very robust and brownish red. Forewing blackish brown with ochreous-orange transverse band and two white subapical spots; basal area reddish brown. No pupilate subapical ocelli and three undulate blackish brown submarginal lines, with a complicated design in discocellular area; posterior part of ochre-orange band clearly visible near margin between median veins. Hindwing brick-red with three ochre-orange spots between radials and before terminal margin, which is dark brown; outer margin dark brown and very dentate; under surface darker; large spot on radial sector and smaller one, greenish ochre, near anal angle; entire surface of wing covered by very complicated design of black, brown and yellow-ochre lines and patches which turn darker near outer margin; discal cell with conspicuous black-brown spot, which is most characteristic detail of total design.

Female (Figs. 10, 11). Forewing blackish brown with white subapical spots larger than in male; outer margin somewhat undulated; transverse band very wide and of glossy cream-white color; basal area with reddish brown color and hindwing, which is more rounded in shape, with same color as male; under surface somewhat paler than male; band of forewing entirely visible; but hindwing paler than on male, yet with basically same pattern, except in black-brown patch of discal cell, which is more reduced. Span: Ca. 80 mm, male and 97 mm, female.

Eryphanis aesacus buboculus Butler

Egg (Fig. 12). Round and white when first laid, with numerous ribs; when fertile, turns to rosy white color with broad maroon ring, which is not closed at one side for space of ½ mm. Diameter ca. 2.3. mm. Hatches in 12 days.

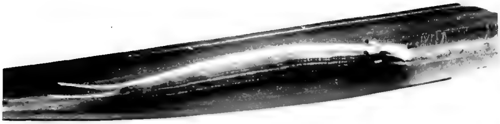


Fig.5

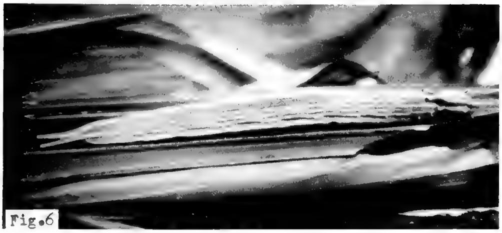


Fig.6

Fig.7

FIGS. 5–7. *Opsiphanes quiteria quirinus*: **5,** fourth instar larva, ca. 53 mm long; **6,** fifth instar larva, ca. 104 mm long; **7,** pupa, lateral aspect, ca. 45 mm long.

First instar larva (Fig. 13). Head rounded, basically reddish brown and covered with fine pilosity. Body yellowish orange with red longitudinal bands; with dark brown forked tail; ventral surface red. After feeding, bands of body turn very multicolored; with green dorsal band limited by two yellow-orange stripes at sides and deep maroon band in quick succession with bluish white band on each side. Ca. 18.5 mm long. Moults in 9 days.

Second instar larva (Fig. 14). Head basically quadrate with three pairs of short incurved horns and particular color pattern of several whitish and greenish brown longitudinal stripes. Body retains essentially same color and forked tail appears more developed. Ca. 28 mm long. Moults in 11 days.

Third instar larva (Fig. 15). Head with horns more developed showing finely textured surface; whitish and greenish brown color pattern persists. Body retains same color as in second instar but now there appears four or five fleshy points along dorsum. Ca. 44 mm long. Moults in 9 days.

Fourth instar larva (Fig. 16). Head retains same shape and color pattern. Body brownish white with broad dorsal line of greenish brown; retaining false spines on dorsum, but now more developed and skin (including forked tail), with very particular texture of tiny protuberances resembling "chicken skin"; between dorsal line and spiracular bands, body also with pair of thin longitudinal dark brown stripes. Ca. 80 mm long. Moults in 11 days.

Fifth instar larva (Fig. 17). Head large and broad; dirty white in color but now covered with fine pilosity. Body light brown-yellow, slender striped with greenish brown lines and longitudinal row of short dark brown lines on each side, just beyond spiracular band; below this band, larva with longitudinal border of short hair, lighter in color than on rest of body; ventral surface reddish brown. During this instar red scent gland of larva, located in front of the prothoraxic legs, particularly visible. Ca. 118 mm long. Duration 26 days.

Prepupa. Prepupal stage very short, requiring two days; characterized by paler and semi-translucent color of body which becomes shorter than fifth instar, larva adopts hanging position for pupation usually attached at tip of fresh rolled leaf of host plant.

Pupa (Fig. 18). Elongated, dirty rosy white with fine pattern of pale grey-brown stripes and patches resembling dried and rolled leaf of bamboo; abdominal segments thickening gradually from A10 to A4; wing cases very compressed, extending from T1 to A4; dorsally, pupa with diffuse grey-brown line and row of fine dark brown points at each side; these points particularly visible on A1 to A4; also, with two more longitudinal lines of same color, one subdorsally with dark brown spot on A4 and another laterally just along spiracular band; cremaster and head cristulae appear darker than rest of pupa; head cristulae apposed and somewhat incurved ventrally; middle of each wing case and just over lateral stripe with small and somewhat diffuse yellow-ochre spot. Ca. 56 mm long. Adult emerges in 20 days.

Adult. Male (Figs. 19, 20). Forewing blackish brown with median area of blue-violet tone; tone also present on hindwing forming band along submarginal area, from subcostal vein to middle of wing and small patch on discal section. Hindwing also with rounded yellowish spot at inner margin with scent scales and black patch between this spot and end of blue-violet submarginal band.

Female (Fig. 21). Paler than male. Forewing with ochreous submarginal band forked anteriorly; with very translucent zone from basal to submedian area and design of underside clearly visible; this zone with pale blue-grey reflection; this pigmentation occurring from the basal to the median area, delimited by broad bluish-brown band from postmedian to outer margin; the inner margin with pale brownish gray color; on underside (Fig. 22), color pattern between male and female very similar, basically with details that permit identification of this species from others of genus, such as well marked and colored designs of gray, black, white and ochre patches and lines and presence of double eyespot on hindwing. Wingspan: 170 mm, male; 112 mm, female.

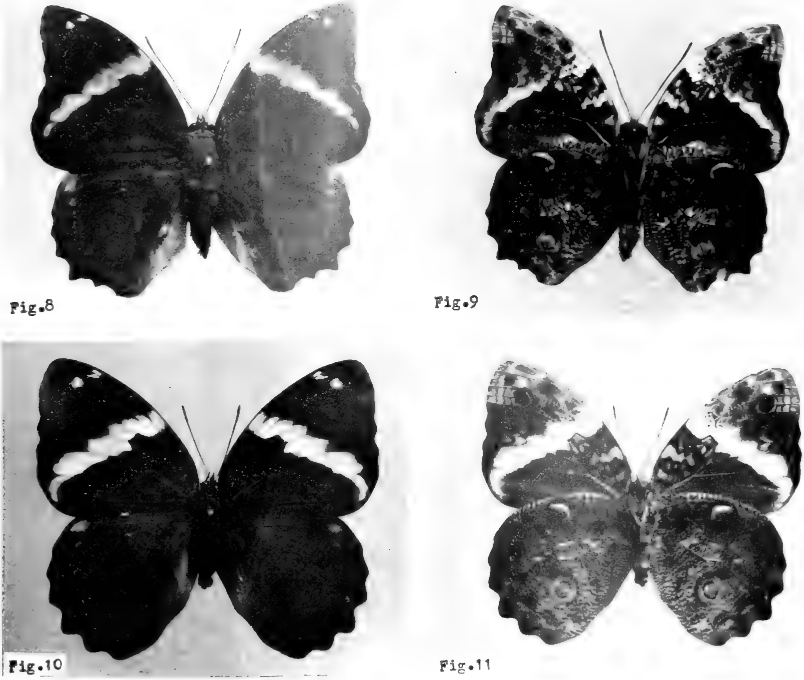
Natural History

According to Fruhstorfer (*in* Seitz, 1924), *Opsiphanes quiteria quirinus* Godman occurs from Guatemala to Panama; nevertheless, it is considered a very rare butterfly. In Costa Rica this species occurs from sea level to about 1000 m in the wet forests but is very seldom seen. It flies generally in the afternoon, mostly in the forests, but sometimes it is possible to observe a specimen flying across open areas.

O. quiteria quirinus represents one of the largest species of the Costa Rican *Opsiphanes*, occurring together with *O. cassina fabricii* Boisduval and *O. invirae cuspidatus* Stichel, and they probably share larval food plants (those in the Palmae family). I once saw a female of the former species ovipositing on a palm of *Geonoma* sp. in an inaccessible place in the forest at Estación Agua Fría at the Tortuguero National Park in the Province of Limón (20 m) and again at Colonia Virgen del Socorro, Province of Heredia (800 m), on the palm, *Prestoea allenii* H. E. More. According to these observations the female lays the eggs singly on the leaf but about four to six per plant. The larva is very cryptic while on the host plant, resting on the underside of the leaf during the first and second instars and later, in a "silk bed" that the caterpillar constructs with the semi-rolled tip of the leaf.

The adult is a very fast flier and feeds (as do all the species of the genus) on sap and rotting or decaying fruits.

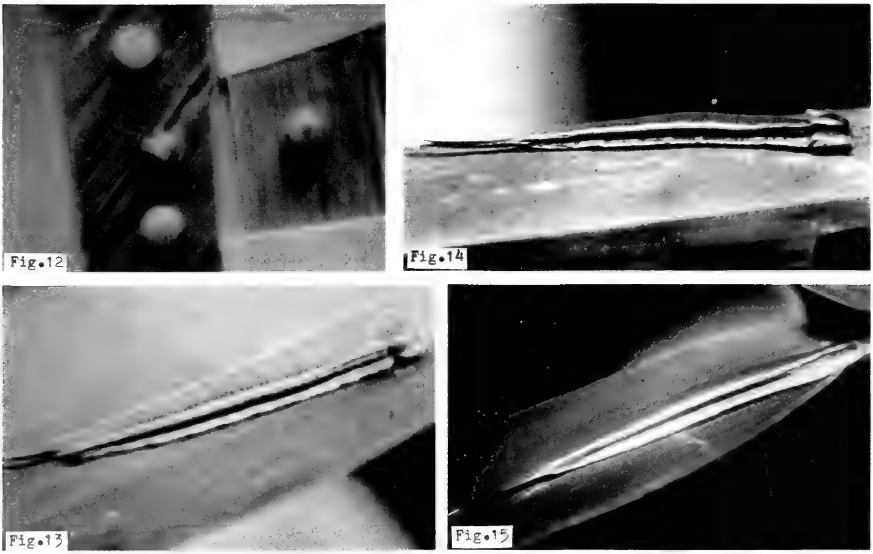
Eryphanis aesacus buboculus Butler has a wide distribution in the Costa Rican forests, and it occurs from 500 to about 1200 m. Nevertheless, with this wide distribution it represents a rare species with very restricted flying areas in association with water courses and bamboo thickets. Little is known of the adult behavior of this butterfly, but



FIGS. 8–11. *Opsiphanes quiteria quirinus*: **8 & 9,** male, dorsal and ventral aspects, 80 mm wingspan; **10 & 11,** female, dorsal and ventral aspects, 95 mm wingspan.

some observations, principally at Hacienda Santa María at the Rincón de la Vieja National Park in the Province of Guanacaste (900 m), reveals that *E. aesacus buboculus* is basically a crepuscular flier. It flies at dusk, essentially a courtship activity, which is characterized by territoriality behavior of the males along the river edges. The blue-violet iridescence of the male wings during their rapid flight is very conspicuous. The female receives the courting male on the surface of broad leaves, always on the river edges and particularly near the water falls. They are active at dusk for a period of about one hour and curiously halt all activity and disappear when bats begin to fly.

I suspect, as a result of a number of experiences using butterfly traps and banana bait, that the feeding habits take place mainly in the morning. *E. aesacus buboculus* feeds on sap and rotting fruits. I observed specimens feeding on decaying fruits, and only once did I see a female feeding on a bunch of fruits of *Ruagea caoba* (C. DC.) Harms (Meliaceae), approximately four meters above the ground near the Río Sarapiquí bridge on the way to Colonia Virgen del Socorro.



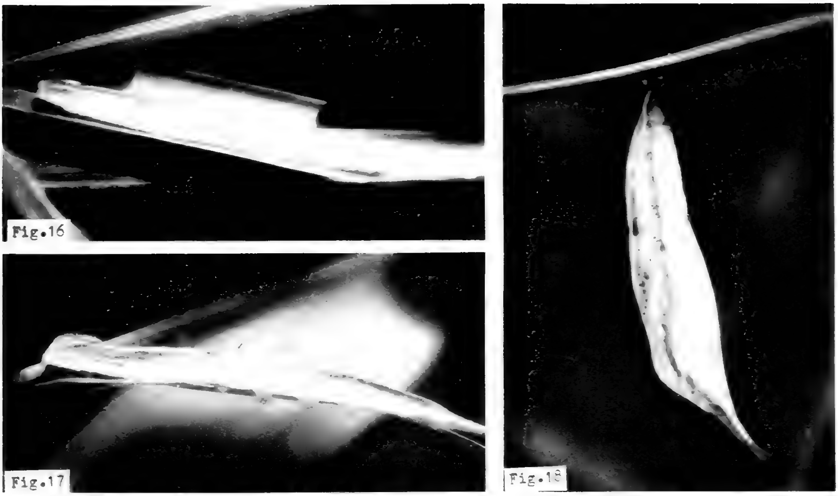
FIGS. 12–15. *Eryphanis aesacus buboculus*: **12,** eggs on *Bambusa vulgaris*; **13,** first instar larva after feeding, ca. 18.5 mm long; **14,** second instar larva, ca. 28 mm long; **15,** third instar larva in resting position, ca. 44 mm long.

My observations of the oviposition habits of *E. aesacus buboculus* are restricted exclusively to my greenhouse work. The female used for this study laid fourteen eggs, from four to six per day. Eggs were laid in pairs or triplets on the leaves of *Bambusa vulgaris* Schard. ex Wendl. (Gramineae), used as a substitute for *Olyra caudata* Trin. (Gramineae), which is the primary natural food plant, at least for the area of Colonia Virgen del Socorro; although, it is possible that *E. aesacus buboculus* is using a wide spectrum of host plants of the Gramineae, including *Chusquea scabra* Sods. & Cald., which is also present there.

The larvae of *E. aesacus buboculus* are very cryptic when on the host plant, especially in the fourth and fifth instars. They rest at the end of the leaves and become very agitated when disturbed, separating and erecting their forked tail and secreting an odorous substance by means of the scent gland located in front of the prothoracic legs. The pupa is also very cryptic. Presently, I do not have any information about specific or generalized parasites for this brassolid.

Discussion

What impressed me is the scarcity of data published about the Brassolidae, especially in respect to the description of early stages and food plant records. It represents a serious problem for the correct identifi-



FIGS. 16–18. *Eryphanis aesacus buboculus*: **16,** fourth instar larva, ca. 80 mm long; **17,** fifth instar larva, ca. 118 mm long; **18,** pupa, lateral aspect, ca. 56 mm long.

cation of the species in a given locality. I still have many problems establishing the exact location of some species in this family, and the possibility of obtaining new data on Brassolidae for Central America looks almost impossible. Fruhstorfer's (*in* Seitz, 1924) data on the early stages are still the most complete information available, but they are insufficient and some of the adult species descriptions are not precise. That is the case with the description of the *O. quiteria quirinus* female, which is different from the original of Godman and Salvin (1879–1901). There are some short papers available that offer some help in establishing a relationship between Central and South American species, with short descriptions of the life cycles as in Rothschild (1916), but it is extremely urgent that there be a complete revision of the Brassolidae.

O. quiteria quirinus feeds on palms, but it is necessary to have more data about the species of palms used. I can supply this information as regards the palms of the genus *Geonoma* and *Prestoea*, in addition to a life cycle study on *O. invirae cuspidatus* using the same host plants. Also, there are more complete works on the common *O. cassina fabricii* as in Young and Muyshondt (1975), in which the palms *Cocos* and *Bactris* are reported as hosts for this species. Therefore, I suggest the possibility that *O. quiteria quirinus* uses a broad spectrum of species in the Palmae as host plants. I reared separately three larvae of *O. quiteria quirinus* on *Chrisalidocarpus lutescens* H. Wendl, which is an introduced species of palm (L. J. Poveda, pers. comm.; Holridge

FIGS. 19–22. *Eryphanis aesacus buboculus*. **19 & 20,** male, dorsal and ventral aspects, 107 mm wingspan; **21 & 22,** female, dorsal and ventral aspects, 112 mm wingspan.

and Poveda, 1975), and I obtained the same satisfactory results as on *Prestoea*. I also have *C. lutescens* at my home in Barva, Province of Heredia (1200 m), and it is constantly frequented by *O. cassina* females for oviposition.

In respect to the *Opsiphanes* caterpillars, it is necessary to mention the paper of Young and Muyshondt (1975), since these authors are in error when they predict that the eversible gland located in front of the prothoracic legs of *Caligo* and *Morpho* caterpillars is absent in *Opsiphanes* spp. I have observed that this gland is present in *O. cassina fabricii, O. invirae cuspidatus* and *O. quiteria quirinus* larvae, and is probably present in all the *Opsiphanes* larvae, including those of the old description of Müller (1886), which was disputed in Young and Muyshondt's article.

Eryphanis aesacus buboculus, according to Fruhstorfer's report (*in* Seitz, 1924), occurs from Nicaragua to Colombia. The distribution reports for the Costa Rican area come from very different habitats in the North, the Pacific and the Atlantic slopes and to some extent due to this circumstance, I suspect that this species uses many genera in the Gramineae as host plants. According to Poveda (pers. comm.) and to Standley's (1937) report, *Olyra caudata* is considered a very rare species, and the identification of this plant was very difficult. To support my theory, I reared some larvae of *E. aesacus buboculus* on *Chusquea scabra* with satisfactory results. Also, I received a report from Miguel Serrano (pers. comm.) of *E. aesacus aesacus* H.-Schaffer being reared on *Bambusa vulgaris* in El Salvador during 1967.

At Colonia Virgen del Socorro, I discovered that *E. aesacus buboculus* uses *Olyra caudata*, together with the satyrid *Oxeoschistus puerta submaculata* Butler and Druce, and curiously, this satyrid shares *Chusquea longifolia* Swallen with the brassolid *Opoptera staundingeri* Godman and Salvin at the Monte de la Cruz, Province of Heredia (2000 m). I hope that future studies with these species can further help us understand their relationships.

Another case of affinity occurs with the early stages and adult behavior observed for *E. aesacus buboculus* and *E. polyxena lycomedon* Felder. The only places where I have reports of the co-existence of these two species are from P. J. deVries (pers. comm.) at Turrialba, Province of Cartago (600 m), and from R. L. Hesterberg (pers. comm.) at Finca El Rodeo, Province of San José (500–600 m). Malcolm Barcant (1970) gives some short references on the adult behavior of *E. polyxena polyxena* Meerb. from Trinidad-Tobago, and it is also very interesting to observe that a close relationship exists between the habits of this species and those of the Costa Rican species of *Eryphanis*.

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THE DEFENSIVE ENSEMBLES OF TWO PALATABLE MOTHS

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ABSTRACT. I compared the primary (before disturbance) and secondary resting places, relative palatabilities, and escape behaviors of a feces-mimicking moth and a specific background matching moth. The components of the defensive ensemble are discussed.

There are two levels of anti-predation mechanisms, primary and secondary. Primary defensive strategies are those which are effective before the attack of the predator, e.g. background matching, aposematism, dispersion, anachoresis. Secondary techniques include protean escapes, noxious discharges, unpalatability, etc. (Edmunds, 1974). Previously, I had shown that there are different types of secondary protective behaviors which accompany aposematism and crypsis (Evans, 1983) and crypsis and Batesian mimicry (Evans, 1978). Possibly different subtypes of crypsis may be accompanied by different types of secondary defensive behavior. It is possible to recognize at least two types of cryptic organisms. Some animals have a specific color pattern, body outline, and behavior which allows them to match a particular portion of their habitat (Sargent, 1981). Apparently, there are other organisms which because of their generalized dull coloration, can blend into several backgrounds but none perfectly. Some authors (Agee, 1969 with *Heliothis zea*; Knight, 1916 with *Pseudaletia unipuncta*) have noted moths which rest in more than one situation in their habitats, but a similar observation could be made with some large mammals.

Resemblance to dung might be considered a third type of crypsis. Some authorities could argue that dung-like organisms are Batesian mimics, since they do not match any background. Cryptics such as stone-like plants (e.g. *Lithops* spp., Mesembryanthaceae) also resemble inedible objects but are found among a general background of the type of stones they resemble. Conversely, bird dung mimics would always be found naturally in ecosystems where bird droppings exist. The two basic strategies, i.e. crypsis and Batesian mimicry, seem to be parts of a continuum of deception types.

In this study I wished to compare the primary and secondary protective activities of a moth which resembled bird droppings to those activities of a moth which seemed to be a good match of a specific background.

Concochares arizonae Hy. Edw. (Noctuidae) is a black and white moth which, in its natural resting position, with wings folded, closely resembles a medium-sized passerine (Aves) dropping. It does not match the background of its habitat in general but it might seek out those specific situations where it would become inapparent. *Bomolocha vaga* (Hübner) (Noctuidae) is a russet and tan colored moth which seemed (to my eyes) successfully cryptic while resting on specific substrates. The dorsal coloration of *B. vega* suggests both the coloration and the texture of the broken stones which are abundant in its environment.

METHODS

Cryptic animals match their resting backgrounds to the exposed color pattern of their bodies (Sargent, 1981), display protean escape upon perceiving predator-like stimuli (Evans, 1983; Humphries & Driver, 1970), and are palatable (Rothschild, 1981). A study of a cryptic animal should touch on each of these points.

I conducted this study on the Yuma (Arizona) Desert near Fortuna wash. The area is a mixed *Larrea-Cercidium* community, the ground littered with weathered and broken dark-red stones. I performed the experiments from sunrise to one hour later in March when the ambient temperature varied 9–17°C and the moisture 18–42% R.H. Both moth species were assembled using an ultraviolet light placed on the ground in open areas the evening before the tests. I found it necessary to change the light's location three times during the course of the experiments because the local bird community repeatedly began to disturb the moths. Similar problems have previously been reported with assembling palatable moths in natural settings (Jeffords et al., 1979). I tested the moths' reactions to a dorsal front-wing touch using a needle as in a previous study (Evans, 1983). The front wing touch mimics the initial tentative attack by an avian insectivore. I recorded the reaction duration (±0.2 s), reaction type, and resting places before and after stimulus. I captured each moth after testing and maintained it at −20°C prior to the palatability tests.

The palatability of the moths was determined using standard techniques (Evans & Waldbauer, 1982; Evans, 1984). The test birds were three wild-caught adult northern catbirds (*Dumetella carolinensis* (L.) and two brown thrashers (*Toxostoma rufum* (L.) (both Passeriformes: Mimidae). Three acceptances in successive offerings for each bird constituted evidence of palatability in that species of moth.

I analyzed the data using r × c contingency tables (Snedecor & Cochran, 1980) since there was a non-normal distribution.

RESULTS

Both species of birds ate the moths. *B. vega* was eaten quickly and usually in preference to the alternative prey, *Tenebrio molitor* L. pu-

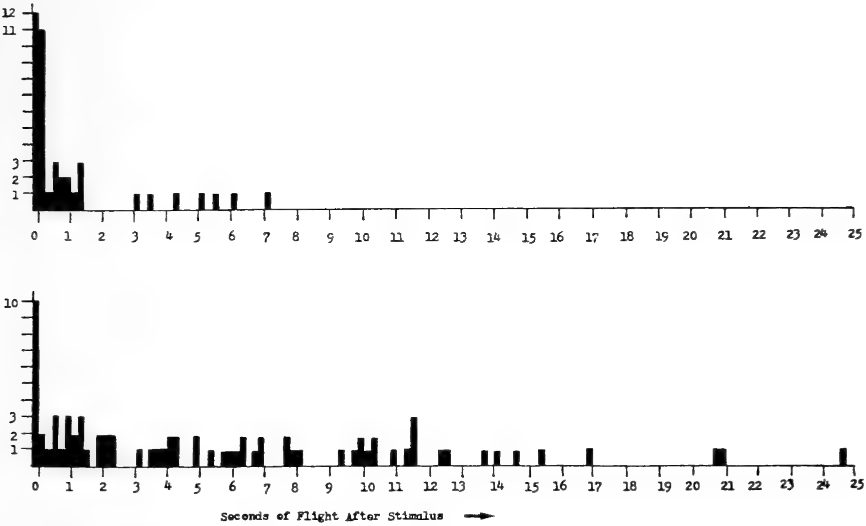

FIG. 1. Flight duration histogram. Flights timed ±0.2 s. Each moth was killed after a single test. The **upper graph** illustrates the flight duration frequencies of *Conochares arizonae* and the **bottom graph** those of *Bomolocha vega* (both Lepidoptera: Noctuidae). Additional times for *C. arizonae* not shown: 34.2 and 66.8 s. Additional durations of *B. vega* not shown: 36.8 and 55.8 s. The two moths have statistically significantly different flight duration frequencies ($P < 0.005$, r × c).

pae (Coleoptera: Tenebrionidae). This moth is doubtless a highly palatable species: I found numbers of their body-less wings near the light later in the day and saw (through a blind) house sparrows (*Passer domesticus* L.) feeding on the insects by first tearing off the moths' wings. The catbirds initially accepted *C. arizonae* with hesitation and after consuming the alternate prey. Upon subsequent presentations, the catbirds became more receptive to *C. arizonae* and began to eat them more quickly. Bent (1948) reports that adult female catbirds sometimes feed on their nestlings' droppings. Initially, nestling droppings are differently shaped than those of adults which *C. arizonae* resembles. The thrashers refused the latter moth species at first, but one of the thrashers began to eat them in later presentations. The other thrasher never touched the droppings-mimic. All four birds would hold this moth in their beaks for some time before ingesting it.

Near the ultraviolet light, I found all of the *B. vega* resting initially on substrates matching that of the dorsal (exposed) surface of their outstretched wings. There was really nothing other than bird feces in the area which matched *C. arizonae*. None of these moths was resting on or near bird feces.

Figure 1 illustrates the flight durations of the two species. I divided the 128 flight durations into 7 groups: 0 (no flight), 0.2–0.8 s, 1.0–1.6, 1.8–2.8, 3.0–4.0, 4.2–5.6, ≥5.8. The difference between the responses in the two moths is statistically significant ($P < 0.005$). Thirty-nine percent of the chi-square value came from the last classification.

Most of the flying moths changed the direction of flight at least once while in the air (*B. vega*, 84%; *C. arizonae*, 80%). The brief (≤0.4 s) flights of the feces mimics, however, were largely (88% of those short flights with at least one change in direction) straight away from the substrate and almost straight back to a place close to the starting point. These moths seemed to land on random objects. *B. vega* flights were typically protean (Roeder & Treat, 1961). When the moths landed, 82% of the *B. vega* landed on a matching substrate. The initial location of the moth was one that it had made, presumably, without the recent stress of the predator-like stimulus. The moths select the secondary landing site under potential pressure from a predator so that occasional mistakes must be made. I saw a few *B. vega* change their secondary landing site.

DISCUSSION

Clearly, the mimic of bird droppings was more likely to make quicker, shorter flights than the specific background matcher, *B. vega*. It seems logical that *C. arizonae* had brief flights since there was no particular background which they matched. In any case, the strategy of a fecal mimic is not to blend in exactly with a particular area but to be an apparent but ignored object. A bird dropping which flew relatively long horizontal distances would attract attention. Conversely, the *B. vega* encountered on their longer flights some non-matching or poorly matching substrates (trees, bushes, dead twigs, etc.) which most avoided. This activity would be likely to require more time. Apparently, if the optimal match is not discovered then a poorer match is sometimes accepted temporarily. In an earlier study (Evans, 1983), another moth resembling an inanimate object, *Datana ministra* (Drury) (dead twig mimic), exhibited a somewhat different pattern of escape behavior than that of taxonomically related general background matchers. Moth flight is ambient temperature dependent; therefore, these two studies are not precisely comparable since the present investigation was conducted with moths at lower air temperatures. Nevertheless, it appears that different escape behavior patterns may accompany different cryptic techniques. There are unified protective ensembles, the components of which can be isolated and shown to be characteristically distinct from analogous components in other life strategies.

ACKNOWLEDGMENTS

I wish to thank my parents, Mr. and Mrs. E. E. Evans for their help while I was in Yuma; Drs. Arslanian, Webb, and Waldbauer for their continued encouragement; and the School of Arts and Sciences of the American University of Beirut for their financial support.

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CYMAENES FINCA, SP. N. (HESPERIIDAE) FROM TRINIDAD, W.I.

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ABSTRACT. *Cymaenes finca*, sp. n. (Lepidoptera: Hesperiidae) is described as new from the island of Trinidad, West Indies. The male genitalia and forewing venation and markings are illustrated. It is compared with *C. tripunctus theogenis* Capronnier, and the male genitalia of that species are also illustrated.

Cymaenes finca, sp. n., described below, was taken by the author on the island of Trinidad, but not included in the recent list of the Hesperiidae of Trinidad and Tobago (Cock, 1982). It is compared with *C. tripunctus* H.-S. and *C. lepta* Hayward. The abbreviations and terminology used follow Evans (1955).

***Cymaenes finca*, new species**

Fig. 1 (♂ FW); 2–5 (♂ genitalia)

Description. ♂ F 15–17 mm. Upf brown; white spot in space 2 below origin of vein 4; another in space 3, and sometimes a very small one in 6; pale brown spot in space 1B faintly apparent and not always present; cilia concolorous (Fig. 1). Uph unmarked, brown; darker in space 7 and along termen, cilia concolorous. Unf brown, black on disc; spots as for upf; broad pale area in space 1B. Unh pale brown; faint white spots in spaces 2 and 3; inconspicuous pale streak in space 1C and along vein 2. Antennae dark above; barred along front margin of shaft; yellow below base of club; orange-brown below apiculus. Palpi paler basally, cheeks pale brown. Thorax and abdomen color match wings, except abdomen paler below. Mid tibiae five spines. Genitalia (Figs. 2–5); end of cuiller broadened, excavate and doubly spined at tip only. Uncus and gnathos deeply and broadly divided viewed dorsally, and deeply divided viewed from side.

♀ F 15 mm. In poor condition. Upf with white spots 1B (faint), 2, 3, 6–8; unf pale area in 1B inconspicuous; unh pale spots 2–6; otherwise as ♂.

Type material. Holotype male: Trinidad, W.I., Las Lomas, Spanish Farm, 17.XII.1980, MJW Cock; allotype female: same locality and collector, 2.VIII.1981; paratype males: same locality and collector, 1 ♂ 7.III.1980; 2 ♂♂ at dusk, 23.III.1980; 1 ♂ at dusk, 4.XI.1980; 1 ♂ 17.XII.1980; 2 ♂♂ 2.VIII.1981.

Deposition of type material. I retain two paratypes, one will be sent to the National Museum of Natural History, Washington, and the remaining paratypes, the allotype and the holotype will be deposited at the British Museum (Natural History).

Discussion. The double spined cuiller tip of the male valve puts this species in the same group as *C. tripunctus* and *C. lepta*. *C. finca*, however, is only doubly spined at the tip of the cuiller. Compared with *C. tripunctus theogenis* Capronnier (Figs. 6–8), *C. finca* is larger, the wings are more produced, and the uncus and gnathos are more strongly divided. *C. lepta* is much more extensively spotted (Evans, 1955), having a "broad continuous row of pale spots from space 1C to 7, broadly dark-edged on both sides and a spot before end cell" on unh and

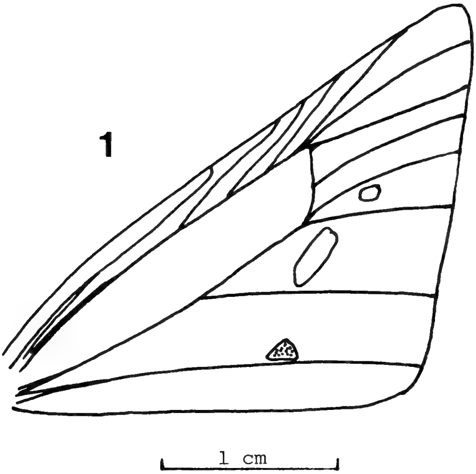
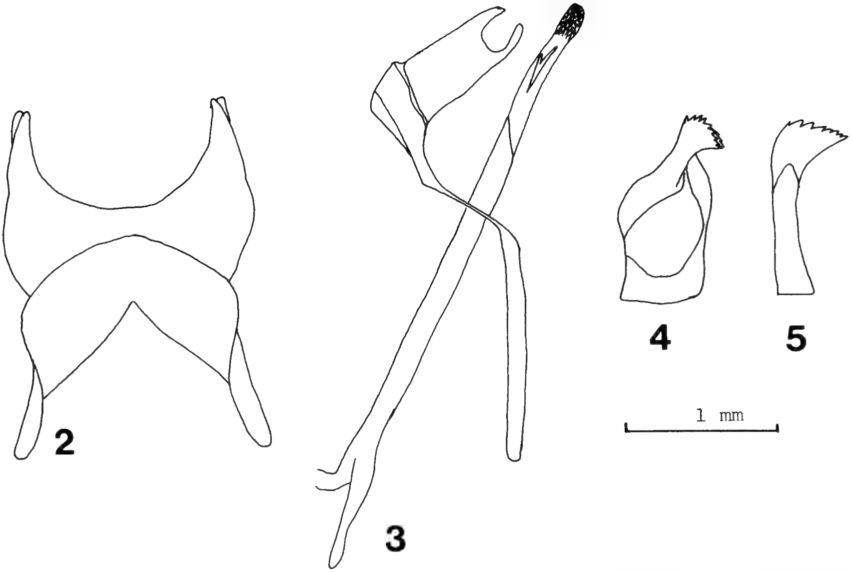


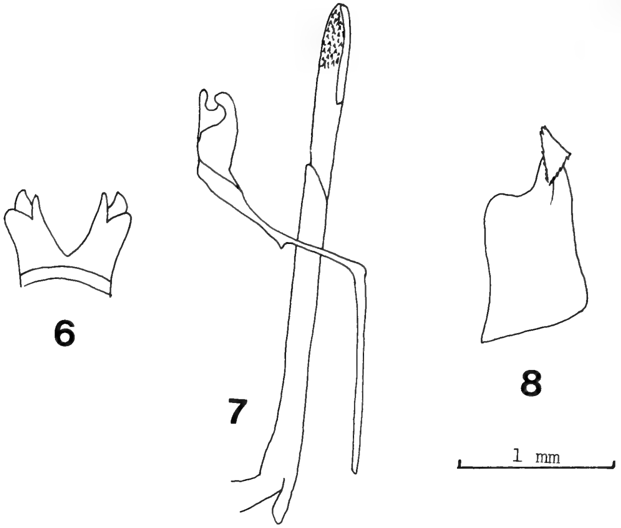
FIG. 1. FW venation and UPS markings of ♂ *Cymaenes finca,* sp. n.

"generally conspicuous white spots in spaces 1B, 2, 3 and 6–8 and may be cell dot" on upf.

The type locality, Spanish Farm, is a small patch of lowland forest on a ridgetop, just north of the road from Las Lomas to San Rafael.



FIGS. 2–5. Male genitalia *Cymaenes finca,* sp. n. **2,** dorsal view uncus and gnathos. **3,** lateral view without claspers. **4,** left clasper internal view. **5,** left clasper ventral view.



FIGS. 6–8. Male genitalia *Cymaenes tripunctus theogenis* Capronnier from Trinidad. **6,** dorsal view uncus and gnathos. **7,** lateral view without claspers. **8,** left clasper ventral view.

As Barcant (1970) has pointed out, it harbors a rich butterfly fauna. *C. finca* is the second species to be described from this locality in recent years. The riodinid *Pachythone barcanti* Tite (not Barcant) was also described from here, although it is also known from other areas of Trinidad, e.g., Sans Souci Estate, Sangre Grande (F. C. Urich, pers. comm.). This and the wide variety of interesting and rare species to be found there justify efforts to preserve what remains of this small wood.

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BOOK REVIEW

LEPIDOPTERA: HESPERIIDAE. NOTES ON SPECIES-GROUP NAMES, by Charles A. Bridges. Urbana, Illinois, publ. by the author: ii + I.129 + II.41 + III.62 + IV.30 + V.13 pp. Price: $35.00 (available from author: 502 W. Main St., Apt. 120, Urbana, IL 61801).

This is an impressive compendium of the known literature on the skipper butterflies of the world. There is a brief Introduction, 129 pages of Species-group Names of Hesperiidae, a 41-page Index of Genera with their included species, an Index of Authors and Bibliography (62 pages), a 30-page Bibliography and a 16-page Index to Journals and Serials. All of these are very useful to the specialist, and it certainly gives an idea of the library that needs to be available for systematic work on a worldwide basis.

Citations for the names are given in Section I, along with type localities and sites of deposition of the type specimens, where these data are known, using a similar format to that used by F. M. Brown and myself in our *Catalogue/Checklist* but much more compact. The type localities are abbreviated, however. It is interesting that on page I.1 the statement is made that the arrangement is based entirely on bibliographic references; that no specimens have been examined and that no new names are introduced. Therein, to some users, is a problem with this volume: but it is not the province of a bibliographic compilation to pass such judgments. One has a right, however, to expect that the bibliographic citations have been checked for their accuracy. Regrettably, such is not always the case in this work. I have closely examined only those citations that impinge on my own work and find that there are definite misstatements in the book.

On page I.2 the citation for *Thorybes aemilea* (Skinner) is given as an incorrect subsequent spelling (ISS) of *aemilia*, but examination of Skinner's original description shows that the proper spelling is indeed "*aemilea.*" The *aemilia* spelling apparently dates from Holland's *Butterfly Book* in 1898, which was copied by Evans in his *Catalogue*. There was at least one ISS in the Miller and Brown *Catalogue/Checklist* that Bridges did not catch: Parker described *Hesperia powesheik* from Grinnell, Iowa in 1870. Grinnell is in Powesh*ie*k county, and we spelled the species name the same as the county name; I have been unable to find that *lapsus* elsewhere, and we must be blamed for it.

Some nomenclatorial errors are also promulgated in this book. For example, on page I.60 *Hesperia julianus* Turton, 1802 is listed under "d" (available, invalid, unused), whereas, *H. julianus* Latreille, [1824] is listed right below it as "c" (available, valid synonym). Clearly, Latreille created an invalid junior homonym, whereas, Turton's name is indeed available; so, the designations on these two names should be reversed. Elsewhere (page I.15), my subspecies *benitoensis* is listed as in the genus *Unkana*, an Indo-Malayan genus. My insect was named in the African genus *Ceratrichia*, and the entire paper was devoted to African skippers. The name in question was applied to a subspecies of *Ceratrichia flava* (Hewitson), rather than *Unkana flava* Evans from India. *C. flava* and several of its subspecies are mentioned in II.8, and the mixup here is puzzling.

These complaints are not made to diminish from the book's great value. They are more to alert workers to the necessity of checking **original** sources in cases of a nomenclatural problem. Secondary sources (of which this book is one) should be used as indications of **where** to find original data and not considered to be the data themselves. In this regard, and with the above caveats, I consider this book to be one of the most significant weapons in the hesperiid systematist's arsenal. Bridges has written me that he intends a revised edition incorporating the corrections that he receives from other workers. This work is a great deal better on names than is the average museum card catalogue, even in its present form, and workers on groups other than the skippers can only hope that Bridges will favor us with volumes on other families in the near future (he is already at work on the Lycaenidae). If the reader has any taxonomic interest in skippers, he/she **must** have this volume. $35.00 is cheap for the "wisdom of the ages" in hesperiid taxonomy.

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GENERAL NOTES

FIRST CALIFORNIA RECORD AND CONFIRMATION OF A ROSACEOUS HOST FOR *ERIOCRANIA* (ERIOCRANIIDAE)

On 27 April 1981, numerous leafmining larvae of an eriocraniid were collected on *Holodiscus discolor* Maxim. The leafmines were abundant on *Holodiscus* bushes growing adjacent to the eucalyptus grove upslope from the entrance to San Bruno Mountain Park, San Mateo Co., CA. At that time, 85–90% of the mines had been abandoned by the fully matured larvae.

The site was revisited on 5 February and 5 March 1982; on the second visit adults of *Eriocrania semipurpurella pacifica* Davis were found in abundance. Adults were observed from 1000 to 1200 h, during which time I observed three pairs in copulo and several females ovipositing on the young expanding leaves of *Holodiscus*. On 4 April 1982, no adults were observed, and many of the larval mines were underway, although few mines had reached maturity.

Davis (1978, Smithsonian Contrib. Zool. 251:1–131) records *Holodiscus discolor* as the probable but questionable host of *E. s. pacifica* based on a larval eriocraniid collection from Vancouver, British Columbia. All other known hosts of eriocraniids are members of the order Fagales. *Holodiscus*, a member of the Rosales, would represent a novel host switch for the family Eriocraniidae. The circumstantial association of larvae and adults and the ovipositional behavior of females confirm *H. discolor* as a primary host of *E. s. pacifica*.

The geographically nearest confirmed record of this insect is Whatcom Co., WA, where J. F. Clarke collected adults in April 1923. However, a single male in poor condition, which may represent this species, was collected by Walsingham in Grant Co., OR (Davis, 1978, loc. cit.).

Davis (1978, loc. cit.) described *E. s. pacifica* as a subspecies distinct from the European and northeastern North American, *Betula*-feeding populations of *E. s. semipurpurella* (Stephens). Despite the morphological resemblance of *E. s. pacifica* to *E. s. semipurpurella*, it seems certain that the former is deserving of specific recognition as it is both allopatric to other known populations of *E. s. semipurpurella* and possesses a novel host association. Among leafminers it would be most unusual to find a single species feeding on plants belonging to different orders, i.e., the Fagales and Rosales (Needham et al., 1928, Leaf-mining Insects. Baltimore: The Williams and Wilkens Co. 351 pp.; and Hering, 1951, Biology of Leaf Miners. s'Gravenhage: W. Junk. 420 pp.).

Previously, three of the five described genera of Eriocraniidae were known from the Californian fauna: *Dyseriocrania* Spuler, *Eriocraniella* Viette, and *Neocrania* Davis. With the addition of *Eriocrania semipurpurella pacifica*, the Californian fauna consists of eight recognized species in four genera, and appears to be the richest in diversity of any region of comparable area.

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AMPHION NESSUS (SPHINGIDAE) ATTRACTED TO PHEROMONES OF *ANISOTA VIRGINIENSIS* (SATURNIIDAE)

On the afternoon of 9 June 1983 in Groton, Middlesex County, Massachusetts, at approximately 1500 h, I noticed a male *Amphion nessus* (Cramer) hovering about an emergence cage containing pupae of several species of moths. It was a bright early summer day with temperature, humidity and wind conditions within normal ranges. Shortly, there were as many as four *A. nessus* males in the vicinity of the cage. The moths were searching the cage and adjacent shrubbery as though they were attempting to locate a "calling" female.

The only moth in the cage was a female *Anisota virginiensis virginiensis* (Drury), whose scent organ was extended. Vegetation in the vicinity of the cage consisted of two evergreen shrubs and lawn. There was little possibility of a wild *A. nessus* female being in the area. Furthermore, it was obvious from the attention the cage was getting from the males that the *A. nessus* were attracted by pheromones coming from the cage itself.

Three *A. nessus* males were captured easily at the cage. The *anisota* female was left in the cage for a second day and again *A. nessus* came to investigate. On the basis of visual observation, these moths were also males.

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A SIMPLE METHOD FOR MEASURING NECTAR EXTRACTION RATES IN BUTTERFLIES

The rate at which nectarivorous animals extract nectar from flowers is one of the major parameters determining the instantaneous rate of energy intake, a quantity which is presumed to be maximized by natural selection (Pyke, Pulliam & Charnov, 1977, Quart. Rev. Biol. 52:137–154). The rate of energy intake equals the rate of nectar extraction (μl/second) multiplied by the energy content of the nectar (Joules/μl). The rate of nectar extraction has been included in theoretical models of feeding energetics in butterflies (Kingsolver & Daniel, 1979, J. Theor. Biol. 76:167–179) and nectarivorous animals in general (Heyneman, Oecologia, 60:198–213). Although this rate has been measured in hummingbirds and incorporated into models of feeding energetics (Hainsworth, 1973, Comp. Biochem. Physiol. 46:65–78), it has apparently never been measured in butterflies (Kingsolver & Daniel, 1979). Here I present a simple technique for measuring extraction rate in butterflies which may be applicable to other nectar feeders as well.

Nectar of a known concentration is loaded into a calibrated microcapillary tube (Drummond Microcaps) which is mounted on a small balsa platform with a millimeter scale alongside the capillary tube. The platform also includes a perch for the feeding butterfly to grasp (Fig. 1). The platform is displaced at a slight angle from horizontal to cause the nectar column to move downward as it is removed. As many butterflies maintain a body temperature somewhat above ambient (Rawlins, 1980, Ecology 61:345–357), and since extraction rate in poikilotherms is most likely temperature dependent, I placed both the butterflies and the apparatus within a styrofoam chamber maintained at about 28°C with a heat lamp.

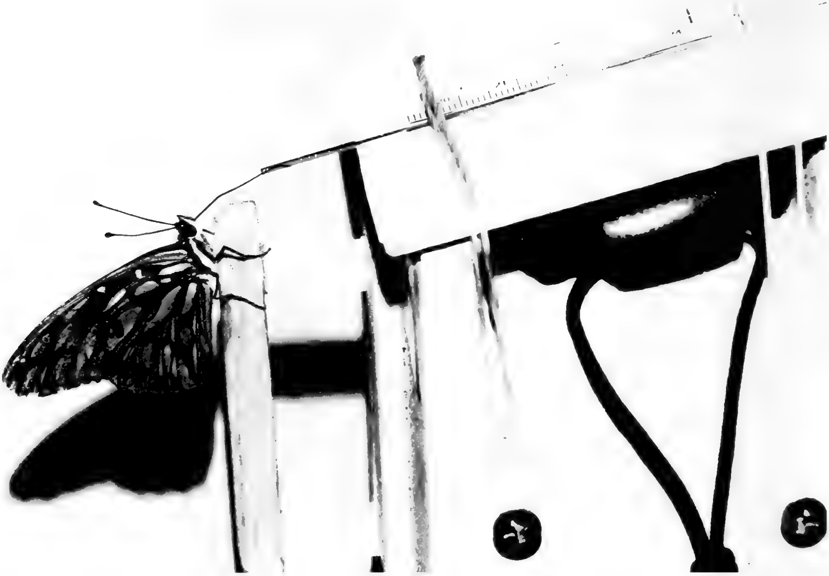

FIG. 1. *Agraulis vanillae* feeding at the described apparatus. The platform encloses a stopwatch with which the feeding bout is timed. Alternatively, the stopwatch can be handheld.

The technique for measuring extraction rate takes advantage of the apparently innate feeding response in butterflies which is released by the contact of the proboscis with a sugar solution. The butterfly is manually placed onto the perch and its proboscis is coaxed into contact with the leading edge of the nectar column contained in the microcapillary tube. As nectar extraction proceeds, the meniscus at the trailing edge of the nectar column can be timed with a stopwatch as it moves along the scale. I have had best success with 100 μl microcapillary tubes (as opposed to smaller sizes), as the hardest part of the process is in establishing by manipulation the initial contact between the proboscis and the nectar. Larger microcapillary tubes have larger internal diameters, thus facilitating this part of the procedure. Reducing the size of the capillary tube would increase the resolution of the system, however.

I have used this method with several species of papilionids, *Basilarchia archippus* (Cramer) and *Agraulis vanillae* (Linnaeus) (Nymphalidae) and *Phoebis sennae* (Linnaeus) (Pieridae) with equal success. All of these species exhibit a similar response to the initial contact of the proboscis with the sugar solution; the proboscis begins a series of probing motions which sometimes pulls it out of the nectar column. If the proboscis does not recontact the solution within a few seconds, the butterfly coils it and ceases probing. If the tip is thrust back into the capillary tube, feeding begins. Once the butterfly begins feeding, it is no longer necessary to restrain the insect as it grasps the perch and feeds as it would at a flower, in some species with a characteristic folding and unfolding of the wings while feeding.

Although my use of this method has been to investigate the relationship between nectar concentration, viscosity and extraction rate (May, in prep.), this method may also be useful for studies of adult diet, in which the effect of various dietary constituents on longevity or fecundity are measured. In studies of this type, researchers often feed the insects to satiation (e.g., Murphy, Launer & Ehrlich, 1983, Oecologia 56:257–263). Using the method described here, one can precisely control the volume of nectar imbibed by individual insects by regulating the volume placed within the capillary tube or by simply removing them from the capillary tube once a predetermined volume has been consumed.

I would like to thank J. A. Cohen and C. S. Hieber for comments on this note.

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OBSERVATIONS ON THE LIFE HISTORY OF *OCCIDRYAS ANICIA BERNADETTA* (NYMPHALIDAE) AT THE TYPE LOCALITY

Although Leussler's checkerspot, *Occidryas anicia bernadetta* (Leussler), was described over 60 years ago (Leussler, 1920, Entomol. News 31:102–103), little is known about its habits, and nothing has been published on the early stages or larval foodplant of this butterfly. Intensive collecting has been done at the type locality, Monroe Canyon (Sioux Co., NE); the latest report was from collections made from 1960–65 (Johnson & Nixon, 1967, Amer. Mid. Nat. 78(2):508–528). Even so, Leussler (1938, Entomol. News 49:3–9, 76–80, 213–218, 275–280) sums up all that had previously been known about *bernadetta*. He states that *bernadetta* is "very abundant along the canyon rims in Sioux Co. in late May and early June."

In an attempt to learn more about *bernadetta*'s life history, two years of observations were made at Monroe Canyon. This report identifies a larval foodplant, describes mature larval and pupal stages, and identifies three parasites associated with the butterfly.

Our experience with *bernadetta* began in 1982, when trips were made to Monroe Canyon on 22 and 29 May to search for larvae and/or adults. Several suspected foodplants were examined for damage, but no larvae were found. Only two adult males were seen and collected on 22 May. *Bernadetta* adults were common on 29 May, with highest densities observed nectaring on choke cherry, *Prunus virginiana* L. Adults were also seen resting on leaves of wolfberry, *Symphoricarpos occidentalis* (Hook.),. which was in close proximity to the *P. virginiana*. After watching *bernadetta* females alight on the *S. occidentalis* leaves, examinations of the leaves were made for ova but none were found. However, a pair of *bernadetta* were observed in copula at 1250 h, less than 0.5 m from the nearest *S. occcidentalis* plant. The pair was taken alive in an attempt to induce oviposition by the female, but the female died in transit.

We returned to the type locality again on 30 May 1983, with hopes of finding immature stages of the butterfly. Chances were better for finding larvae in 1983 since the season was slightly retarded due to a late spring snowfall. An afternoon of collecting resulted in many Lepidoptera, including a few male *bernadetta* caught on the canyon slopes, but no larvae were found until the sky became overcast about 1600 h. Several extremely fresh male *bernadetta* were flushed out of the grass near a stand of *S. occidentalis*. A search of the *S. occidentalis* yielded a dozen large larvae feeding on newly visible leaf tips of the plants. Damage was seen only upon very close examination; it seemed that larval feeding was restricted to newer leaves. A thorough search of the area also revealed pupae and desiccated larvae. Other stands of *S. occidentalis* were examined for larvae, but only several on the higher hillsides contained larvae. Altogether, 18 larvae and three pupae were found on 30 May.

FIG. 1. Larva of *Occidryas anicia bernadetta* on *Symphoricarpos occidentalis*.

The next morning (again under an overcast sky), 27 more larvae were found, which led us to believe that *bernadetta* larvae normally fed during crepuscular to nocturnal hours. This might explain why larvae had been previously overlooked in the field.

The overall color of the mature *bernadetta* larva is white. A thin mid-dorsal black stripe is interrupted by orange spots, centrally located on the dorsal area on each segment. A heavy, black, sub-dorsal stripe is present, and a thin, black stripe bisects the spiracular area. The basal color of the supraspiracular row of scoli is orange. The head and scoli are black, covered with black setae (Fig. 1).

The overall color of the pupa is white. Black and orange spots and/or markings are present, especially on the thorax and abdomen. Wings are streaked with black. Antennal segments alternate black and white (Fig. 2).

Of the 45 larvae collected, 19 (42%) were parasitized. The remaining pupated and eclosed as eight males and 18 females.

The parasitized larvae were categorized by two main symptoms: (1) they would either shrink lengthwise, swell, and desiccate, or (2) they would remain normal size, desiccating only after small parasitic larvae had crawled out of the *bernadetta* larva and made cocoons nearby. The parasites that emerged from the swollen *bernadetta* larvae were identified as ichneumonids, *Benjaminia* sp. (probably new). Only one *Benjaminia* adult emerged per parasitized *bernadetta*. The parasites that emerged from the normal size *bernadetta* larvae were identified as braconids, *Cotesia koebelei* (Riley). Up to 30 *C. koebelei* adults emerged from a single *bernadetta* larva. Another ichneumonid parasite, *Pterocormus* sp., emerged from the anterior region of a single *bernadetta* pupa. No parasites were observed in the field.

As other trips to the type locality are planned, observations on *bernadetta* will continue to be made. Other larval food plants are suspected; efforts will be made to identify them. The overwintering habits of *bernadetta* remain unknown and need to be researched.

We wish to thank the following people for making identifications: R. C. Lommasson,

FIG. 2. Pupae of *Occidryas anicia bernadetta.*

School of Life Sciences, University of Nebraska, Lincoln, NE 68588 (*S. occidentalis*); V. K. Gupta, Center for Parasitic Hymenoptera, Gainesville, FL 32602 (*Benjaminia* sp., *Pterocormus* sp.); S. R. Shaw and P. M. Marsh, Systematic Entomology Laboratory, USDA-ARS, Insect Identification and Beneficial Insect Introduction Institute, Beltsville, MD 20705 (*C. koebelei*).

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NOTE ON CRUMB'S "LIBERAE ET CONFLUENTAE" COUPLET (NOCTUIDAE)[1,2]

The first major systematic treatment of the larvae of North American Noctuidae was written by Crumb (1956, Larvae of the Phalaenidae, USDA Tech. Bull. 1135. 356 pp.). It is a monumental work, containing extensive diagnostic keys, larval descriptions, geo-

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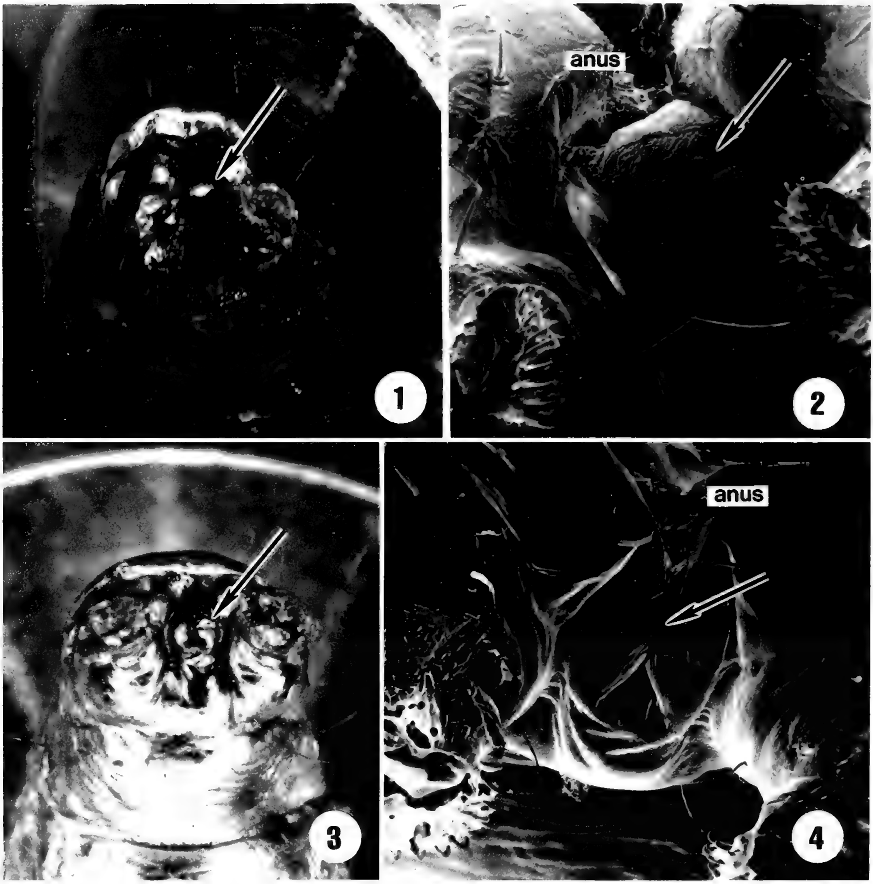
[1] Partially funded by the Illinois Agricultural Experiment Station Project 12-361 Biosystematics of Insects.
[2] Michigan Agricultural Experiment Station Journal Article No. 11102.



FIGS. 1–4. Tenth abdominal segments showing ventral and subanal regions of last instar noctuid larvae. **1 & 2,** truncate or convex condition of posterior margin of venter (subanal region) (see arrows) (*Alypia octomaculata*); **3 & 4,** medially impressed or grooved condition of the same region (see arrows) (*Papaipema nebris*). (Figs. 1 & 3 were photographed through a Leitz Aristophot, printed sizes = 9× and 13×, respectively; 2 & 4 were taken with the aid of a scanning electron microscope, printed sizes = 36×; all photographs by G.L.G.)

graphic distributions, and a wealth of host plant information. Experienced entomologists as well as students taking courses on immature insects have used it with varying degrees of satisfaction, but many have had interpretive difficulties with the keys.

The most obvious problems, according to a number of workers, are encountered in the first couplet of Crumb's "Key to subfamilies" (p. 2) and his figures "A" and "B" in Plate 1. At this point users of the key encounter Crumb's first major division of the noctuid larvae. He summarized the choices as "liberae" and "confluentae" in reference to the spatial separation between the subanal and ventral areas on the 10th abdominal segment. The difficulty lies, not so much in the terminology, but in the user's trying to determine the perspective of the figures, which is obliquely posterior with the ventral side up, and in relating the lengthy couplet to the line drawings. But even when one knows the perspective, it is difficult to position a caterpillar in the same view under a dissecting microscope and still keep it submerged in alcohol.

The purpose of our paper is to clarify this couplet by rewording it and offering light and SEM photographs of the appropriate structures. Hopefully, the overall utility of Crumb's publication will be enhanced. In all due respect, it should be noted that Crumb's publication was completed during a period of the author's failing eyesight in his retirement years (Clarke, pers. comm.). Otherwise, we are quite certain that it would have been more clearly illustrated and keyed.

Thus, our suggested alternative for the first couplet is:

1. Venter of abdominal segment 10 not grooved posteriorly, the posterior margin (subanal region) truncate or convex (Figs. 1, 2) **2**
   Venter of abdominal segment 10 grooved posteriorly, the posterior margin (subanal region) medially impressed (Figs. 3, 4) **9**

These differences show reasonably well in the accompanying illustrations of *Alypia octomaculata* Fabricius (eight-spotted forester) and *Papaipema nebris* (Guenée) (common stalk borer). However, proceed with caution, because as Crumb noted, the actual condition is sometimes very difficult to interpret if the specimen has been inflated or has had its rectum everted.

ACKNOWLEDGMENTS

This project was aided by the advice of J. R. Byers, Entomology Research Institute, Agriculture Canada, Ottawa, Ontario, Canada, and H. R. Sandberg, formerly with the Center for Electron Microscopy, University of Illinois, Urbana-Champaign. J. F. G. Clarke, U.S. National Museum of Natural History, Washington, DC, is thanked for his information about Crumb's career.

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EGG PARASITISM OF *APANTESIS PARTHENICE* (ARCTIIDAE) THROUGH APPARENT PHORESY BY THE WASP *TELENOMUS* SP. (SCELIONIDAE)

On 8 Aug. 1982 while hiking along the north fork of Rock Creek near Saddlestring (Johnson Co.), Wyoming at the HF Bar Ranch (elev. 5400 ft) at 1400 h, I collected a nearly fresh female specimen of an arctiid moth, *Apantesis parthenice* Kirby. The insect was resting on sagebrush a few inches above the ground and was hand-caught. I pinched its thorax lightly and placed it in a folded glassine envelope (size 3.5 × 2 in) which then was quickly transferred into my enclosed leather collecting pouch. Upon returning to the ranch after several hours of hiking, all of the envelopes containing specimens taken that afternoon were dated and put into a plastic bag with a card containing collection data. This bag in turn was tightly folded, sealed with masking tape, and placed in a closed cigar box in a dresser drawer in my cabin at the ranch.

Upon returning to Maryland later in the month, the cigar box was opened and unpacked in my laboratory at U.M.B.C. on 27 Aug. At this time I discovered 71 small dark

FIGS. 1–3. Arctiid moth egg shells (*Apantesis parthenice* and scelionid phoretic egg parasites, *Telenomus* sp.). **1,** moth egg shells, showing wasp emergence holes and single shed puparium within each egg; **2,** lateral view of wasp specimen; **3,** general microscopic view of wasps and eggs.

eggs which had been laid by the moth. Six first instar larvae had emerged. One of them was dead, but the others were crawling around inside the glassine envelope. Also found within the envelope were four live minute wasps (later identified as Proctotrupoidea, Scelionidae, *Telenomus* sp.). These wasps and the moth eggs are shown in Figs. 1–3. Further examination of all of the remaining darkened eggs using a stereo-microscope revealed that each contained a single fully matured wasp inside of the transparent egg chorion. The small wasps were living, and their wings had fully expanded within the eggs. The arctiid eggs all were placed into a covered plastic petri dish with a small square of moistened filter paper. Several wasps were watched as they emerged through the egg shells after chewing small holes (Fig. 1). The wasps were about 1 mm long, had yellowish legs and antennae, and had nearly veinless transparent round-margined wings (Fig. 2). By Monday 30 Aug., 52 additional wasps representing both sexes had emerged from 53 remaining eggs (Fig. 3). Evidently, all but six of the eggs had been parasitized.

The maternal parasitic wasp must have been introduced into the glassine envelope at the same time the specimen of *Apantesis* was placed there. There was little (if any) opportunity for the wasp to have found her way into the closed envelope at a later time, although no wasp was seen at the time of collection, and none has been found clinging to the pinned moth despite thorough observation through the stereo-microscope. Most likely the maternal wasp was clinging to the resting moth (perhaps hiding beneath her wings or within the thick carpet of abdominal or thoracic scales) and was inadvertently introduced by me into the glassine envelope in this way.

A number of arthropods including chalcid, trichogrammatid, and scelionid wasps are known to exhibit phoresy, the phenomenon of attaching themselves to another insect for purposes of transportation (Borrer, DeLong & Triplehorn, 1964, An introduction to the study of insects, 4th ed., Holt, Rinehart and Winston, N.Y., 852 pp.; Comstock, 1964, An introduction to entomology, 9th rev. ed., Comstock Publ. Assoc., Ithaca, N.Y., 1064 pp.; Frost, 1959, Insect life and insect natural history, 2nd rev. ed., Dover Publ., Inc., N.Y. 526 pp.). This behavior has been particularly well-documented for wasp species attacking the eggs of spiders, Hemiptera, Orthoptera, and mantids (Askew, 1971, Parasitic insects, Amer. Elsevier Publ. Co., Inc., N.Y. 316 pp.; Muesebeck, 1972, Nearctic species of Scelionidae (Hymenoptera: Proctotrupoidea) that parasitize the eggs of grasshoppers, Smiths. Contribs. Zool. No. 122, Smiths. Instit. Press, Wash., D.C. 33 pp.; and Rabaud, 1922, Note sur la comportement de *Rielia manticida* Kieff., Proctotrupide parasite des ootheques de Mantes, Bull. Soc. Zool. Fr. 47:10–15). L. Van Vuuren (1935, Waarnemingen omtrent *Phanurus beneficiens* (Zehnt.) (Hym. Scelionidae) op *Schoenobius bipunctifer* Walker, Ent. Meded. Ned.-Indië 1:29–33) describes the phoretic behavior of an Oriental scelionid which is a common parasite of pyralid moth eggs. The female wasps cling to the female host (either beneath her wings or to her body) until she lays eggs, at which time the parasite quickly detaches herself from the host and parasitizes the freshly laid eggs. This relationship is not an obligatory one, however.

TABLE 1. Records of (A) *Telenomus* wasps (Scelionidae) known to attack arctiids (with known localities of occurrence) and (B) parasitoids having *Apantesis* moth hosts, based on Muesebeck et al., 1951 and Krombein et al., 1979 (information courtesy of R. T. Mitchell).

Moth hosts	Wasp parasites
A) *Telenomus* species known to attack arctiids:	
Hyphantria cunea (Drury)	*Telenomus bifidis* Riley, D.C., Mo.
Diacrisia virginica (Fabr.)	*T. nigriscapus* Ashm., Mich., Ill.
Diacrisia virginica (Fabr.)	*T. spilosomatus* Ashm., D.C., Va., Kans.
B) Parasitoids having *Apantesis* moth hosts:	
Apantesis mais (Drury)	*Coelopisthia forbesii* (D.T.) Pteromalidae
A. virgo (L.)	*Casinaria genuina* (Nort.) Ichneumonidae
Apantesis sp.	*Hyposoter rivalis* (Cress.) Ichneumonidae
Apantesis sp.	*Apanteles phobetri* Rohwer, Brachonidae

Since the *A. parthenice* moth's thorax had been pinched, she probably oviposited over the next day or two only following collection (9–10 Aug. 1982). The wasp parasite in turn must have laid her own eggs at that time (or shortly thereafter) as well. Both moth egg-laying and wasp egg location and parasitization within the confines of the glassine envelope must have occurred in totally dark conditions inside the closed cigar box and closed dresser drawer. Development time of the *Apantesis* larvae and the full maturation of the proctotrupoid wasps both required between 17–19 days, basically at room temperature (i.e., indoors).

Whether or not these tiny egg parasites of Lepidoptera often search for, locate, and remain with females of their hosts, as these observations suggest, needs to be verified in the field. Such an egg-locating strategy would seem to be a very efficient one, especially, if fresh soft eggs are required for successful parasite oviposition. The overall frequency of moth egg parasitism was 65/71 eggs (or 91.5%) within the cramped confines of the glassine envelope. Such phoretic behavior would seem to convey a tremendous selective advantage to those individuals which practice it, as compared to the alternative strategy of directly seeking out individual eggs (or egg masses in the case of *A. parthenice*). Since only a single wasp parasite emerged from each moth egg, it is likely the maternal wasp was capable of distinguishing unparasitized (e.g., newly laid eggs) from those she had previously parasitized. Such chemosensory capabilities are widely known among parasitic Hymenoptera.

Although numerous parasitoids of the arctiidae are known, neither Muesebeck et al. (1951, Hymenoptera of America north of Mexico. Synoptic Catalogue, U.S. Govt. Print. Off., Wash., D.C. 1420 pp.) nor Krombein et al. (1979, Catalogue of Hymenoptera in America north of Mexico, Smiths. Inst. Press, Wash., D.C. Vols. 1 and 2, 275 pp.) list any parasitoids for *A. parthenice*. Only six wasp genera are included for the entire moth genus, as shown in Table 1. Fifty-three species of *Telenomus* wasps have been described from North America, but only three of them (as listed in the Table) are known to attack arctiid moths. The species of *Telenomus* here described may possibly be a new one, since this host record is new, and those previously reported are either eastern or midwestern. Also, only about one quarter of the total telenomid species in North America have so far been described (P. M. March, pers. comm.). This possibility presently is being investigated further. Scelionid wasps in some cases have been successfully used as biological control agents for insect pests.

I am grateful to Dr. P. M. Marsh for identifying the wasps, and to Dr. D. C. Ferguson for confirming the moth species. Both persons are from the Systematic Entomology Laboratory, U.S.D.A., U.S. Natural History Museum, Wash., D.C. 20560. I thank R. T. Mitchell of Silver Spring, Maryland for providing the information contained in Table 1, and for comments on the manuscript.

Covell, Jr. (1984. A field guide to the moths of eastern North America. Houghton Mifflin Co., Boston. 496 pp.) places this tiger moth in genus *Grammia*. Dr. Norman Johnson, Department of Entomology, Ohio State University, presently is revising the taxonomy of Scelionid wasps. He recently informed me (pers. comm.) that most of the early type specimens of *Telenomus* are females but that the male genitalia possess important diagnostic features for determining species status. This wasp species in his opinion may be undescribed and no specific designation can be given at this time.

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NOTES ON THE HABITAT AND FOODPLANT OF *INCISALIA HENRICI* (LYCAENIDAE) AND *PYGRUS CENTAUREAE* (HESPERIIDAE) IN MICHIGAN

The foodplant of *Incisalia henrici* (Grote and Robinson) in Michigan was unknown until 1981, when it was confirmed that maple-leaf viburnum, *Viburnum acerifolium* L. (Caprifoliaceae) is an acceptable foodplant. According to 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) and Pyle (1981, The Audubon Society field guide to North American butterflies, A. Knopf, Inc., NY), viburnum is not listed as a known foodplant for *I. henrici*.

I first became acquainted with Henry's Elfin in 1953, when a series was collected in the Langston State Game Area, Montcalm County, on 15 and 23 May. Since that time, *I. henrici* has been collected and observed in the same area in close proximity to second growth aspen (*Populus grandidentata* Michx. and *tremuloides* Michx.), white oak (*Quercus alba* L.) and red maple (*Acer rubrum* L.), with scattered white pine (*Pinus strobus* L.) on sandy soil. Most of the adults have been taken (before full leaf development along sandy trails and narrow wooded sunny openings) while perched on small shrubs, on dried leaves and twigs or on bare sand. At this site, adults could easily be overlooked because of their small size and dark color. Only once was an adult observed nectaring on choke cherry, *Prunus virginiana* L., along the trail. During this period, the elfin gave no clues to the preferred larval foodplant despite the presence in the Game Area of *Prunus* sp. and *Vaccinium* sp., two previously recorded foodplants for *I. henrici*.

It wasn't until 3 June 1979, that Harry King and I discovered several Lycaenidae larvae feeding on the flower cymes of *V. acerifolium* in a similar aspen-oak woods, located one and one-half miles north of the original site. The greenish slug-shaped larvae, with pale lateral stripes, appeared to resemble *I. henrici*, based on the brief description in Klots (1951, Field guide to the butterflies, Houghton Mifflin Co., MA). The larvae were removed and kept in captivity until the following spring when (to my disappointment) *Celastrina ladon* (Cramer) emerged. Then during 1980–1982, I examined flower cymes of *V. acerifolium* at both Game Area locations and found numerous larvae of various instars representing *C. ladon* and what was believed to be *I. henrici*. Subsequent emergence of *I. henrici* in 1981 and 1983 from over-wintering pupae finally confirmed the use of *Viburnum acerifolium* as the preferred foodplant in this location.

In 1974, Larry West, noted nature photographer, observed a female *Pygrus centaureae wyandot* (Edwards) oviposit an egg on the underside of a wild strawberry leaf, *Fragaria virginiana* Duchesne, on 22 May in Otsego County, Michigan. Since 1958, the grizzled skipper has been collected from 15 May to 3 June on a pine barren in an area of short grasses and sedges (including *Danthonia spicata* (L.) Beauv. and *Carex pennsylvanica* Lam.) on sandy soil. This skipper is not easily seen on the wing but can be collected with some frequency while nectaring on wild strawberry scattered in large patches throughout the open areas. Butterfly species that occur in the same area during the approximate flight period of *P. centaureae* include *Euchloe olympia* (Edwards), *Oeneis chryxus strigulosa* McDunnough and *Hesperia metea* Scudder.

With wild strawberry as the possible foodplant for *P. centaureae*, I searched strawberry patches during the summer from 1975 to 1979 for signs of larvae. Several mid-instar larvae were finally found in leaf nests on wild strawberry; the nests varied from a single folded leaf to three leaves held together with silk. The larval nests were constructed so the larvae rested on the upper leaf surface. Frequently, the heat of the day would curl many leaves, or a spider would curl a leaf for its egg mass, making it frustrating and difficult to find *P. centaureae* larval nests. The larvae were removed to captivity and finished feeding by late summer and over-wintered in the pupa stage. In reviewing the literature, this is the first record of wild strawberry as the foodplant for *P. centaureae wyandot*; other authors (Pyle, ibid.; and Ferris & Brown, 1981, Butterflies of the Rocky Mountain states, Univ. Oklahoma Press, OK) have cited *Rubus* and *Potentilla* (Rosaceae) as foodplants for *P. centaureae* in other parts of its range.

Perhaps both species will prove to be more widespread in the Great Lakes region when collectors are aware of their habitat and foodplant requirements. I wish to express my deep appreciation to Harry King and Larry West for sharing their field observations with me.

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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: Micropylar end view (×130) of the egg of *Sericosema* sp. (probably *juturnaria*) (Geometridae). The scanning electronmicrograph was taken by Thomas D. Eichlin, Sacramento, of eggs furnished by Ron Robertson, Santa Rosa, California.

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MAINTAINING SPECIES INTEGRITY BETWEEN SYMPATRIC POPULATIONS OF *HYALOPHORA CECROPIA* AND *HYALOPHORA COLUMBIA* (SATURNIIDAE) IN CENTRAL MICHIGAN

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ABSTRACT. The available literature suggests that *Hyalophora cecropia* and *Hyalophora columbia* have identical ethological requirements with respect to reproductive behavior and F_1 hybrids have often been produced in the laboratory. As a result, investigators have long been puzzled by the rarity of natural hybrids since the two species occur sympatrically over much of the northern Great Lakes region.

Field observations in Montcalm County, Michigan, identified a series of progressive barriers which operate to prevent hybridization. The prezygotic isolating mechanisms, seasonal isolation, daily allochronic flight behavior, and mechanical incompatibility restrict most of the interaction between the two species. However, when individuals occasionally overcome those barriers and a successful hybrid mating occurs, several postzygotic isolating mechanisms are then tested. As a result of the overall effectiveness of these systems, the gene pool of each species is protected, thereby allowing the two species to co-exist.

The large moths of the genus *Hyalophora* (Saturniidae) are represented by two species within the state of Michigan. The cecropia moth, *Hyalophora cecropia* (L.), is widely distributed, while *Hyalophora columbia* (S. I. Smith) is a much more localized species.

When Moore (1955) published his checklist of the Michigan moths, he listed 18 county records for *H. cecropia* from such varied locales as Dickinson County in the western portion of the Upper Peninsula to metropolitan Wayne County in the southeastern portion of the Lower Peninsula. He also cited statewide adult capture dates ranging from 27 May to 5 August.[1] The author's recent review of additional material in public and private collections has increased to 48 the number of counties from which *H. cecropia* has been reported (Fig. 1). The pa-

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[1] The 5 August date is based upon a reared specimen probably maintained under artificial conditions. Such late dates are highly unlikely in nature.

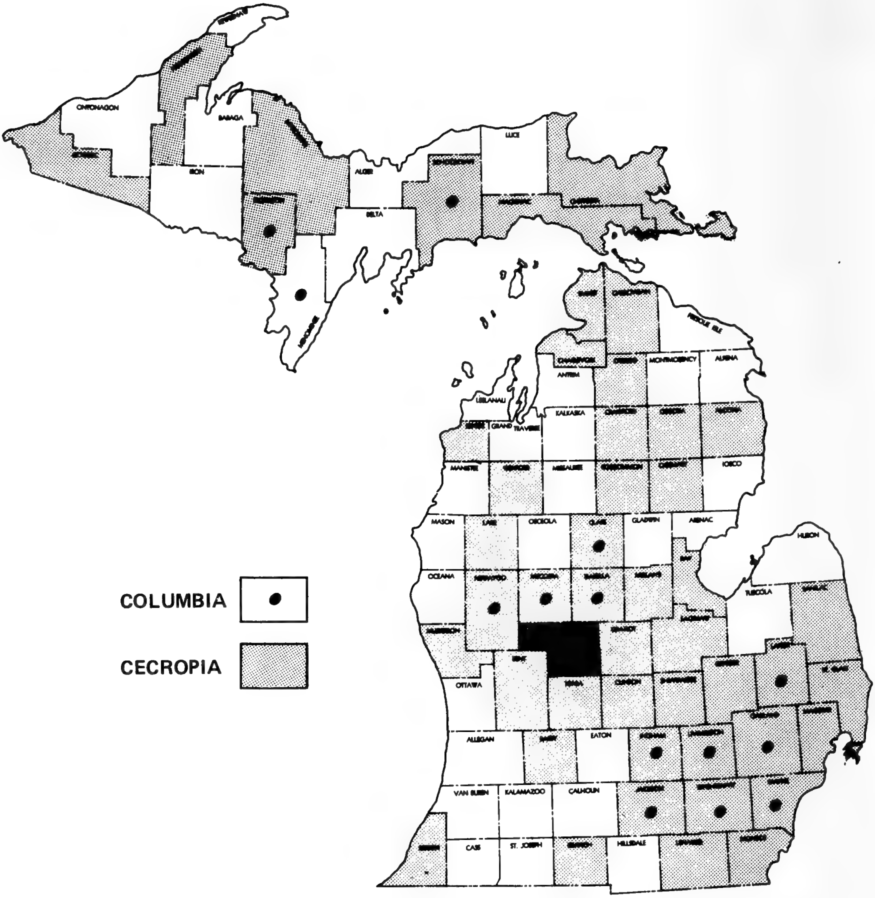

FIG. 1. Distributional map of *H. cecropia* and *H. columbia* in Michigan. Montcalm County (darkened) is the site of the present study.

rameters of the adult flight period were also expanded when wild capture dates as early as 22 May were discovered.

The distribution of *H. cecropia* within the state is greatly enhanced by the acceptance of a wide array of larval foodplants. Tietz (1972) lists 75 specific larval foodplant records, which include many of the native Michigan broadleaved trees and shrubs. This adaptability to varied plant communities is extremely important to a cosmopolitan species such as *H. cecropia.*

Although there are still a number of counties from which *H. cecropia* has not been reported, this would appear to be due to a lack of collecting. Based upon the adaptability of the species, the lack of restrictive topographical barriers within the state and the distribution of existing county records, it is reasonable to assume that *H. cecropia* occurs in all of Michigan's 83 counties.

In contrast to the large amount of data available on *H. cecropia*, the existing Michigan records of the distribution and flight period of *H. columbia* are extremely limited. Based exclusively on wild collected cocoons, Moore (1955) cited records for *H. columbia* from Lapeer, Montcalm, Oakland, Washtenaw, and Wayne counties. Since the publication of Moore's checklist there have been records from Ingham (Collins & Weast, 1961), Dickinson, Jackson, Livingston, Mecosta, Newaygo (Ferguson, 1972), Clare, Menominee, Schoolcraft (M. C. Nielsen, in litt.), and Isabella counties (Ted Herig, pers. comm.) (Fig. 1). Most of these additional records are also based upon wild collected cocoons.

In fact, prior to the present study, there were only six reports of *H. columbia* adults having been collected in Michigan. Three adults have been collected at light: a male collected in Menominee County on 10 June 1971; a female collected in Schoolcraft County on 21 June 1971; and a male (specimen lost) collected in Dickinson County (M. C. Nielsen, in litt.). In addition, in June 1978, single *H. columbia* males were attracted on each of three successive nights to a *H. cecropia* female in Montcalm County (Frank Hedges, pers. comm.).

Unlike the widespread distribution of *H. cecropia*, the range of *H. columbia* is limited by its dependency on larch (*Larix laricina*) as the larval foodplant. Although there are records of *H. columbia* being reared in captivity on choke cherry (*Prunus virginiana*) (Collins & Weast, 1961) and weeping willow (*Salix babylonica*) (Norman Tremblay, pers. comm.), it is now generally accepted that the larvae feed exclusively on larch in nature.

Many old foodplant records were erroneously based on cocoons found attached to plants growing in association with larch. This is clearly reflected in the type description of *H. columbia*, when Smith (1863) cites "*Nemopanthes canadensis* and *Rhodora canadensis*" as larval foodplants and only incidentally mentions larch as a possible alternate host. This can now be explained by the tendency of full-fed larvae to wander in search of an appropriate cocoon spinning site.

In Michigan's Upper Peninsula larch abounds as a dominant tree species in conifer bog and swamp community associations (Barnes & Wagner, 1981). As a result of the widespread distribution of larch in this area, *H. columbia* should be expected to occur regularly. The relatively few records from this region are almost certainly due to limited collecting.

The existing county records for *H. columbia* in Michigan's Lower

Peninsula occur as two separate pockets which include seven counties in the southeast and five counties in the central portion of the peninsula. In these areas, larch occurs only in poorly drained "kettle hole" type situations. Such bogs may be isolated by several miles of unsuitable habitat and are historically very susceptible to human influence.

An examination of specimens at the University of Michigan reveals several records for *H. columbia* from Wayne County prior to 1900. However, drainage and the resulting development have eliminated all of the suitable habitat. As a result, there are no records of *H. columbia* from Wayne County in this century.

H. columbia populations in Michigan's Lower Peninsula are, therefore, restricted to those undisturbed areas where larch occurs in sufficient numbers to effectively support the insect. One such locale is the Stanton State Game Area in Montcalm County (Fig. 1). In this area, which serves as the site of the present study, *H. columbia* occurs sympatrically with *H. cecropia*.

Within zones of contact between closely related species such as *H. cecropia* and *H. columbia*, effective mate recognition behavior must be established if both species are to co-exist over an extended period of time (Mayr, 1970). Yet, the available literature suggests that *H. cecropia* and *H. columbia* lack such discriminatory behavior.

The existing data indicate that *H. cecropia* and *H. columbia* adults emerge at the same time of the year (Moore, 1955; Collins & Weast, 1961; Ferguson, 1972). Both species also mate during the hours immediately preceding dawn (Collins & Weast, 1961; Ferguson, 1972).

In addition, even the earliest breeders were able to obtain interspecific *Hyalophora* hybrids in the laboratory (Morton, 1895; Soule, 1907). Since that time, almost all possible crosses, backcrosses, and reciprocal crosses have been attempted (Sweadner, 1937; Weast, 1959; Collins & Weast, 1961; Wright, 1971; Kohalmi & Moens, 1975).

Investigators thus learned that congeneric males would readily respond to calling[2] non-specific females. Sweadner (1937) effectively exploited this ability by using *H. cecropia* females to attract wild *H. columbia* and *H. gloveri nokomis* (Brodie) males in western Ontario and Manitoba. More recently, *H. cecropia* females have been successfully used to attract wild *H. columbia* males in Manitoba (Collins, 1973), Ontario (Kohalmi & Moens, 1975), Quebec (Gilles Deslisle, pers. comm.), Wisconsin (Ferge, 1983), and Michigan (Frank Hedges, pers. comm.).

Yet, in spite of these apparent behavioral similarities and the relative ease with which hybridization occurs in captivity, very few valid nat-

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[2] Extension of the ovipositor resulting in the release of a sexual pheromone.

ural hybrids between *H. cecropia* and *H. columbia* have been reported. The author agrees with Ferguson (1972) who states, "Careful scrutiny of the literature reveals that at least some of the records of natural hybrids may be false, especially those based on cocoons only. Freeman's experience of having a normal *cecropia* emerge from what looked like a hybrid cocoon on larch, already noted, casts suspicion on all reports based on cocoons of intermediate appearance."

Ferguson (1972) does cite two records of hybrids emerging from cocoons collected in Mecosta County, Michigan, and Fraserburg, Ontario. He also mentions a wild collected hybrid male collected on 13 June in Oakland County, Michigan. The author has examined a wild male collected on 17 June 1973, in Oakland County, Michigan, which appears to reflect a hybrid background. During the present study in Montcalm County, only one of 259 *Hyalophora* adults examined showed any hybrid influence.

In the spring of 1981, the author observed the emergence of *Hyalophora* adults in outdoor cages in Ann Arbor, Michigan. An extended emergence pattern was observed in the caged *H. cecropia* adults. A comparison with the concentrated emergence of the *H. columbia* adults in the adjacent cage suggested partial temporal isolation. These observations supplied the impetus for the present study which offers data and discusses the reproductive isolating mechanisms which allow such closely related species to co-exist.

MATERIALS AND METHODS

Field studies were conducted at two sites in the immediate vicinity of the village of Stanton in Montcalm County. The two bogs are approximately 3 km apart and separated by farmland and the small Stanton residential community.

Throughout this area, naturally occurring and ornamentally planted maple (*Acer*), oak (*Quercus*), elm (*Ulmus*), and aspen (*Populus*) predominate. Within the bogs, which are dominated by larch, there also occur willow (*Salix*), cherry (*Prunus*), and the lower growing dogwoods (*Cornus*).

At the first Stanton site a five foot tall trap, modeled after the type proven effective by Sternburg and Waldbauer (1969), was erected near the edge of the bog. The trap was situated so that pheromone released by bait *H. cecropia* females was carried throughout the bog by prevailing westerly winds. Trap construction did not allow responding wild males access to the confined females. As a result, the males are drawn into the trap and eventually settle on the sides. The males were collected daily, killed and then stored for later examination.

In order to maintain an adequate supply of bait females for the trap, approximately 300 *H. cecropia* cocoons[3] were taken from the outdoors on 1 January of 1982 and 1983 and placed in a temperature controlled environment of 6°C. Starting in the middle of March of each year, cocoons were removed from the controlled environment, slit open, and sexed by examining the pupal antennae (Miller, Highfill & Cooper, 1982) until a female was identified. Any male pupae were discarded and the female pupa was placed in an emergence chamber at room temperature (20°C). From that date forward and until the first week of June, at least one additional female was placed in the emergence chamber each day.

Within approximately six weeks the bait females began emerging. They were placed in the trap on the day of their emergence and were not removed until after they had died. These unmated females lived 5–10 days and continued to call each morning from approximately 0330 h (EDST) until well after sunrise.

By maintaining the above described schedule, the trap contained at least one, and usually several, calling *H. cecropia* females every day from 3 May–15 July 1982. The following year, the trap contained at least one calling *H. cecropia* female every day from 1 May–20 July 1983. The duration of availability of calling females in the trap extended well beyond the anticipated emergence season of the local *H. cecropia* and *H. columbia* populations. Therefore, the wild *Hyalophora* males responding to the trap reflect the natural seasonal flight periods of both species.

Since the bait-trap samples only males, a second method was also used to gather data on the seasonal flight periods of both species. During the fall of 1981 and 1982, *H. cecropia* and *H. columbia* cocoons reared from Stanton area stock were stored in wire cages near the village of Sheridan (approximately 9 km from the Stanton sites) and exposed to natural weather conditions. During the spring of 1982 and 1983, the emergence date and sex of each eclosing adult in this caged group were recorded, and the resulting data were compared with the trap data.

At the second Stanton site, the *H. cecropia* and *H. columbia* females emerging from the caged group kept at the Sheridan site served an additional purpose. Females of both species were alternately tied-out[4] at 50 m intervals along the western edge of the bog. Unlike the bait females in the trap at the first site, the females at this site were readily accessible to responding males. These females were checked at 15 mi-

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[3] Livestock was reared by the author and also obtained from other breeders.

[4] Tethering of an unmated female to a tree, shrub, or other fixed object.

TABLE 1. Isolating mechanisms between *H. cecropia* and *H. columbia* in Montcalm County, Michigan.

I. Precontact Mechanisms
A. Seasonal isolation
1. species variation in annual availability of adults
2. variation in male-female emergence
B. Daily allochronic flight behavior

II. Contact Mechanisms
A. Mechanical isolation
B. Intraspecific remating

III. Postmating Mechanisms
A. Embryonic mortality
B. Larval acceptance of oviposition substrate
C. Inviability of F_1 progeny
1. larval
2. pupal
3. adult
D. Hybrid sterility*
E. Activity of hybrid adults*
1. seasonal emergence
2. daily flight behavior

Note: Precontact Mechanisms (I) and Contact Mechanisms (II) are prezygotic, the transfer of gametes not having taken place. Postmating Mechanisms (III) are postzygotic, hybrid zygotes having been formed.
* Due to the limited number of hybrid adults obtained, these factors could not be addressed but are offered to complete the table.

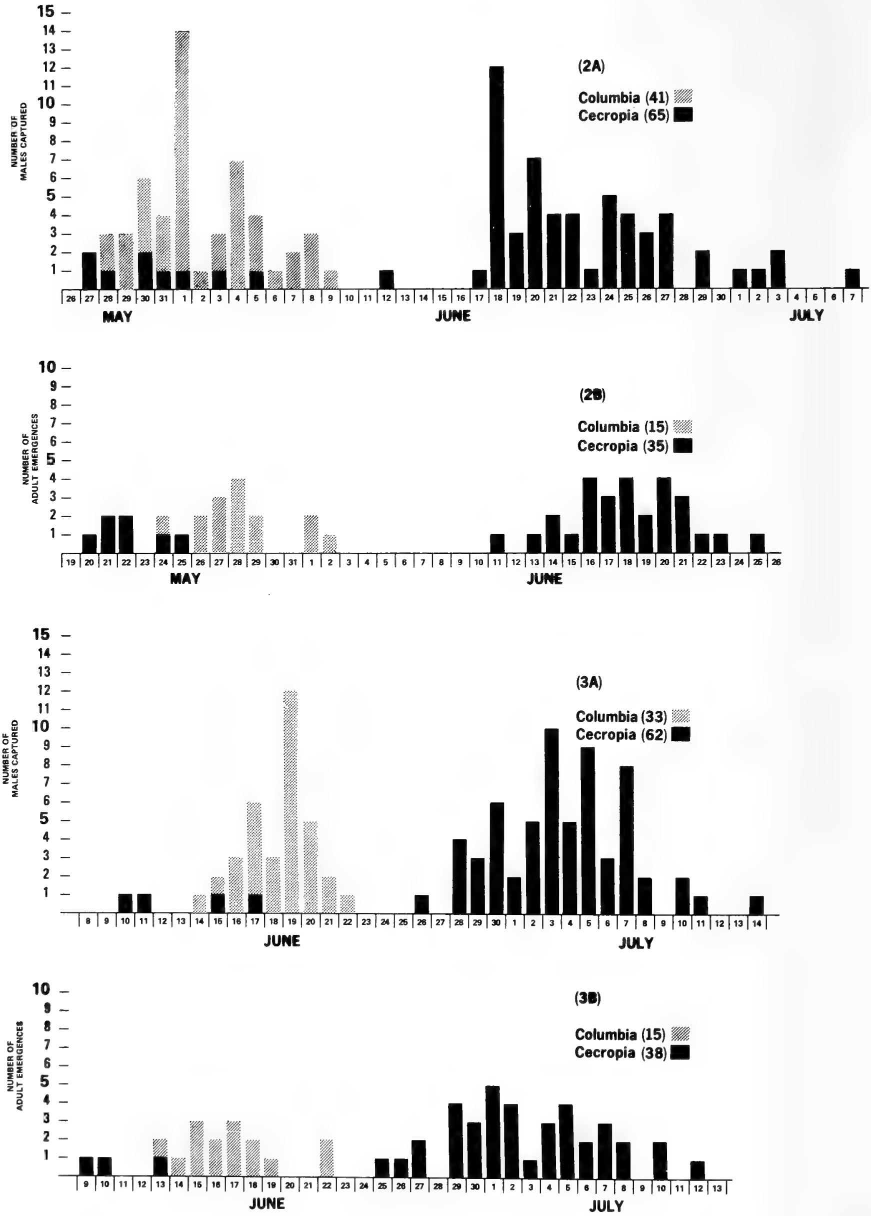
nute intervals from sunset until 0300 h and were then continuously monitored until well after sunrise to determine when each female began calling. Males visually identified as conspecific with the female to which it was responding were netted and held for later examination; the female being allowed to continue calling. Males involved in interspecific contacts were allowed to attempt copulation. Only those males which began to "hover" within 1–3 m of a calling female or actually attempted copulation were scored in the response count.

In addition, during the course of the study, a limited number of pairings between *H. cecropia* and *H. columbia* were obtained. In each case, the activities of the mated females were closely monitored, mortality during all developmental stages was recorded, and the behavior of the hybrids in all stages was noted.

RESULTS

Table 1 lists the isolating mechanisms between *H. cecropia* and *H. columbia* in Montcalm County, Michigan. The table is broken down into three sequentially applied categories: Precontact Mechanisms, Contact Mechanisms, and Postmating Mechanisms.

The first Precontact Mechanism is seasonal isolation which occurs in two facets. The primary facet of seasonal isolation involves variation in the annual emergence pattern of each species.



FIGS. 2–3. Comparative data for *H. cecropia* and *H. columbia*. **2A,** trap capture of wild males at the first Stanton, Michigan site in 1982. **2B,** total cage emergence of adults at Sheridan, Michigan in 1982. **3A,** trap capture of wild males at the first Stanton, Michigan site in 1983. **3B,** total cage emergence of adults at Sheridan, Michigan in 1983.

A total of 65 wild *H. cecropia* males was attracted to the trap from 27 May–7 July 1982 (Fig. 2A). The trap data indicate an early phase of the *H. cecropia* flight period occurred from 27 May–5 June 1982. This phase involved 9 males or 13.8% of the total *H. cecropia* trap sample. The main phase of the *H. cecropia* flight period occurred from 17 June–7 July 1982.

A total of 41 wild *H. columbia* males was attracted to the trap from 28 May–9 June 1982 (Fig. 2A). In contrast to the extended flight period of *H. cecropia,* the range of dates for *H. columbia* is very concentrated.

The emergence pattern of the 1982 caged group at Sheridan, Michigan (Fig. 2B) compares quite favorably with the trap results. There is a shift to the right in the trap capture dates (Fig. 2A) when compared to the emergence dates of the caged group (Fig. 2B). However, as pointed out by Sternburg and Waldbauer (1969), such a shift is to be expected.

During the replicate field studies of 1983, a total of 62 *H. cecropia* males was collected in the trap between 10 June–14 July 1983 (Fig. 3A). The early phase of the *H. cecropia* flight period extended from 10–17 June 1983 and involved only four males or 6.4% of the total *H. cecropia* trap sample. The main phase of the *H. cecropia* flight period occurred from 26 June–14 July 1983.

A total of 33 wild *H. columbia* males was captured in the trap between 14–22 June 1983 (Fig. 3A). As in the previous year, the *H. columbia* flight period is very concentrated.

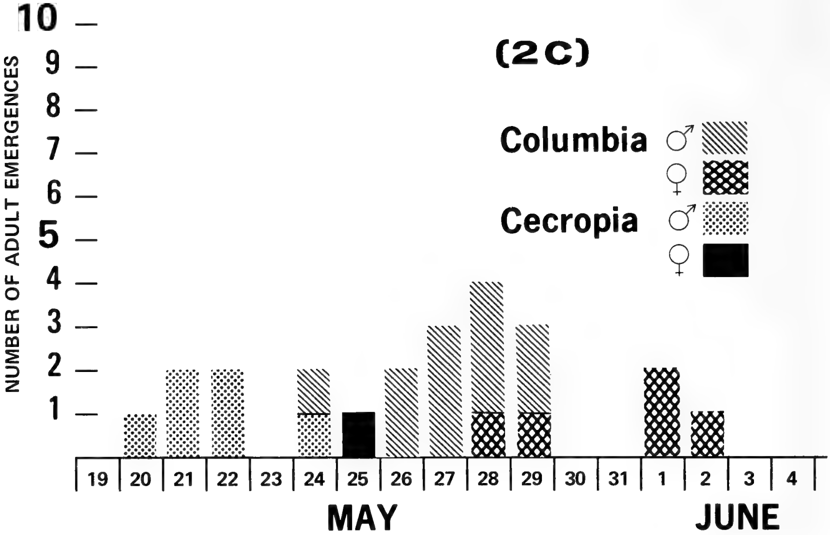
Figure 3B depicts the emergence of the 1983 caged group at Sheridan, Michigan. As in the preceding year, the emergence pattern of the caged group (Fig. 3B) parallels the trap captures (Fig. 3A).

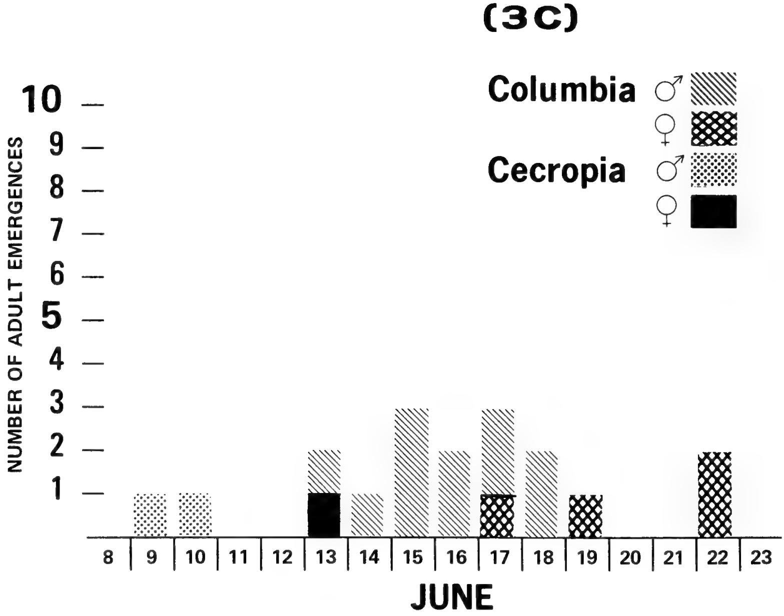
The second facet of seasonal isolation involves variation in male-female emergence. Such an analysis was based on the emergence pattern of the *H. columbia* and those early phase *H. cecropia* in the caged groups at Sheridan, Michigan (Figs. 2B & 3B).

In the 1982 caged group (Fig. 2C), the potential for contact between *H. columbia* males and *H. cecropia* females clearly existed, since all emergences occurred between 24–29 May 1982. However, the potential for reciprocal contact was greatly reduced, since the *H. cecropia* males emerged from 20–24 May 1982, and the *H. columbia* females emerged from 28 May–2 June 1982.

In the 1983 caged group (Fig. 3C), a similar pattern was observed when *H. columbia* males and *H. cecropia* females emerged between 13–18 June 1983. The *H. cecropia* males emerged on 9–10 June 1983, while the *H. columbia* females emerged between 17–22 June 1983.

The second type of Precontact Mechanism is daily allochronic flight behavior. *Hyalophora* females tied-out at the second Stanton site were





FIGS. 2C & 3C. The cage emergence of early phase *H. cecropia* and *H. columbia* adults at Sheridan, Michigan. **2C,** in 1982. **3C,** in 1983.

closely monitored during the two year study. The earliest time a *H. cecropia* female was observed calling was 0325 h and unmated females continued to call for almost two hours after sunrise. During the same periods, the earliest time a *H. columbia* female was observed calling was 0445 h. As with *H. cecropia,* unmated *H. columbia* females continued to call well after sunrise.

Figure 4 depicts the arrival time of wild *Hyalophora* males to calling *Hyalophora* females at the second Stanton site in 1982. The data presented are the results of pooled observations of male arrivals from 29 May–1 June 1982. The first *H. cecropia* male arrived at 0335 h and the uninterrupted response continued until 0450 h. Only two *H. cecropia* males were attracted after sunrise, which occurred at 0500 h. In contrast, the wild *H. columbia* males did not begin responding until after daybreak. The first *H. columbia* male was attracted at 0520 h, and males continued to respond until 0625 h.

Figure 5 illustrates the arrival time of wild *Hyalophora* males to calling *Hyalophora* females at the second Stanton site in 1983. Pooled observations of male arrivals were made from 17–19 June 1983. The lone *H. cecropia* male taken during the year was attracted at 0445 h. One *H. columbia* male was attracted at 0435 h, which was the only record of a *H. columbia* male responding prior to sunrise (0450 h). The remainder of the *H. columbia* response began at 0503 h and continued until 0614 h.

As a result of maintaining a continuous release of pheromone and the apparent lack of pheromone differentiation, a number of interspecific contacts were noted at the second Stanton site. During 1982 (Fig. 4), 14 conspecific contacts were scored: 8 *H. cecropia* contacts and 6 *H. columbia* contacts. During that same time period, 16 interspecific contacts were scored, all of those contacts being *H. columbia* ♂ × *H. cecropia* ♀. During 1983 at the second Stanton site (Fig. 5), 23 conspecific contacts were scored, all of those being *H. columbia* contacts. During that same time period five interspecific contacts were scored: 4 *H. columbia* ♂ × *H. cecropia* ♀ and 1 *H. cecropia* ♂ × *H. columbia* ♀.[5]

During the two year study only one contact between a *H. cecropia* male and a *H. columbia* female was observed. On 17 June 1983, at 0445 h, a male *H. cecropia* coupled with a calling *H. columbia* female at the second Stanton site. As a result of the pairing, the genitalia of the female was ruptured, and she soon died. Previous investigators had

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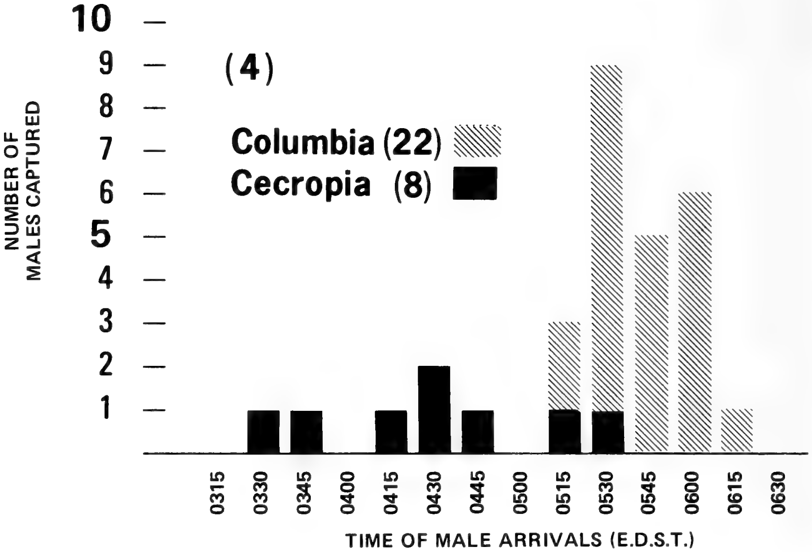
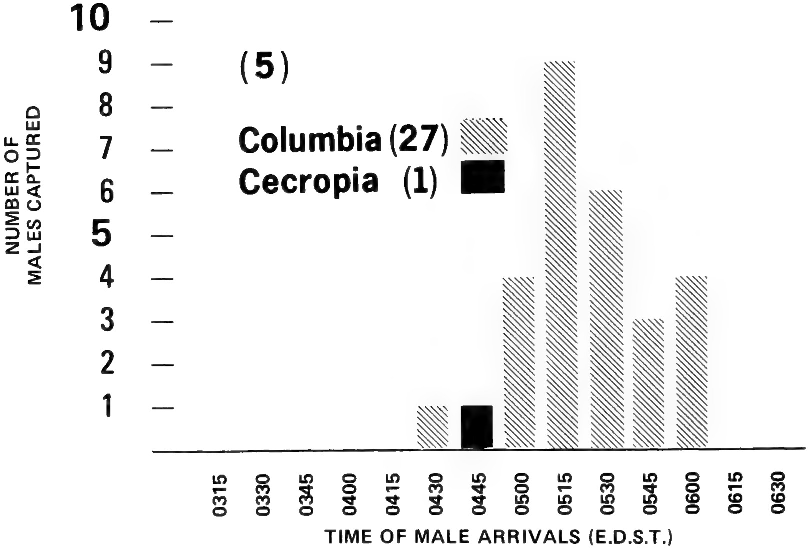
[5] On 19 June 1983, only calling *H. columbia* females were available and 11 conspecific *H. columbia* contacts were scored. As a result, the total ratio of conspecific to interspecific contacts was significantly higher in 1983.





FIGS. 4 & 5. The arrival times of wild *H. cecropia* and *H. columbia* males to calling *Hyalophora* females at the second Stanton, Michigan, site. **4**, data based on pooled observations from 29 May–1 June 1982. **5**, data based on pooled observations from 17–19 June 1983.

similar experiences while attempting crosses between the *Callosamia* (Peigler, 1977) and other *Hyalophora* (Collins & Weast, 1961).

In contrast, 20 contacts between *H. columbia* males and *H. cecropia* females at the second Stanton site were scored during the study. On most every occasion the author observed the *H. columbia* male make numerous unsuccessful attempts to clasp onto the larger calling *H. cecropia* female and then fly away.

On only two occasions did the author see a *H. columbia* male "successfully" clasp onto a calling *H. cecropia* female. On 1 June 1982, at 0608 h, a wild *H. columbia* male coupled with a *H. cecropia* female. The female appeared uneasy during the entire contact and after 15–20 minutes managed to break away from the male. On 2 June 1982, the same female was mated to a wild *H. cecropia* male in Troy, Michigan. The resulting offspring were reared through as pure *H. cecropia*.

Even more interesting were observations of a wild *H. columbia* male coupled with a *H. cecropia* female at 0435 h on 17 June 1983. The pair remained in copula until 0910 h. At dusk on that same day the *H. cecropia* female immediately laid 44 ova and then settled on the side of the cage.

On 18 June 1983, at 0345 h, the same *H. cecropia* female once again began calling. At 0522 h the female attracted another *H. columbia* male but was not allowed to mate. During that evening the female made no attempt to lay any additional ova.

On 19 June 1983, the same *H. cecropia* female was cage-mated to a *H. cecropia* male from Troy, Michigan. During that evening 161 additional ova were laid.

Dissection approximately two weeks later revealed that none of the *H. columbia* × *H. cecropia* ova contained embryos. However, 97.5% (157 of 161) of the ova resulting from the *H. cecropia* × *H. cecropia* mating hatched. The resulting offspring were reared through as pure *H. cecropia*.

Attempts to obtain hybrid livestock to study the various Postmating Mechanisms were hindered by the effectiveness of the prezygotic mechanisms and the limited supply of breeding stock. Fortunately, on 2 June 1982, by placing a number of adults in one cage, Tom Carr was able to obtain one pairing of *H. cecropia* ♂ × *H. columbia* ♀ and one pairing of *H. columbia* ♂ × *H. cecropia* ♀ which produced viable ova.

A high degree of mortality during embryonic development was observed in the hybrid ova. Only 29.1% (7 of 24) of the ova laid by the cross-mated *H. columbia* female hatched and 17.8% (18 of 101) of the ova laid by the cross-mated *H. cecropia* female hatched. In both cases, the females laid far less than a full complement of ova. Yet dissection of collapsing ova from each lot indicated that all of the ova contained embryos.

The loss of hybrids due to larval reluctance to accept potential foodplants was also noted. Hybrid larvae were sleeved-out[6] on several locally preferred parental larval foodplants (Tables 2A & 2B). Wild cherry (*Prunus serotina*) was given to larvae from both crosses, since it appears to be the best foodplant on which to rear *Hyalophora* hybrids (Sweadner, 1937; Wright, 1971). In addition, the hybrid larvae were reared in close proximity and under the same conditions as a control group of pure *H. cecropia* larvae. Based upon observations of the hybrid groups and the control group, it did not appear that external factors played a significant role in hybrid larval mortality.

Table 2A depicts the development of hybrids resulting from the *H. cecropia* ♂ × *H. columbia* ♀ cross. Since *H. columbia* females naturally oviposit only on larch, the seven larvae from this cross were offered only larch and wild cherry. The five larvae offered larch died in the early instars after very little feeding. The two larvae reared on wild cherry grew without apparent difficulty and spun cocoons.

Table 2B shows the development of hybrids resulting from the *H. columbia* ♂ × *H. cecropia* ♀ cross. In addition to wild cherry, the 18 larvae from this cross were offered black willow (*Salix nigra*), gray dogwood (*Cornus racemosa*), and silver maple (*Acer saccharinum*). The five larvae offered silver maple all died in the 1st instar without any evidence of feeding. The five larvae on gray dogwood fed slowly and all of them died by the 4th instar. Some degree of success was had with black willow, since three of the five larvae spun cocoons. The three larvae offered wild cherry completed their development and spun cocoons.

Inviability of the F_1 hybrids also became apparent. During the fall of 1982 the eight hybrid cocoons resulting from the two crosses (Tables 2A & 2B) were stored with the caged group in Sheridan, Michigan. By mid-summer of 1983 only one hybrid adult had emerged from the cocoons. Upon cutting the remaining cocoons open, it was determined that five of the hybrids had failed to pupate and died in their cocoons as larvae. The other two hybrids had successfully pupated but the adults had not been able to escape from their cocoons.

A hybrid female which emerged on 14 June 1983, was the only resulting adult from the two crosses. During the female's lifespan no attempts were made at calling. Later dissection revealed that the female did not contain ova.

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[6] A four foot cylinder of nylon screening is extended over a branch of the living foodplant, the larvae are placed inside, and boths ends are tied off.

TABLE 2A. Comparative development of *H. cecropia* ♂ × *H. columbia* ♀ hybrids reared on different larval foodplants.

Number of ova	Foodplant	Larval development	Pupal development	F_1 adults
2	Wild cherry *Prunus serotina*	both completed development	1 pupated 1 died in cocoon as larva	1 male failed to escape from cocoon
5	Larch *Larix laricina*	4 died in 1st instar 1 died in 2nd instar	—	—

DISCUSSION

The results indicate that the three general categories of isolating mechanisms (Precontact, Contact, and Postmating) form two independently operating systems. The prezygotic mechanisms (Precontact and Contact) limit interaction between *H. cecropia* and *H. columbia* by controlling adult activities. By restricting interspecific matings and the actual exchange of gametes, the reproductive potential of the individual female is protected, and more importantly, the opportunity for introgression is minimized.

In contrast, the loss of *H. cecropia* × *H. columbia* hybrids due to reduced viability is the result of genetic incompatibility. Although further limiting the possibility of breeding F_1 hybrid adults, it is doubtful that postzygotic (Postmating) barriers evolved as a back-up system for the prezygotic isolating mechanisms.

A step by step analysis of Table 1 identifies individual isolating mechanisms but also emphasizes their effectiveness when acting in a synergistic manner. As a result of its "front-line" nature, seasonal iso-

TABLE 2B. Comparative development of *H. columbia* ♂ × *H. cecropia* ♀ hybrids reared on different larval foodplants.

Number of ova	Foodplant	Larval development	Pupal development	F_1 adults
3	Wild cherry *Prunus serotina*	all completed development	2 pupated 1 died in cocoon as larva	1 female failed to escape from cocoon 1 female emerged on 14 June 1983
5	Black willow *Salix nigra*	1 died in 1st instar 1 died in 2nd instar	3 died in cocoon as larvae	—
5	Gray dogwood *Cornus racemosa*	3 died in 1st instar 1 died in 3rd instar 1 died in 4th instar	—	—
5	Silver maple *Acer saccharinum*	all died in 1st instar	—	—

lation is the single-most effective mechanism in limiting interaction between *H. cecropia* and *H. columbia,* since interspecific contact is avoided and mate discrimination is not required. The early phase of the *H. cecropia* flight period in Montcalm County represents only a small part of the total population: 13.8% in 1982 and 6.4% in 1983. This flight pattern is similar to previously observed bimodal *H. cecropia* populations in Missouri and Illinois (Rau & Rau, 1912, 1914; Marsh, 1941; Sternburg & Waldbauer, 1969). Since the *H. columbia* flight period overlaps only the early *H. cecropia* flight phase, the potential for interaction between the species is substantially reduced (Figs. 2A, 2B & 3A, 3B).

A dramatic change in temperature was recorded at the U.S. Weather Service reporting station in Greenville, Michigan (approximately 17 km from the trap site), in the month of May 1982, and the month of May 1983. This change presented an opportunity to examine the validity of seasonal isolation as an annually utilized isolating mechanism in Montcalm County. The monthly mean temperature for May 1982 was 17.7°C. However, May 1983 was unseasonably cool with a monthly mean temperature of only 11.7°C. As a result of the temperature drop in 1983, the arrival of wild *Hyalophora* males at the trap and the emergence of the caged group began two weeks later than in the previous year. In spite of this, the positioning of the *H. cecropia* flight period with respect to the *H. columbia* flight period remained constant during both years, the entire pattern shifting two weeks to the right during the temperature delayed 1983 season. As a result, any interaction between the two species and all further discussions involve only those *H. cecropia* of the early flight phase and *H. columbia.*

The second facet of seasonal isolation takes a closer look at the potential for interaction by analyzing male-female availability. Rau and Rau (1914) noted that *H. cecropia* males consistently emerged several days earlier than *H. cecropia* females. Prior to the present study, the author had made similar casual observations in both *H. cecropia* and *H. columbia.*

This mechanism does not minimize contact between *H. columbia* males and *H. cecropia* females since both are emerging at the same time of the year (Figs. 2C & 3C). However, careful analysis of the cage emergences indicates that the potential for the occurrence of the *H. cecropia* ♂ × *H. columbia* ♀ cross is greatly reduced by the nature of male-female emergence patterns. A gap of four days (1982) and seven days (1983) existed between the emergence of the last *H. cecropia* male from the early emergence phase and the first *H. columbia* female in the caged group during the two years of the study (Figs. 2C & 3C). Such a seemingly insignificant gap is very important in affecting the mating behavior of the short-lived *Hyalophora* adults. Therefore, the potential for contact between *H. cecropia* males and *H. columbia* females rapidly decreases as each day passes, the *H. cecropia* males dying out while the emergence of *H. columbia* males is peaking and the emergence of *H. columbia* females is just beginning.

For those individuals emerging during the brief seasonal overlap, the subtle variation in daily flight activity of each species serves as the next step in reproductive isolation. Variation in circadian rhythm has been well documented as an effective isolating mechanism in *Callosamia* (Brown, 1972; Ferguson, 1972; Peigler, 1980(81)) and *Hemileuca* (Collins & Tuskes, 1979).

The mating activity of *Hyalophora* adults appears to be closely controlled by some type of internal biological clock, *H. cecropia* activities beginning at approximately 0330 h[7] while *H. columbia* activities are delayed until approximately 0500 h (Figs. 4 & 5). As a result of becoming active prior to the *H. columbia* adults, there is a period of time in which conspecific *H. cecropia* matings are almost exclusively favored. While unmated *H. cecropia* females were observed calling well after dawn, it must be remembered that such behavior by tied females was artificially induced at the second Stanton site.

Conversely, by the time the *H. columbia* females begin calling, the availability of unmated *H. cecropia* males may be reduced significantly by pairing. It is not clear whether the limited *H. cecropia* male response after the commencement of *H. columbia* flight activity is the result of mating or circadian rhythm terminating flight activity.

Seasonal and diurnal differences between *H. cecropia* and *H. columbia* mating behavior are very important for maintaining reproductive isolation, since no pheromone specificity appears to exist in *Hyalophora*. The significance of these mechanisms in avoiding interspecific contacts can not be overemphasized when considering calling females. Interspecific contacts may result in the death of the female or the successful exchange of gametes.

When individuals overcome these Precontact Mechanisms and interspecific mating is attempted, the incompatibility of genitalia poses a further hurdle to successful pairing. Sweadner (1937) noted that less than two hours is sufficient to complete fertilization in *Hyalophora*. Yet even in the *H. columbia* ♂ × *H. cecropia* ♀ pairing which lasted almost five hours, gametes were not exchanged. While there are minor structural genitalic differences between *H. cecropia* and *H. columbia*

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[7] Exceptions have been noted in the literature (Sweadner, 1937; Ferge, 1983). In addition, recent observations by Quimby Hess, Les Kohalmi, and Norm Tremblay (pers. comm.) indicate that *H. cecropia* flight activity routinely occurs between 2100–0200 h in southcentral Ontario.

(Ferguson, 1972), the variation in overall size appears to be the single most restrictive factor to successful copulation.

In addition, the tendency of a cross-mated female to re-mate with a male of her own species was noted in the present study and has also been observed by other investigators (Weast, 1959; Les Kohalmi, pers. comm.). The ability of re-mated females to produce pure offspring makes this factor very significant.

On those occasions when a successful interspecific mating occurs and gametes are transferred to the female, the various Postmating Mechanisms further restrict the potential for F_1 hybrid adults. In contrast to the prezygotic mechanisms, which maintain the integrity of each gene pool by avoiding interspecific matings, postzygotic mechanisms may prevent the development of hybrids but at the expense of the reproductive potential of the individual female. Yet these barriers also protect the gene pools by limiting (albeit not eliminating) the successful development of hybrids. While previous knowledge of prezygotic mechanisms was limited, a great deal of information about postzygotic mechanisms was learned by collectors attempting to obtain hybrid *Hyalophora* adults in the lab. As a result, investigators learned that the survival rate of F_1 hybrids varies greatly from one interspecific pairing to the next (Sweadner, 1937; Weast, 1959; Kohalmi & Moens, 1975).

During the present study embryonic mortality claimed a large percentage of the hybrid ova. Although dissection revealed that fertility was nearly complete, eclosion of the ova only reached 29.1% in the *H. cecropia* ♂ × *H. columbia* ♀ cross and 17.8% in the *H. columbia* ♂ × *H. cecropia* ♀ cross. The variability, not only in eclosion but also in fertility, between individual cross-matings has been noted by several other investigators (Sweadner, 1937; Tom Carr, Ted Herig & Les Kohalmi, pers. comm.).

By ovipositing on a locally preferred parental foodplant, a cross-mated female inadvertently may be further reducing the chance of survival for her hybrid progeny. It was noted by the author and by previous investigators (Packard, 1914; Sweadner, 1937; Wright, 1971) that wild cherry is an excellent foodplant for rearing hybrid *Hyalophora* larvae. However, it also became obvious that other natural larval foodplants successfully utilized by the parent species would not effectively support *H. cecropia* × *H. columbia* larvae (Tables 2A & 2B).

The body of existing literature seems to indicate that the ability of *H. cecropia* × *H. columbia* hybrids to survive is greatly reduced by inviability in all developmental stages (Sweadner, 1937; Weast, 1959). The results of the present study would certainly support this conclusion, i.e., eclosion of only a small percentage of the fertile ova, a high degree of unsuccessful pupation, and the inability of adults to escape from their cocoons.

Since only one hybrid adult was obtained during the study, no attempt was made to examine sterility or variation in temporal activity. However, the existing literature contains information which helps complete Table 1.

Varying degrees of sterility have been reported in F_1 hybrid *Hyalophora* adults. While it is generally agreed that F_1 hybrid males are fertile (Sweadner, 1937; Weast, 1959; Collins & Weast, 1961), varied results have been obtained with F_1 hybrid females. Earlier investigators (Sweadner, 1937; Freeman, 1940; Weast, 1959; Collins & Weast, 1961) all reported F_1 hybrid females to be totally barren. Recent results (Tom Carr & Ted Herig, pers. comm.) indicate that partial fertility is occasionally obtained in F_1 hybrid females backcrossed to one of the parent species.

An overview of the results of the study indicates that, at least in Montcalm County, Michigan, the occurrence of hybrid *Hyalophora* adults is greatly reduced by a series of isolating mechanisms acting in concert. The significance of individual mechanisms may vary from year to year and locale to locale. A comparison with other interacting *Hyalophora* populations would be very interesting.

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THE BIOLOGY AND IMMATURE STAGES OF *SPHINGICAMPA ALBOLINEATA* AND *S. MONTANA* IN ARIZONA (SATURNIIDAE)

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ABSTRACT. The biology and immature stages of *Sphingicampa abolineata* and *Sphingicampa montana* are described for the first time. The larvae of both species have five instars. Development is rapid with only 34–40 days required to progress from egg to adult. Evidence indicates that *S. albolineata* is multiple brooded. The larval host plant in Arizona is probably prairie acacia, *Acacia angustissima*. The larval host of *S. montana* in Arizona remains unknown but based on a selection of native Arizona legumes offered to larvae, only sweet acacia, *Acacia farnesiana*, was found to be acceptable.

Biological information regarding *Sphingicampa albolineata* (Grote & Robinson) and *Sphingicampa montana* (Packard) has been lacking due in part to the rarity of both species, their restricted distribution within the United States, and a past inability to rear the larvae in captivity. Ferguson (1971) noted that nothing was known about the biology or immature stages of either species and was able to find only six U.S. records for both species combined. The purpose of this paper is to present new information on the biology, distribution, and immature stages of *S. albolineata* and *S. montana*.

Sphingicampa albolineata

Sphingicampa albolineata is a Mexican species which extends north to southern Arizona and Texas. In Arizona the species has a very limited distribution and is a resident species in the Huachuca Mts. which straddle Cochise and Santa Cruz cos. Specimens have been collected most frequently at Washington Camp, Copper Canyon, Miller Canyon, Garden Canyon, and occasionally in Ash Canyon. Most Arizona specimens have been captured between early July and mid August with the majority from the first week of August; there is evidence of a second generation which flies in mid September.

Recent records from Texas and northern Mexico indicate two or possibly three generations occur per year in those areas. Current Texas records include: Black Gap Refuge, Brewster Co., IV-29-82; Brownsville-Southmost, Hidalgo Co., IV-18-82, VI-2-84, X-7-82, and X-20-74. Ferguson (1971) also cited a record for Brownsville, XI-10-28. Specimens from the Gomez-Farias area in Coahuila, Mexico were collected X-10-77. A series from Temoris in Chihuahua, Mexico was captured between 19 July and 28 August which is similar to the main flight period in Arizona.

Phenotypically, adults from Arizona, western and southern Texas, Chihuahua and Coahuila, Mexico appear indistinguishable. There is, however, variation in the male genitalia between some of these populations. Texas and Coahuila specimens have a very distinct long thin spine on the valve of the male genitalia. Males from central Chihuahua have no spine on the valve, while those from Arizona have a short stout spine. Fifteen genitalia were examined, and the pattern appeared consistent. Because Arizona and Texas populations can be separated on the basis of the male genitalia, it is possible that their status may change. Therefore, it should be noted that all biological observations reported here are based on observations of the Arizona population.

The habitats in which adults have been taken are quite diverse and range from thorn forest and oak grassland to mixed forest. Prairie acacia, *Acacia angustissima* (Mill.), is one of the few legumes found at all locations where adults have been captured in the Huachuca Mts. *Acacia angustissima* occurs in southern Arizona, Texas and Mexico and is a short, multiple-stemmed thornless species with bipinnately compound leaves and white flowers. Seeds of *angustissima* were collected in the fall and germinated so that potted plants would be available if any females were captured. The following year a female was collected at the mouth of Copper Canyon and allowed to oviposit in a paper bag.

The ova are green in color and dorsoventrally compressed forming a flattened ovoid with a diameter of 2.4 × 1.9 mm. As the embryo develops, small gas bubbles appear before the head and body develop. At 29°C the ova hatched in 9–11 days. There are five larval instars, and development is rapid, requiring only 5–6 weeks to progress from egg to adult.

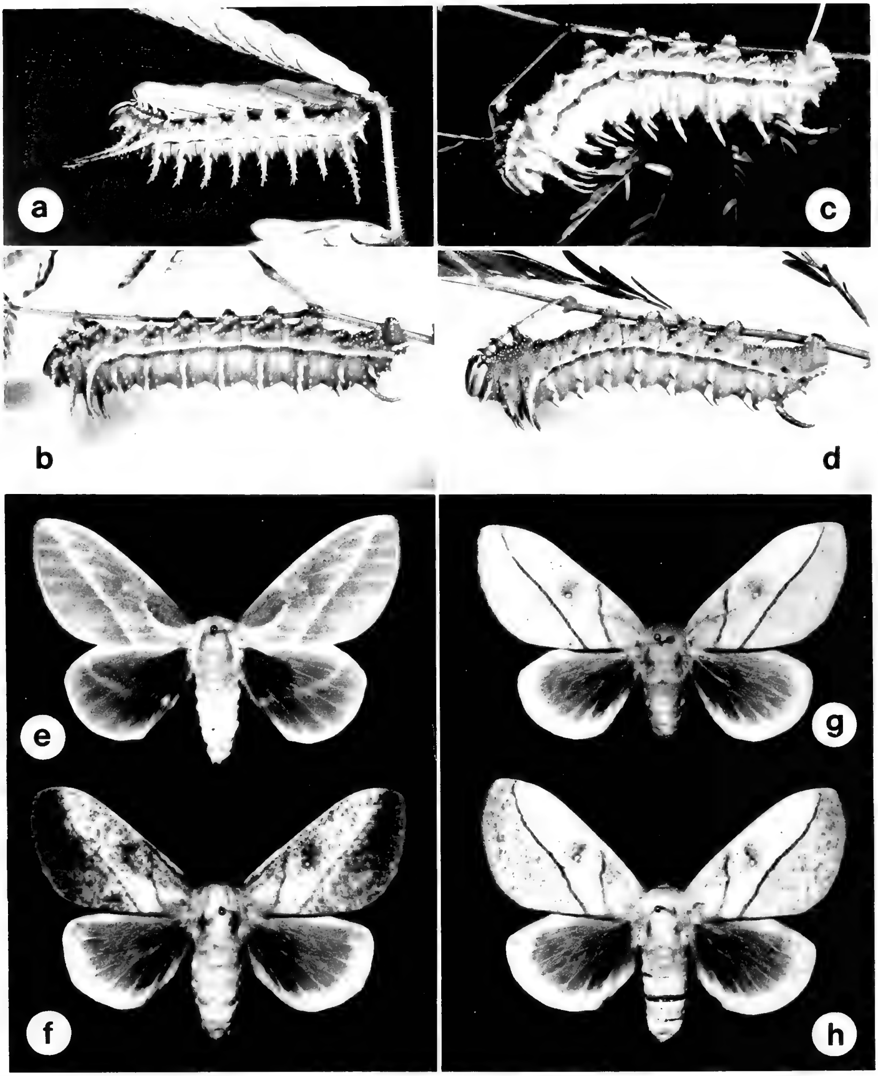
In addition to the suspected host, larvae were offered various native legumes with mixed results. All larvae perished in the first or second instar when offered screwbean mesquite, *Prosopis pubescens* Benth.; Jerusalem-thorn, *Parkinsonia aculeata* L.; paloverde, *Cercidium floridum* Benth.; or sweet acacia, *Acacia farnesiana* Willd. Larvae reared on honeylocust, *Gleditsia triacanthos* L., had heavy mortality; most survivors were stunted and required 3–6 weeks longer to develop compared to those reared on *A. angustissima*. Honeylocust is a common host plant for *Sphingicampa bicolor* (Harris) and *S. bisecta* (Lintner), both of which are from the eastern United States, while mesquite is the most frequent host of *S. heiligbrodti* (Harvey) and *S. hubbardi* (Dyar) from the southwest. Larvae offered *A. angustissima* developed to maturity and pupated in 21 to 28 days without mortality. Prairie acacia is presumed to be the native host plant of *albolineata* in southern Arizona. Texas prairie acacia, *Acacia texensis* Torr. & Gray, has been treated as a subspecies of *angustissima* and was an equally suitable host.

First instar larvae reared on *angustissima* cling to the underside of the petiole and feed at the base of the leaflet. By the end of the second day they are large enough to consume a leaflet without moving completely off the petiole. During the 3rd through last instar they chew a notch on the underside of the petiole and bend the entire leaf back; the petiole gives way at the weak point and easily bends into a "v" without separating from the plant (Fig. c). In this manner the larva is able to consume the distal-most leaflets without having to crawl to the tip. Although feeding damage is light during the first four instars, the mature larva will consume all of the edible leaves on three to five stems. Larvae prefer to feed on leaves of intermediate age. Old leaves are avoided and the new growth is not eaten until those of intermediate age are consumed. The larva will often leave the plant and wander on the ground in search of a new plant prior to consuming the oldest and most discolored leaves.

While on the plant the larva is difficult to find because of its cryptic coloration. The silver dorsal and dorsolateral blade-like scoli break up the solid green pattern and give the larva the general appearance of the thin bipinnately compound leaves on the acacia. Prior to pupation the larval coloration changes from a leaf green to dull green, and within hours it leaves the plant in search of a pupation site in the soil. The pupae reared from ova collected on 31 July eclosed between 16 and 24 September. They in turn produced another brood which pupated in mid October of the same year.

Based on the mid September emergence of reared material and a field record from Miller Canyon (IX-14-71) it is probable that at least a partial second flight occurs. Considering the rarity of the moth and the lack of spring and fall collecting efforts, it is not surprising that additional late summer records are lacking.

In captivity adults emerged from the soil after sunset to 0500 h, with a peak between 2200 and 2400 h. Wing expansion is rapid and adults are ready to fly within one hour (Fig. e). Individuals that hatch after 0300 h usually remained quiescent until the next night. In the field moths are generally attracted to black lights between 2300 and 0330 h. Mating occurs after 2200 h, and the pair remain together until the following evening. Females that were allowed to oviposit on caged potted plants deposited eggs singly on the underside of the leaflets. Larval and adult phenotypes within the Arizona population are very uniform. The larval description is based on reared material from ova deposited by a female captured at the mouth of Copper Canyon, Cochise Co., Arizona.



FIGS. a–h. **a,** late second instar *Sphingicampa albolineata* larva feeding on leaflet. **b,** mature fifth instar *S. albolineata* larva. **c,** fifth instar *S. albolineata* larva on stem while consuming leaflets and petiole, note notched petiole. **d,** mature fifth instar *S. montana* larva, note differences in length and shape of dorsal scoli and size and number of small tubercles on lower lateral surface. Adult females: **e,** *S. albolineata*; **f,** *S. montana,* dark form with numerous brownish-black spots on forewings; **g,** *S. montana,* light form with few or in some instances no brownish-black forewing spots; **h,** *S. montana,* typical phenotype.

Larval Descriptions

First instar. Head. Diameter 0.9 mm. Light brown with few short brown secondary setae. Dark brown line extends from antenna tapering dorsally to vertex of each lobe; frontal area dark brown. **Body.** Ground color green. Length 8.5–9.0 mm, width 2.0 mm. Dorsal and dorsolateral meso- and metathoracic scoli (2.0–2.2 mm) light brown with short black spines on shaft; tip of each scoli with small brown bulb each with 2 short black spines. Dorsal intersegmental area between meso- and metathoracic segments reddish brown. Abdominal dorsal, dorsolateral and lateral scoli green and raised with thin black spine extending from each. Mid-dorsal caudal scolus (0.7 mm) light brown with numerous short black spines on shaft. Lateral surface with thin dark bluish green line above lateral scoli, extending from abdominal (A) segment 1 to A8. Ventral surface and true legs green. Prolegs green with dark green shields.

Second instar (Fig. a). **Head.** Diameter 2.7 mm. Color green with yellow medial and black distal stripe extending from antennae, tapering dorsally to vertex of each lobe. **Body.** Ground color green. Length 14–15 mm, width 2.5 mm. Dorsal and dorsolateral meso- and metathoracic scoli elongated (1.8–2.0 mm), yellow at base with reddish brown shafts. Shaft with numerous short black spines; scoli tip with small brown bulb each with 2 short black spines. Dorsal intersegmental area between meso- and metathoracic scoli maroon. Dorsal abdominal scoli light green with light green blade-like projections. Dorsal lateral scoli similar to dorsal scoli but half their size. Lateral scoli yellow and reduced in size. Sublateral scoli appear as spines on A1, A2, and A7. All abdominal scoli with short single black spine. Mid-dorsal caudal scolus (1 mm) green basally with reddish brown shaft; numerous short black spines on shaft. Thin black spiracular and light yellow subspiracular line that encompasses lateral scoli, extends from A1 to A8. Ridge of small light yellow tubercles form collar on dorsal anterior portion of prothoracic segment. Numerous small light yellow tubercles appear on dorsal, lateral, and ventral surfaces, some of which form a ring around base of each proleg. Prolegs green. True legs light tan.

Third instar. Head. Diameter 2.3–2.5 mm. Color green with light yellow stripe extending from antennae, tapering dorsally to vertex of each lobe; ocelli at inferior edge of line. **Body.** Ground color green. Length 19–21 mm, width 4.7 mm. Dorsal meso- and metathoracic scoli blue, dorsolateral scoli green. Both dorsal and dorsolateral scoli enlarged with short black spines on shaft; tips of scoli with small reddish brown bulb, each with 2 small black spines. Dorsal intersegmental area between meso- and metathoracic segments maroon. Dorsal and dorsolateral abdominal scoli blade-like, light yellow at base with silver shaft. Abdominal lateral and sublateral scoli reduced and light yellow. Mid-dorsal caudal scolus green with small green spines. Maroon spiracular line extends from A1 to A8. White line extends from base of dorsolateral metathoracic scoli to become subspiracular line extending from A1 to A8. Ridge of small light yellow tubercles form collar on dorsoanterior portion of prothoracic segment and ridge between meso- and metathoracic dorsal scoli. Ridge of yellow tubercles start just dorsal to maroon spiracular line and extends over back on posterior and anterior portions of each abdominal segment. Light yellow tubercles form ring around base of each proleg, and form 2 poorly organized somewhat diagonal lines between prolegs and lateral scoli. True legs and prolegs green.

Fourth instar. Head. Diameter 3.2–3.4 mm. Color green with light yellow stripe extending from antenna, tapering dorsally to vertex of each lobe. **Body.** Ground color green. Length 31–36 mm, width 6 mm. Dorsal meso- and metathoracic scoli turquoise-blue with small black spines on shaft. Dorsolateral meso- and metathoracic scoli green with small green spines on shaft. Dorsal intersegmental area between meso- and metathoracic segments green or with trace of maroon. Dorsal and dorsolateral abdominal scoli blade-like with yellow base and silver shaft; mesal portion green. Lateral and sublateral abdominal scoli reduced to small yellow spines. Mid-dorsal caudal scolus green with small white or yellow spines on shaft. Pinkish red spiracular line extends from A1 to A8. White line extends from base of dorsolateral metathoracic scoli to become subspiracular line extending from A1 to A8. Ridge of small light yellow tubercles form collar on dorsoanterior portion of prothoracic segment and ridge between meso- and metathoracic dorsal scoli. Ridge of yellow tubercles start just dorsal to spiracular line and extend over back on posterior and anterior portions of each abdominal segment. Light yellow tubercles form ring around base of each proleg and form 2 poorly organized diagonal lines between prolegs and subspiracular line. Series of yellow tubercles on lateral thoracic segments just dorsal to true legs forming transverse lines on the ventral segmental area of A1 and A2. Spiracles orange. True and prolegs green.

Fifth instar (Figs. b, c). **Head.** Diameter 4.5–5.5 mm. Color bluish green with light yellow stripe extending from antennae, tapering dorsally to vertex of each lobe. Antennae light yellow. Clypeus green and cream. **Body.** Ground color green. Length 54–60 mm, width 10–12 mm. Dorsal meso- and metathoracic scoli turquoise-blue with yellow tips; shaft smooth or slightly knobbed. Dorsolateral meso- and metathoracic scoli yellow with silver base; shaft with short white knobs bearing short setae. A line of yellow or silver tubercles cross over the mid-dorsal area forming ridge between meso- and metathoracic dorsal scoli. Dorsal intersegmental area between meso- and metathoracic segments green. Dorsal and dorsolateral abdominal scoli blade-like with silver shaft; mesal portion green. Lateral and sublateral abdominal scoli reduced to yellow knobs with small whitish setae extending from each. Mid-dorsal caudal scolus greenish yellow with small knobs on shaft. Approximate scoli length: thoracic dorsal and dorsolateral, 6–7 mm; mid-dorsal caudal, 5–6 mm; dorsal abdominal, 3.5 mm; dorsolateral abdominal, 2 mm. All enlarged scoli either curved or oriented with their tips in posterior direction. Purplish pink spiracular line extends from A1 to A8. White or cream colored subspiracular line extends from base of dorsolateral metathoracic scoli to A8. Bridge of small light yellow or silver tubercles from collar on dorsal anterior portion of prothorax. A more widely spaced ridge of smaller silver tubercles starts just dorsal to spiracular line and extends over back on posterior and anterior portions of each abdominal segment. Light yellow tubercles form ring around base of each true leg and base and tip of each proleg. A series of silver and yellow tubercles form 3 ridges on lateral surface: diagonal ridge above base of prolegs; cradle under lateral scoli; on lateral thoracic segments just dorsal to true legs. Ventral surface of A1, A2, and frequently A7 and A8 with enlarged yellow tubercles forming prominent transverse segmental ridge. Anal shield yellow or yellow and silver with silver tubercles. True legs and prolegs green. Spiracles orange.

Sphingicampa montana

Although present in portions of northern Mexico, *Sphingicampa montana* has an extremely limited distribution in the United States and is known from only a few locations in southern Arizona. Ferguson (1971) cited five records for this species, all from Pena Blanca Lake, with capture dates from 18 July to 8 August. In addition to Pena Blanca Lake, this species has been collected at Sycamore Canyon, Nogales, and Patagonia in Santa Cruz Co. and Madera Canyon and Box Canyon, Pima Co. The flight season extends from late June to mid August with a peak between 26 July and 8 August.

In Arizona, adults are associated with areas dominated by thorn forest. The larval host plant in Arizona remains unknown since larvae have not been field collected. First instar larvae were offered a wide variety of native legumes in an effort to find a suitable host plant. Larvae reared on sweet acacia, *Acacia farnesiana* Willd. developed from egg to adult in six weeks with no mortality. The larvae offered other native legumes usually died during the first or second instar; these plants included: screwbean mesquite, *Prosopis pubescens*; Jerusalem-thorn, *Parkinsonia aculeata*; paloverde, *Cercidium floridum*;

prairie acacia, *Acacia angustissima*; and *Mimosa* spp. Some larvae were successfully reared to maturity on honeylocust, *Gleditsia triacanthos*. It is interesting to note that the two legumes accepted by *montana* larvae are either totally unacceptable to *albolineata* larvae or result in stunted growth and high larval mortality. Conversely, *montana* larvae could not be reared successfully on prairie acacia, which is the larval host plant for *albolineata*. Steve Prchal (pers. comm.) has collected larvae which are believed to be that of *montana* in Sonora, Mexico. The larvae were feeding on *Haematoxylon brasalita* and a large leaved cassia, *Cassia emarginata*, and were reared to maturity on sweet acacia.

The larvae reared from eggs deposited on 3 August developed rapidly and emerged as adults between 18 and 27 September and subsequently produced another generation which pupated between 14 and 23 October. The adults reared from larvae collected in Mexico during late August by Prchal emerged beginning on 7 September. There are no records which indicate a fall flight, thus, the second brood may have been an artifact of the rearing conditions.

The larval feeding habits, female oviposition and mating behavior are similar to those described for *albolineata*. The only major difference is that the petiole of sweet acacia is much shorter than that of prairie acacia. As a result, mature *montana* larvae consumed the entire leaf without notching the petiole. On longer petiole leaves, such as honeylocust, the petiole was notched so that it could be bent towards the larva. Little phenotypic variation was observed among the larvae (Fig. d). Of 78 mature larvae only one individual lacked the enlarged silver dorsal and dorsolateral scoli on a single segment. Steve Prchal indicated that larvae collected in Mexico have little or no silver coloration but when their offspring were reared on *Acacia smallii*, a small-leaved acacia, the majority had silver on all segments.

The adults are variable. Some have brown wings and brown bodies; some have brown wings and yellow bodies; and some have yellow wings and yellow bodies. In addition, the brownish black spots of the forewing, which are common on most specimens may be totally absent (Fig. g) or so dense as to give the marginal area a blackish appearance (Fig. f). The specimens which Ferguson (1971) illustrated in color are typical of most wild specimens. The colors of reared specimens are richer, and in the females the medial forewing area is much lighter in coloration than the basal or marginal area of the wing (Fig. h). Newly emerged brown specimens are a deep tan, while yellow ones are actually a golden yellow.

The larval description is based on reared material from ova deposited by a female captured at Pena Blanca Lake, Santa Cruz Co., Arizona.

Larval Descriptions

First instar. Head. Diameter 0.9 mm. Light brown with few short brown secondary setae. Dark brown line extends from antenna tapering dorsally to vertex of each lobe. **Body.** Ground color green. Length 8.0–9.0 mm, width 1.8 mm. Dorsal and dorsolateral meso- and metathoracic scoli brownish red with short black spines on shaft; tip of each scoli with small black bulb each with 2 short black spines. Abdominal dorsal, dorsolateral and lateral scoli green and raised with thin black spine extending from each. Mid-dorsal caudal scolus brownish red with numerous short black spines on shaft. Caudal scolus about 3 times longer than dorsal abdominal scoli. Lateral surface with thin dark bluish green line above lateral scoli, extending from abdominal segment 1 to 8. Ventral surface green, true legs light brown or green, prolegs brown.

Second instar. Head. Diameter 1.8 mm. Color green with yellow medial and black distal stripe extending from antennae, tapering dorsally to vertex of each lobe. **Body.** Ground color green. Length 12–14.5 mm, width 2.2 mm. Dorsal and dorsolateral meso- and metathoracic scoli elongated and brown with numerous short brown spines on shaft. Tip of each with small brown bulb each with 2 short black spines. Dorsal abdominal, dorsolateral and lateral scoli light yellow with dark brown blade-like projection extending from each, lateral scoli reduced in size. Sublateral scoli appear as short spine on A1, A2, and A7. Mid-dorsal caudal scolus brown wtih numerous short brown spines on shaft. Thin purplish brown spiracular and light yellow subspiracular line, that encompasses lateral scoli, extends from A1 to A8. Numerous small light yellow tubercles appear on the dorsal, lateral and ventral surfaces. Prolegs green with brown shields, true legs light brown.

Third instar. Head. Diameter 2.4–2.6 mm. Color, green with light yellow, black stripe extending from antennae, tapering dorsally to vertex of each lobe; ocelli at inferior edge of line. **Body.** Ground color green. Length 17–19 mm, width 4 mm. Dorsal meso- and metathoracic scoli brownish red, dorsolateral thoracic scoli yellowish brown. Both dorsal and dorsolateral thoracic scoli enlarged with short black spines on shaft; tips of scoli with small brown bulb each with 2 small black spines. Dorsal and dorsal abdominal scoli blade-like and silver and green. Abdominal lateral and sublateral scoli yellow and reduced. Mid-dorsal caudal scolus reddish brown with short cream colored spines. Red subspiracular line and yellow subspiracular lines extend from base of dorsolateral metathoracic scoli to A8. Ridge of small light yellow tubercles form collar on dorsoanterior portion of prothoracic segment. Ridge of yellow tubercles start just dorsal to spiracular line and extend over back on posterior and anterior portions of each abdominal segment. Light yellow tubercles form ring around base of each proleg, and scattered on lateral surface between prolegs and subspiracular line. True and prolegs green.

Fourth instar. Head. Diameter 3.4–3.6 mm. Color green with light yellow stripe extending from antennae, tapering dorsally to vertex of each lobe. **Body.** Ground color green. Length 31–36 mm, width 5.5 mm. Dorsal meso- and metathoracic scoli blue with small black spines on shaft. Dorsolateral meso- and metathoracic scoli green to yellow with black or white short spines on shaft. Dorsal and dorsolateral abdominal scoli blade-like with silver shaft; mesal portion red. Lateral and sublateral abdominal scoli reduced to small red spines. Mid-dorsal caudal scolus red or green with small light yellow spines on shaft. Thin pink spiracular line extends from A1 to A8. Light yellow line extends from base of dorsolateral metathoracic scoli to become subspiracular line extending from A1 to A8. Ridge of small light yellow tubercles form collar on dorsoanterior portion of porthoracic segment. Ridge of yellow tubercles start just dorsal to spiracular line and extends over back on posterior and anterior portions of each abdominal segment. Yellow tubercles form ring around base of each proleg, and true leg, and scattered on lateral surface below subspiracular line. A series of yellow and silver tubercles traverse mid-dorsal area of meso- and metathoracic segments forming a line that connects base of dorsal thoracic scoli, another series forms transverse line on ventral segmental area of A1 and A2. Anal shield green with yellow, silver, and red tubercles. Spiracles light brown. True legs and prolegs green.

Fifth instar (Fig. d). **Head.** Diameter 5.3–5.7 mm. Color bluish green with light yellow stripe extending from antennae, tapering dorsally to vertex of each lobe. Antennae light yellow. Clypeus green and cream. **Body.** Ground color green. Length 54 to 60 mm, width 10–12 mm. Dorsal and dorsolateral meso- and metathoracic scoli with green base, red shaft and yellow tip; shaft with short red knobs bearing short setae. A line of yellow tubercles cross over mid-dorsal area forming ridge between meso- and metathoracic dorsal scoli. Dorsal intersegmental area between meso- and metathoracic segments green. Dorsal and dorsolateral abdominal scoli somewhat triangular shaped with tips curved posteriorly; shaft silver with red tip, mesal portion red. Lateral and sublateral scoli reduced to red knob with small black setae extending from some. Mid-dorsal caudal scolus red with small red or cream colored knobs on shaft. Approximate scoli length: thoracic dorsal and dorsolateral, 5 mm; mid-dorsal caudal, 5.5 mm; dorsal abdominal, 2.2 mm; dorsolateral abdominal, 1.3 mm. All enlarged scoli are curved with their tips oriented posteriorly. Red spiracular line extends from A1 to A8. White to yellow subspiracular line extends from base of dorsolateral metathoracic scoli to A8. Ridge of small light yellow tubercles form collar on dorsoanterior portion of prothoracic segment. A more widely spaced ridge of smaller yellow tubercles start just dorsal to spiracular line and extend over back on posterior and anterior portions of each abdominal segment. Light yellow and red tubercles form ring around base of each true leg and proleg; forms semicircle below reduced red lateral scoli and diagonal pattern above base of prolegs. Ventral surface of A1, A2 and frequently A7 and A8 with enlarged red and yellow tubercles forming prominent transverse segmental ridge. Anal shield green with yellow or yellow and silver tubercles. True legs and prolegs green. Spiracles orange-brown.

DISCUSSION

Of the three species of *Sphingicampa* occurring in Arizona only the biology and distribution of *S. hubbardi* was previously known (Comstock, 1947). Although the general shape and appearance of the larvae are similar, there are numerous differences between the mature larvae of each species. Last instar *albolineata* larvae have blue dorsal and yellowish green dorsolateral meso- and metathoracic scoli. The dorsal and dorsolateral abdominal scoli are silver and yellowish green as is the mid-dorsal caudal scolus. The tubercles below the spiracular line are yellow and silver. Mature *montana* larvae have red dorsal and dorsolateral meso- and metathoracic scoli. The dorsal and dorsolateral abdominal scoli are red and silver and the mid-dorsal caudal scolus is red. The tubercles below the spiracular line are yellow and red. Finally, mature *hubbardi* larvae have purplish red and yellow dorsal scoli, and green and yellow dorsolateral meso- and metathoracic scoli. The dorsal and dorsolateral abdominal scoli are silver with a touch of red or pink and the mid-dorsal caudal scolus is purple or green. The tubercles below the spiracular line are yellow or yellow and red. During the early instars the larvae of *albolineata* have a dark maroon intersegmental patch on the dorsal surface between the meso- and metathoracic segments; *montana* and *hubbardi* larvae lack such a patch. Many additional differences between *albolineata* and *montana* larvae are revealed in the larval descriptions.

The cryptic coloration of *albolineata* and *montana* larvae make them very difficult to locate while feeding on acacia. The enlarged blade-like dorsal and dorsolateral scoli break up the solid green pattern so that the size of the green patches are similar to those of the leaflets, and the silver scoli represent the space between leaflets. Larvae of *montana* on acacia are as difficult to located as those of *albolineata*, but individuals reared on honeylocust were easy to locate. This is because the leaf on the honeylocust is 4–6 times larger than the acacia leaves. It might be expected that populations which feed on large leafed hosts would have some of the silver scoli reduced or absent so that the pattern would more closely match that of the leaves.

During the first four instars the dorsal and dorsolateral scoli of all three *Sphingicampa* species orient at 90° to the body, or slant forward (Fig. a). In the fifth instar, the dorsal and dorsolateral scoli are curved towards the posterior and a series of posterior slanting tubercles form a transverse ridge on the ventral surface of abdominal segments 1 and 2 and to a lesser degree on A7 and A8. The change in orientation of the prominent scoli and development of the ventral ridges are probably adaptations to help the larva enter the soil. Posteriorly oriented spines might reduce drag while entering the soil and could act to anchor the body and prevent it from slipping backwards as it pushes its way through the soil.

ACKNOWLEDGMENTS

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NEVADA BUTTERFLIES: PRELIMINARY CHECKLIST AND DISTRIBUTION

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ABSTRACT. The distribution by county of the 189 species (over 300 taxa) of butterflies occurring in Nevada is presented along with a list of species incorrectly recorded for the state. There are still large areas which are poorly or not collected.

Nevada continues as one of the remaining unknown areas in our knowledge of butterfly distribution in North America. Although a comprehensive work on the state's butterflies is in preparation, there is sufficient demand for a preliminary checklist to justify the following. It is hoped this will stimulate those who have any data on Nevada butterflies and their biology to forward such for inclusion in the larger study.

Studies of Nevada butterflies are hampered by a paucity of resident collectors, a large number of mountain and valley systems and vast areas with little or no access. Non-resident collectors usually funnel into known and well worked areas, and, although their data are valuable, large areas of the state remain uncollected. Intensive collecting, with emphasis on poorly known areas, over the past seven years by Nevada State Museum personnel and associates has gone far to clarify butterfly distribution within the state. The gaps in knowledge are now more narrowly identifiable and will be filled during the next few seasons.

There is no all encompassing treatment of Nevada's butterfly fauna. The only state list is an informal recent checklist of species (Harjes, 1980). Regional works are those for the Carson Range (Herlan, 1962) and Clark County (Austin & Austin, 1980). Many records for the eastern, approximately one-third, of the state are mapped by Stanford (*in* Ferris & Brown, 1981). Otherwise, published Nevada records occur scattered in various taxonomic revisions, life history and distribution studies and in the season summaries of the Lepidopterists' Society.

Data for the present paper were obtained from the following sources:

1. Collection of the Nevada State Museum (NSM), Carson City.
2. Private collections of G. T. Austin, Las Vegas; J. F. Leser, formerly of Las Vegas; C. S. Lawson, Las Vegas; C. Crunden, Las Vegas; S. D. Mattoon, Chico, California and C. Hageman, Yuba City, California.
3. Collection of the Los Angeles County Museum (Clark Co. material only).
4. Collection of the Lake Mead National Recreation Area, Boulder City (in part).
5. Collection of the Department of Biological Sciences, University of Nevada, Las Vegas.

(6) Collection of the Department of Biology, University of Nevada, Reno.
(7) Ongoing collections for a Great Basin biogeographic study directed by P. Ehrlich, Stanford University, Stanford, California.
(8) Data supplied by various non-resident collectors (see acknowledgments, some of whose specimens have been examined; also included are some second-hand data, many of which were kindly supplied by R. E. Stanford).
(9) Data from literature sources (including those in the season summaries of the Lepidopterists' Society, most have been subsequently verified through correspondence).

It is hoped that most important specimens will be examined before publication of the larger work.

Presentation of distributional data for Nevada in a simplified, yet meaningful, manner is difficult. Counties, with few exceptions, are huge; some reach asinine proportions when trying to consider distribution. The worst, Nye County, extends nearly half the length and breadth of the state from hot Mojave Desert to alpine conditions in the Toiyabe Mountains. For present purposes, Nye County is divided into two sections at 38° latitude and the northern and southern portions herein designated as Nye N and Nye S, respectively. This essentially divides the county between the Great Basin and Mojave deserts. Other counties (e.g., Washoe, Elko) also create problems but are not subdivided here. Carson City was previously Ormsby County. Figure 1 illustrates the counties, and Table 1 indicates the number of taxa recorded in each.

Nomenclature generally follows Howe (1975; see Ehrlich & Murphy, 1981) at the generic level and Miller and Brown (1981) at the specific. All taxonomic decisions are the author's, although in some cases they were arrived at after consultation with other, more knowledgeable, students of the particular taxon. Generally accepted nomenclature is presented without comment. In cases where my concepts run counter to those in the literature, brief justification is presented. Manuscripts in preparation will amplify and further justify these decisions. A question mark indicates that reported specimens were not examined and questionable or that the sample was too small for definite subspecific determination.

In an area as large as Nevada, it is expected that there are a number of blend zones between populations of different subspecies. This is, in fact, the case. In a checklist of this type, however, it is out of place to discuss these. The various populations are herein "pigeon-holed" into their "best fit" to available names, and a more thorough discussion will await forthcoming papers.

COUNTY RECORDS OF NEVADA BUTTERFLIES

HESPERIIDAE

1. *Epargyreus clarus huachuca* Dixon—Clark.
2. *Polygonus leo arizonensis* (Skinner)—Clark, Elko, Lander, Nye N, Nye S.

3. *Thorybes pylades* (Scudder)—Carson City, Clark, Douglas, Washoe.
4a. *Thorybes mexicana nevada* Scudder—Carson City, Douglas, Washoe.
4b. *Thorybes mexicana blanca* Scott—Lyon, Mineral(?). This taxon was recently described (Scott, 1981).
5. *Systasea zampa* (W. H. Edwards)—Clark.
6. *Chiomara asychis georgina* (Reakirt)—Clark.
7. *Erynnis icelus* (Scudder & Burgess)—Carson City, Elko, Lander, Nye N, Washoe, White Pine.
8. *Erynnis brizo burgessi* (Skinner)—Clark, Lincoln.
9. *Erynnis telemachus* Burns—Clark, Lincoln, White Pine.
10. *Erynnis propertius* (Scudder & Burgess)—Carson City, Douglas, Washoe.
11. *Erynnis meridianus meridianus* Bell—Clark, Lincoln.
12. *Erynnis pacuvius lilius* (Dyar)—Carson City, Douglas, Lyon, Washoe.
13. *Erynnis funeralis* (Scudder & Burgess)—Clark, Nye S.
14. *Erynnis persius* (Scudder)—Carson City, Douglas, Elko, Eureka, Humboldt(?), Lander, Nye N, Washoe, White Pine. Burns (1964) presented a valid argument for not recognizing subspecies at our present state of knowledge.
15. *Pyrgus ruralis ruralis* (Boisduval)—Douglas, Washoe.
16. *Pyrgus scriptura* (Boisduval)—Clark, Lincoln, Nye N, Nye S, White Pine.
17a. *Pyrgus communis communis* (Grote)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.
17b. *Pyrgus communis albescens* Plötz—Carson City, Clark, Esmeralda, Lincoln, Nye N, Nye S. This and the preceding are tentatively considered conspecific based mainly on the existence of intermediate populations (Tilden, 1965).
18. *Heliopetes domicella domicella* (Erichson)—Clark.
19. *Heliopetes ericetorum* (Boisduval)—Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, White Pine.
20. *Pholisora catullus* (Fabricius)—Carson City, Douglas, Elko, Lander, Lincoln, Lyon, Nye N, Storey, Washoe.
21a. *Pholisora libya libya* (Scudder)—Clark, Lincoln, Nye S, White Pine.
21b. *Pholisora libya lena* (W. H. Edwards)—Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lyon, Mineral, Nye N, Nye S, Pershing, Washoe.
22. *Pholisora alpheus oricus* W. H. Edwards—Churchill, Clark, Douglas, Esmeralda, Humboldt, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Washoe.
23. *Pholisora gracielae* MacNeill—Clark.
24. *Copaeodes aurantiaca* (Hewitson)—Clark, Lincoln.
25. *Hylephila phyleus muertovalle* Scott—Carson City, Churchill, Clark, Elko, Lincoln, Nye S. This was recently named by Scott (1981).
26a. *Pseudocopaeodes eunus* nr. *wrightii* (W. H. Edwards)—Churchill, Lyon, Washoe.
26b. *Pseudocopaeodes eunus alinea* Scott—Nye S. The Amargosa population is distinct from others in the state and appears closest to this recently described taxon (Scott, 1981).
26c. *Pseudocopaeodes eunus* nr. *eunus* (W. H. Edwards)—Carson City. The Eagle Valley population is distinct from others in Nevada and may be worthy of a name.
27a. *Hesperia uncas lasus* (W. H. Edwards)—Elko, Lander, Lincoln, Lyon, Nye N, White Pine.
27b. *Hesperia uncas macswaini* MacNeill—Douglas, Esmeralda, Lyon, Mineral, Washoe.
27c. *Hesperia uncas* W. H. Edwards ssp.—Elko, Eureka, Lander, Nye N, White Pine. This is the large, bright (vs. pale *lasus*) phenotype of the central Great Basin mountains.
27d. *Hesperia uncas* W. H. Edwards ssp.—Mineral. This insect is small and occurs at relatively low elevations in extreme western Nevada and adjacent California.
28. *Hesperia juba* (Scudder)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

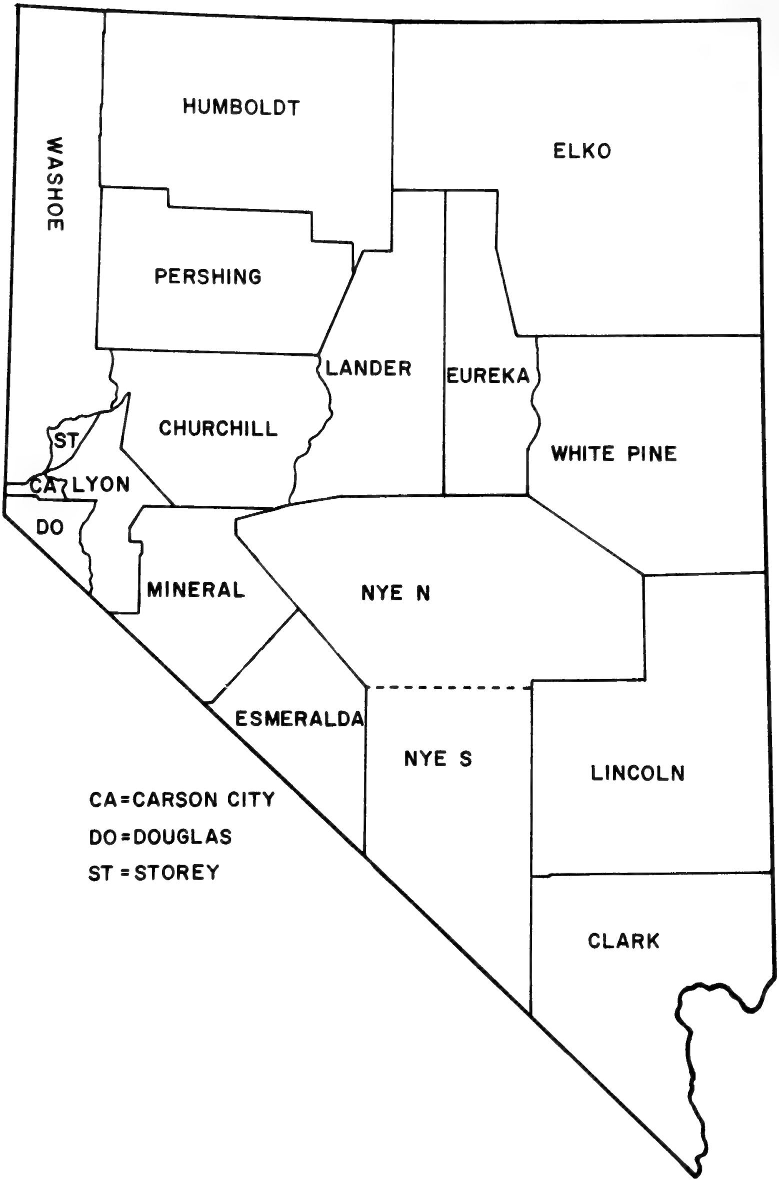

FIG. 1. Map of Nevada showing counties (dashed line shows division between northern and southern Nye County as used herein).

TABLE 1. Distribution of number of butterfly taxa recorded in each county of Nevada.

County	Number of species	Number of taxa
Carson City	106	114
Churchill	76	79
Clark	121	132
Douglas	110	119
Elko	111	127
Esmeralda	80	87
Eureka	85	89
Humboldt	84	96
Lander	96	106
Lincoln	110	119
Lyon	93	100
Mineral	90	94
Nye	116	145
Nye N	103	119
Nye S	67	76
Pershing	74	76
Storey	73	75
Washoe	117	130
White Pine	105	115
State	189	308

29a. *Hesperia comma harpalus* (W. H. Edwards)—Carson City, Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Storey, Pershing, Washoe, White Pine. Nevada material has been referred to the synonymous *idaho* (W. H. Edwards) and *cabelus* (W. H. Edwards).

29b. *Hesperia comma* (Linnaeus) spp.—Clark, Nye S. The Spring Range population is distinct from any other known population.

30. *Hesperia pahaska martini* MacNeill—Clark, Lincoln.

31. *Hesperia lindseyi* (Holland)—Washoe.

32. *Hesperia miriamae* MacNeill ssp.—Esmeralda. The White Mountains population is distinct from those in the Sierra Nevada.

33a. *Hesperia nevada nevada* (Scudder)—Elko.

33b. *Hesperia nevada* (Scudder) ssp.—Carson City, Clark, Douglas, Lyon, Mineral, Storey, Washoe. The Sierra Nevada populations are separable from the more eastern ones as previously suggested (MacNeill, 1964).

34a. *Polites sabuleti sabuleti* (Boisduval)—Carson City, Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lyon, Mineral, Nye N, Pershing, Storey, Washoe. The name *genoa* (Plötz), described from Nevada, is synonymous.

34b. *Polites sabuleti tecumseh* (Grinnell)—Carson City, Douglas, Washoe.

34c. *Polites sabuleti chusca* (W. H. Edwards)—Clark, Lincoln, Nye S.

34d. *Polites sabuleti* (Boisduval) ssp.—Eureka, Lander, Nye N, White Pine. These very pallid populations are unlike any others in the state.

34e. *Polites sabuleti* (Boisduval) ssp.—Esmeralda. A distinctive high elevation race occurs in the White Mountains.

34f. *Polites sabuleti* (Boisduval) ssp.—Elko, Lincoln, White Pine. A blackish phenotype in eastern Nevada is very distinctive.

35. *Polites draco* (W. H. Edwards)—Clark.

36a. *Polites sonora sonora* (Scudder)—Carson City, Douglas, Esmeralda, Lyon, Mineral, Storey, Washoe.

36b. *Polites sonora utahensis* (Skinner)—Humboldt.

37. *Atalopedes campestris campestris* (Boisduval)—Clark, Lincoln, Nye S.

38a. *Ochlodes sylvanoides sylvanoides* (Boisduval)—Carson City, Churchill, Douglas, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Storey, Washoe, White Pine. These populations may eventually be shown to be distinct enough to warrant recognition as different from California populations (*fide* J. F. Emmel).

38b. *Ochlodes sylvanoides bonnevilla* Scott—Elko, Eureka, Humboldt, Lander, Pershing, White Pine. This pallid taxon was described by Scott (1981).

39. *Ochlodes yuma* (W. H. Edwards)—Clark, Elko, Esmeralda, Humboldt, Lander, Lincoln, Mineral, Nye N, Nye S, Pershing, Washoe.

40. *Euphyes vestris vestris* (Boisduval)—Washoe. The name *ruricola* (Boisduval) apparently applies to another taxon (*fide* J. F. Emmel).

41. *Atrytonopsis python* (W. H. Edwards)—Clark.

42. *Lerodea eufala* (W. H. Edwards)—Clark, Lincoln, Nye S.

43. *Capodes ethlius* (Stoll)—Clark.

44. *Agathymus alliae* (D. Stallings & Turner) ssp.—Clark, Lincoln. Material represents an unnamed eastern Mojave Desert population.

45a. *Megathymus coloradensis maudae* D. Stallings, Turner & J. Stallings—Clark, Esmeralda, Lincoln, Nye S. These were referred to as *navajo* Skinner in Austin and Austin (1980).

45b. *Megathymus coloradensis browni* D. Stallings & Turner—White Pine.

PAPILIONIDAE

46. *Parnassius clodius baldur* W. H. Edwards—Washoe. This was originally reported as *altaurus* Dyer (1967, Lepid. Soc. Season Summary).

47. *Parnassius phoebus sayii* W. H. Edwards—Elko. The synonym *rubina* Wyatt was based on Nevada material.

48. *Battus philenor philenor* (Linnaeus)—Clark, Lincoln.

49. *Papilio polyxenes coloro* W. G. Wright—Clark, Lincoln, Nye S. The use of this combination follows Ferris and Emmel (1982); *rudkini* F. & R. Chermock is thus synonymous.

50. *Papilio bairdii* W. H. Edwards—Clark, Esmeralda, Lander, Lincoln, Nye N, White Pine.

51. *Papilio oregonius oregonius* W. H. Edwards—Elko. This may be a *bairdii* subspecies.

52. *Papilio zelicaon nitra* W. H. Edwards—Carson City, Churchill, Douglas, Elko, Eureka, Humboldt, Lander, Lyon, Nye N, Pershing, Storey, Washoe, White Pine. Nevada populations are closer to this rather than California *zelicaon* Lucas (see Fisher, 1977). The form "gothica" Remington has been suggested as occurring in the state (e.g., Emmel *in* Howe, 1975).

53a. *Papilio indra indra* Reakirt—Carson City, Douglas, Lyon.

53b. *Papilio indra panamintinus* J. Emmel—Clark, Lincoln(?), Nye N(?). Placement here is tentative pending further study (*fide* J. F. Emmel). This subspecies was recently described (Emmel, 1981).

53c. *Papilio indra nevadensis* T. & J. Emmel—Elko, Esmeralda, Lander, Mineral, Nye N, Pershing, White Pine. Material from Esmeralda and Mineral counties is intermediate towards *panamintinus*.

53d. *Papilio indra* Reakirt ssp.—Clark. The populations in the Sheep and certain other Clark County mountains are unlike that in the Spring Mountains.

54a. *Papilio rutulus rutulus* Lucas—Carson City, Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine. The taxon *ammoni* Behrens, described from Nevada, appears unrecognizable as a subspecies.

54b. *Papilio rutulus arizonensis* W. H. Edwards—Clark. The Spring Mountains population is different from those in the rest of the state and comes closest to this weakly defined race.

55. *Papilio multicaudata* W. F. Kirby—Carson City, Churchill, Clark, Douglas, Elko,

Eureka, Humboldt, Lander, Lincoln, Lyon, Nye N, Pershing, Storey, Washoe, White Pine.

56. *Papilio eurymedon* Lucas—Carson City, Douglas, Elko, Humboldt, Storey, Washoe, White Pine.

PIERIDAE

57a. *Neophasia menapia menapia* (C. & R. Felder)—Carson City, Douglas, Humboldt, Lyon, Mineral, Washoe.

57b. *Neophasia menapia* (C. & R. Felder) ssp.—Churchill, Clark, Elko, Eureka, Lander, Lincoln, Nye N, White Pine. Central and eastern Nevada material differs consistently from that from the Sierra Nevada and warrants recognition.

58. *Pieris beckerii* W. H. Edwards—Carson City, Clark, Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

59a. *Pieris sisymbrii elivata* Barnes & Benjamin—Carson City, Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe. These were called nominate *sisymbrii* by Edwards (1884) before the description of *elivata*.

59b. *Pieris sisymbrii* Boisduval ssp.—Clark, Lincoln, Nye N, Nye S, White Pine. Southern Nevada material is consistently distinguishable from that of the Rocky Mountains and most of the Great Basin.

60. *Pieris protodice* Boisduval & Leconte—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

61. *Pieris occidentalis occidentalis* Reakirt—Carson City, Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine.

62. *Pieris napi pallidissima* Barnes & McDunnough—Elko, White Pine. I prefer to recognize *pallidissima* as distinct from Rocky Mountain *macdunnoughi* Remington.

63. *Pieris rapae rapae* (Linnaeus)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

64. *Euchloe ausonides ausonides* (Lucas)—Carson City, Churchill, Douglas, Elko, Eureka, Humboldt, Lander, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine. These may be distinct enough from the nominate to require a new name (*fide* J. F. Emmel).

65a. *Euchloe hyantis lotta* Beutenmüller—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

65b. *Euchloe hyantis* (W. H. Edwards) ssp.—Carson City, Douglas. This is the Sierra Nevada segregate after Opler (1968).

66a. *Anthocharis cethura* C. & R. Felder ssp.—Churchill, Esmeralda, Lyon, Mineral, Nye S, Pershing, Washoe. The names *caliente* W. G. Wright and *morrisoni* W. H. Edwards have been attributed to the Nevada fauna (1967 and 1974 Lepid. Soc. Season Summaries). The former appears strictly synonymous with nominate *cethura*; the latter is probably distinct but does not occur in the state. Typical *cethura* is restricted to southern California; Great Basin material requires a name (*fide* J. F. Emmel).

66b. *Anthocharis cethura* nr. *pima* W. H. Edwards—Clark, Lincoln, Nye S. I consider *pima* as conspecific with *cethura* on the basis of apparent intermediate populations. The Mojave Desert populations are not like southern Arizona *pima*.

67a. *Anthocharis sara thoosa* (Scudder)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

67b. *Anthocharis sara browningi* Skinner—Elko, Humboldt.

67c. *Anthocharis sara stella* W. H. Edwards—Carson City, Douglas, Washoe.

68. *Anthocharis lanceolata lanceolata* Lucas—Carson City, Douglas, Washoe.

69. *Colias philodice eriphyle* W. H. Edwards—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine. This was referred to nominate *philodice* Godart by Austin and Austin (1980).

70. *Colias eurytheme* Boisduval—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

71. *Colias alexandra edwardsii* W. H. Edwards—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine. Some males from most populations have orange discal spots on the secondaries and probably represent intergrades towards *astraea* W. H. Edwards (see Ferris, 1973). The name *emilia* W. H. Edwards attributed to the state is synonymous.

72. *Colias cesonia cesonia* (Stoll)—Clark, Esmeralda, Lander, Lincoln, Lyon, Mineral, Nye N, White Pine.

73. *Phoebis sennae marcellina* (Cramer)—Clark, Lander, Nye N.

74. *Eurema mexicana* (Boisduval)—Clark, Eureka, Nye N.

75. *Eurema nicippe* (Cramer)—Clark, Lincoln, Nye S.

76. *Nathalis iole* Boisduval—Clark, Elko, Esmeralda, Eureka, Lander, Lincoln, Mineral, Nye N, Nye S, White Pine.

LYCAENIDAE

77a. *Lycaena arota virginiensis* (W. H. Edwards)—Carson City, Churchill, Douglas, Elko, Esmeralda, Humboldt, Lander, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine.

77b. *Lycaena arota schellbachi* (Tilden)—Lincoln, Nye N, White Pine.

78a. *Lycaena cupreus cupreus* (W. H. Edwards)—Douglas, Washoe.

78b. *Lycaena cupreus artemisia* Scott—Elko. The Great Basin phenotype was recently named by Scott (1981).

79a. *Lycaena editha editha* (Mead)—Carson City, Douglas, Humboldt, Lander, Storey, Washoe. Scott (1979) considered *editha* synonymous with *xanthoides* (Boisduval). I believe them to be no less than semispecies.

79b. *Lycaena editha nevadensis* Austin.—Elko, Humboldt. This phenotype is plainly distinct from that in western Nevada and was described by Austin (1984).

80a. *Lycaena rubidus rubidus* (Behr)—Humboldt, Washoe.

80b. *Lycaena rubidus sirius* (W. H. Edwards)—Carson City, Churchill, Douglas, Elko, Eureka, Humboldt, Lander, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine. Until the recent revision (Johnson & Balogh, 1977), most material from west of the Rocky Mountains (including Nevada) was referred to nominate *rubidus*.

80c. *Lycaena rubidus* nr. *monachensis* K. Johnson & Balogh—Esmeralda, Lyon.

81. *Lycaena heteronea heteronea* Boisduval—Carson City, Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine.

82. *Lycaena dorcas castro* (Reakirt)—Clark, Elko. Scott (1978a) argued that western members of this group are *helloides*. Whatever the case, certain Elko County populations are phenotypically distinct from *helloides*. I thus follow Ferris (1977) in treating these as a *dorcas* W. Kirby.

83. *Lycaena helloides* (Boisduval)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

84a. *Lycaena nivalis nivalis* (Boisduval)—Carson City, Douglas, Esmeralda, Humboldt, Washoe. The name *ianthe* (W. H. Edwards), described from Nevada material, is synonymous.

84b. *Lycaena nivalis browni* dos Passos—Elko, Lander.

85. *Hypaurotis crysalus crysalus* (W. H. Edwards)—Lincoln.

86. *Habrodais grunus grunus* (Boisduval)—Douglas, Washoe.

87. *Atlides halesus estesi* Clench—Clark, Douglas, Lincoln, Nye S. This seems to be the currently accepted name for western populations rather than *corcorani* dos Passos.
88. *Harkenclenus titus immaculosus* (W. P. Comstock)—Elko, Eureka, Humboldt, Lander, Lincoln, Nye N, Pershing, Washoe, White Pine. Western Nevada populations may be distinct enough to warrant recognition.
89a. *Satyrium behrii behrii* (W. H. Edwards)—Carson City, Churchill, Clark, Douglas, Esmeralda, Lander, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe.
89b. *Satyrium behrii crossi* (Field)—Elko, Eureka, Nye N, Lincoln, White Pine. Most eastern Nevada populations are darker and more heavily marked beneath and larger than Sierran material. These seem to represent *crossi*. Most specimens from Nye and Lander counties are large but pale beneath.
90a. *Satyrium fuliginosum fuliginosum* (W. H. Edwards)—Carson City, Douglas, Lyon, Mineral, Washoe.
90b. *Satyrium fuliginosum semiluna* Klots—Elko, Eureka, Humboldt.
91a. *Satyrium californica californica* (W. H. Edwards)—Elko, Eureka, Humboldt, Lander, Lincoln, Nye N, Pershing, Washoe, White Pine. This is the dark, non-Sierran phenotype which occurs over much of the state. It is similar to material from west of the Sierra Nevada and is thus included, for now, in that concept.
91b. *Satyrium californica cygnus* (W. H. Edwards)—Carson City, Douglas, Esmeralda, Lyon, Mineral, Storey, Washoe. Sierran material is sufficiently different from that in the rest of Nevada that the name *cygnus* is raised from synonymy.
92a. *Satyrium sylvinus sylvinus* (Boisduval)—Carson City, Churchill, Douglas, Esmeralda, Humboldt, Lyon, Pershing, Storey, Washoe. The subspecific assignments for this species are tentative at best until a thorough revisional study is undertaken. There appears to be considerable blending between phenotypes.
92b. *Satyrium sylvinus putnami* (Hy. Edwards)—Elko, Lander, Lincoln, Nye N, White Pine.
92c. *Satyrium sylvinus* (Boisduval) ssp.—Carson City, Churchill, Douglas, Elko, Eureka, Humboldt, Lander, Lyon, Mineral, Pershing, Storey, Washoe. This large, pale phenotype occurs in, mostly, the river valleys.
93. *Satyrium tetra* (W. H. Edwards)—Carson City, Douglas, Storey, Washoe. The name *adenostomatis* (Hy. Edwards) is apparently synonymous.
94a. *Satyrium saepium saepium* (Boisduval)—Carson City, Douglas, Storey, Washoe. The name *fulvescens* (Hy. Edwards) described from Lake Tahoe appears synonymous. At least four phenotypes of *saepium* occur in the state. Pending a review of the taxon, the listing herein represents the best fit to available names.
94b. *Satyrium saepium provo* (Watson & W. P. Comstock)—White Pine. Eastern Great Basin and Rocky Mountain populations are separable from those of the Sierras; this name then refers to the former.
94c. *Satyrium saepium* nr. *okanagana* (McDunnough)—Elko, Humboldt. These are very dark with high contrast beneath.
94d. *Satyrium saepium* (Boisduval) spp.—Lincoln. This is a distinctive insect (also known from Washington County, Utah) with low contrast beneath and broad white edgings on the submarginal markings.
95. *Ministrymon leda* (W. H. Edwards)—Clark, Elko, Lincoln, Nye N, Nye S.
96. *Callophrys dumetorum dumetorum* (Boisduval)—Douglas. The name *dumetorum* may actually refer to what is now called *viridis* (W. H. Edwards) whereby the name *perplexa* Barnes & Benjamin would apply to populations currently referred to *dumetorum* (*fide* J. F. Emmel).
97. *Callophrys affinis affinis* (W. H. Edwards)—Elko, Eureka, Humboldt, Lander, Lincoln, Nye N, White Pine. This taxon apparently intergrades with *dumetorum* further north (Scott & Justice, 1981); in fact the entire green *Callophrys* complex may represent a superspecies (*fide* J. F. Emmel).
98. *Callophrys comstocki* Henne—Clark, Esmeralda, Lincoln, Mineral, Nye N, Nye S.
99. *Callophrys lemberti* Tilden—Carson City, Churchill, Douglas, Elko, Humboldt, Lander, Lyon, Mineral, Pershing, Storey, Washoe.

100. *Callophrys spinetorum spinetorum* (Hewitson)—Carson City, Churchill, Clark, Douglas, Elko, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, White Pine. All Nevada material is of the nominate race and not like the Rocky Mountain *ninus* (W. H. Edwards) (see Clench, 1981).

101. *Callophrys nelsoni nelsoni* (Boisduval)—Carson City, Douglas, Washoe.

102a. *Callophrys siva rhodope* (Godman & Salvin)—Clark, Lincoln, Nye S. Green populations from Nevada are much closer to this recently revived taxon (Clench, 1981) than to Colorado examples of nominate *siva* (W. H. Edwards) to which southern Nevada material has been heretofore referred (Austin & Austin, 1980). Clench (1981) referred one Clark County specimen to nominate *siva*; the population, however, is closer to *rhodope*.

102b. *Callophrys siva chalcosiva* Clench—Carson City, Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine. This is the widespread, brown, Great Basin phenotype recently described (Clench, 1981).

103a. *Callophrys augustus iroides* (Boisduval)—Carson City, Douglas, Elko, Eureka, Humboldt, Pershing, Storey, Washoe.

103b. *Callophrys augustus*(?) (W. Kirby) ssp.—White Pine. A short series from the Snake Range either represents an undescribed *augustus* or *Callophrys mossii* (Hy. Edwards). It is tentatively placed in *augustus* but it somewhat resembles Sierran *mossii windi* (Clench). The latter taxon is considered separable from *fotis* based on pattern and, especially, biological differences.

104. *Callophrys fotis* (Strecker)—Clark, Esmeralda, Lincoln, Nye N, Nye S, White Pine.

105. *Callophrys eryphon eryphon* (Boisduval)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Lander, Lincoln, Lyon, Mineral, Nye N, Storey, Washoe, White Pine.

106a. *Strymon melinus pudica* (Hy. Edwards)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Washoe, White Pine.

106b. *Strymon melinus setonia* McDunnough—Humboldt.

107. *Brephidium exilis* (Boisduval)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

108. *Leptotes marina* (Reakirt)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

109. *Hemiargus ceraunus gyas* (W. H. Edwards)—Clark, Lincoln, Nye N, Nye S, White Pine.

110. *Hemiargus isola alce* (W. H. Edwards)—Carson City, Clark, Elko, Esmeralda, Eureka, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, White Pine.

111. *Everes amyntula amyntula* (Boisduval)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

112a. *Celastrina ladon echo* (W. H. Edwards)—Carson City, Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lyon, Mineral, Nye N, Pershing, Storey, Washoe. This and the next have long been specifically called *argiolus* (Linnaeus). It has been argued that *ladon* (Cramer) is probably correct for North American material (Clench & Miller, 1980).

112b. *Celastrina ladon cinerea* (W. H. Edwards)—Churchill, Clark, Lander, Lincoln, Nye N, Nye S, White Pine.

113a. *Euphilotes battoides glaucon* (W. H. Edwards)—Carson City, Douglas, Elko, Humboldt, Lyon, Mineral, Pershing, Storey, Washoe. The use of *Euphilotes* follows Mattoni (1977).

113b. *Euphilotes battoides baueri* (Shields)—Carson City, Churchill, Clark, Douglas, Esmeralda, Humboldt, Lander, Lincoln, Nye N, Nye S.

113c. *Euphilotes battoides intermedia* (Barnes & McDunnough)—Carson City, Douglas, Washoe.

113d. *Euphilotes battoides martini* (Mattoni)—Clark, Lincoln, Nye S.

113e. *Euphilotes battoides* nr. *bernardino* (Barnes & McDunnough)—Esmeralda, Eureka, Mineral, Nye N, White Pine.

113f. *Euphilotes battoides* (Behr) ssp.—Clark. This population is like the fall flying phenotype of the eastern Mojave Desert of California (Emmel & Emmel, 1973; Shields, 1975, 1977). It has been referred to as near *ellisi* (Shields).

113g. *Euphilotes battoides* (Behr) ssp.—White Pine. The Baking Powder Flat population is distinctive (see Shields, 1975).

113h. *Euphilotes battoides* (Behr) ssp.—Churchill, Lander, Lyon, Mineral. This entity flies in June and associates with *Eriogonum heermannii*. It has been variously referred to as near *ellisi* and near *bernardino*.

113i. *Euphilotes battoides* (Behr) ssp.—Nye S. A distinctive insect flying in July in the Grapevine Mountains (*fide* J. F. Emmel).

114a. *Euphilotes enoptes ancilla* (Barnes & McDunnough)—Churchill, Elko, Eureka, Humboldt, Lander, Lyon, Mineral, Nye N, Pershing, Storey, Washoe.

114b. *Euphilotes enoptes enoptes* (Boisduval)—Carson City, Douglas, Lyon, Storey, Washoe.

114c. *Euphilotes enoptes dammersi* (J. A. Comstock & Henne)—Clark, Lincoln.

114d. *Euphilotes enoptes* (Boisduval) ssp.—Clark, Nye S. This dark and broad-margined phenotype in the Spring Mountains is undescribed.

114e. *Euphilotes enoptes* (Boisduval) ssp.—Esmeralda, Nye N. This phenotype, somewhat intermediate between *ancilla* and the Spring Mountains population, occurs in two areas, one in the White Mountains and the other in the Quinn Canyon Range.

115a. *Euphilotes mojave mojave* (Watson and W. P. Comstock)—Clark. I follow Mattoni (1977) in considering *mojave* as a distinct species.

115b. *Euphilotes mojave langstoni* (Shields)—Esmeralda, Mineral.

116a. *Euphilotes rita pallescens* (Tilden & Downey)—Churchill, Elko, Esmeralda, Nye N. This taxon is considered subspecies of *rita* (Barnes & McDunnough) after Mattoni (1977). The Sand Mountain population in Churchill County may be distinct.

116b. *Euphilotes rita elvirae* (Mattoni)—Carson City, Lyon, Mineral, Washoe. These populations were considered within the variation of *pallescens* by Shields (1977). I believe them closer to *elvirae* than to *pallescens*.

116c. *Euphilotes rita mattonii* (Shields)—Elko.

116d. *Euphilotes rita emmeli* (Shields)—Lincoln.

117. *Euphilotes spaldingi spaldingi* (Barnes & McDunnough)—Lincoln, White Pine. I follow Mattoni (1977) in retaining this as a separate species.

118. *Philotiella speciosa speciosa* (Hy. Edwards)—Churchill, Clark, Esmeralda, Lyon, Mineral, Nye N, Nye S, Pershing. The use of this genus follows Mattoni (1977).

119a. *Glaucopsyche piasus piasus* (Boisduval)—Carson City, Douglas, Washoe. This species is undoubtedly a *Glaucopsyche* as pointed out by Brown (1971).

119b. *Glaucopsyche piasus nevada* F. M. Brown—Churchill, Elko, Esmeralda, Eureka, Lander, Lincoln, Lyon, Mineral, Nye N, White Pine. These were called *daunia* (W. H. Edwards) before *nevada* was described.

119c. *Glaucopsyche piasus toxeuma* F. M. Brown—Douglas, Humboldt, Pershing, Washoe.

120a. *Glaucopsyche lygdamus oro* (Scudder)—Churchill, Clark, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, White Pine.

120b. *Glaucopsyche lygdamus columbia* (Skinner)—Carson City, Douglas, Humboldt, Lyon, Mineral, Storey, Washoe. The name *orcus* (W. H. Edwards) may have been applied to Nevada material (see Brown, 1970b).

120c. *Glaucopsyche lygdamus* (Doubleday) ssp.—Clark, Lincoln, Nye S. This is the large-spotted, desert phenotype with an *Astragalus* host.

121. *Plebejus idas anna* (W. H. Edwards)—Carson City, Douglas, Washoe. The name *argyrognomon* (Berstrasser) is considered synonymous (see News Lepid. Soc., 1983: 66).

122a. *Plebejus melissa melissa* (W. H. Edwards)—Carson City, Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine.

122b. *Plebejus melissa fridayi* F. H. Chermock—Carson City, Douglas, Esmeralda, Mineral, Washoe.

122c. *Plebejus melissa* (W. H. Edwards) ssp.—Clark, Lincoln. This is the distinctive small phenotype of, at least, the Colorado River drainage.

123a. *Plebejus saepiolus gertschi* dos Passos—Elko, White Pine.

123b. *Plebejus saepiolus saepiolus* (Boisduval)—Carson City, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lyon, Mineral, Nye N, Storey, Washoe, White Pine.

123c. *Plebejus saepiolus* (Boisduval) ssp.—Esmeralda. This is an unnamed high elevation population in the White Mountains.

124a. *Plebejus icarioides fulla* (W. H. Edwards)—Carson City, Churchill, Clark, Douglas, Elko, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine. This name is the earliest (*fide* J. F. Emmel) to refer to populations of Great Basin influence with nearly immaculate ventral hindwings (see Downey *in* Brown, 1970b). These have heretofore been called *ardea* (W. H. Edwards).

124b. *Plebejus icarioides* (Boisduval) ssp.—Clark, Nye S. The Spring Mountains population is distinctive. This was referred to as *evius* (Boisduval) by Austin and Austin (1980).

124c. *Plebejus icarioides* (Boisduval) ssp.—Esmeralda, Mineral. Certain populations in these two counties do not belong in any described taxon.

125a. *Plebejus shasta minnehaha* (Scudder)—Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Pershing, White Pine. Emmel and Shields (1978) suggested that *minnehaha* was a "catch all" name for several distinctive populations.

125b. *Plebejus shasta shasta* (W. H. Edwards)—Carson City, Washoe.

125c. *Plebejus shasta charlestonensis* Austin—Clark. This was recently described by Austin (1980).

126a. *Plebejus acmon lutzi* dos Passos—Elko, Humboldt, Pershing, White Pine.

126b. *Plebejus acmon texanus* Goodpasture—Clark, Esmeralda, Lander, Lincoln, Nye N, Nye S, White Pine.

126c. *Plebejus acmon acmon* (Westwood & Hewitson)—Carson City, Churchill, Clark, Douglas, Esmeralda, Eureka, Humboldt, Lander, Lyon, Mineral, Nye N, Pershing, Storey, Washoe.

127a. *Plebejus lupini lupini* (Boisduval)—Carson City, Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine.

127b. *Plebejus lupini* nr. *monticola* (Clemence)—Clark, Nye S.

128. *Plebejus franklinii podarce* (C. & R. Felder)—Carson City, Douglas, Storey, Washoe. There is no general concensus as to the proper specific name for this insect (see Ferris & Brown, 1981; Miller & Brown, 1981). Previously, both *glandon* (de Prunner) and *aquilo* (Boisduval) have been used.

RIODINIDAE

129. *Calephelis nemesis californica* McAlpine—Clark.

130. *Calephelis wrighti* Holland—Clark.

131a. *Apodemia mormo mormo* (C. & R. Felder)—Carson City, Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine. There are, at least, three different *mormo* in Nevada. With the restriction of the type locality to near Pyramid Lake, Washoe County (Miller & Brown, 1981), the small, dark, univoltine (late summer), northern Nevada phenotype belongs here.

131b. *Apodemia mormo* nr. *deserti* Barnes & McDunnough—Clark, Esmeralda, Lincoln, Nye S. This is the small, pale, multivoltine (or at least vernal), desert associated phenotype. The insistence by Opler and Powell (1961) that it does not fall into their conception of *deserti* prevents me from definately placing it there as have others. I, however, can see no consistent differences.

131c. *Apodemia mormo* (C. & R. Felder) ssp.—Clark, Lincoln. This is a large, dark, fall univoltine which occurs at moderate elevations.

132. *Apodemia palmerii palmerii* (W. H. Edwards)—Clark, Lincoln, Nye S. The name *marginalis* (Skinner) is synonymous, but this phenotype differs from that further east.

LIBYTHEIDAE

133. *Libytheana bachmanii larvata* (Strecker)—Clark, Lincoln.

HELICONIIDAE

134. *Agraulis vanillae incarnata* (Riley)—Clark.

NYMPHALIDAE

135. *Euptoieta claudia* (Cramer)—Churchill, Clark, Lincoln, Nye N, White Pine.

136a. *Speyeria cybele leto* (Behr)—Carson City, Douglas, Lyon, Washoe.

136b. *Speyeria leto letona* dos Passos & Grey—White Pine.

137a. *Speyeria nokomis nokomis* (W. H. Edwards)—Elko, White Pine. The Ruby Valley population is somewhat intermediate towards *apacheana*. Ferris and Fisher (1971) discussed the blending of *nokomis* and *apacheana* across Utah.

137b. *Speyeria nokomis apacheana* (Skinner)—Carson City, Douglas, Lander, Lincoln, Lyon, Mineral, Nye N, Washoe, White Pine.

138. *Speyeria coronis snyderi* (Skinner)—Carson City, Churchill, Douglas, Elko, Eureka, Humboldt, Lander, Lyon, Nye N, Pershing, Storey, Washoe, White Pine. Nevada specimens were referred to nominate *coronis* (Behr) by Edwards (1897) before *snyderi* was described. Material from the Sierra Nevada and associated ranges is smaller with a browner disc and may be more closely associated with *simaetha* dos Passos & Grey.

139a. *Speyeria zerene zerene* (Boisduval)—Carson City, Douglas, Washoe.

139b. *Speyeria zerene malcolmi* (J. A. Comstock)—Douglas, Mineral, Storey.

139c. *Speyeria zerene carolae* (dos Passos & Grey)—Clark.

139d. *Speyeria zerene platina* (Skinner)—Elko, Nye N, White Pine.

139e. *Speyeria zerene gunderi* (J. A. Comstock)—Churchill, Elko, Eureka, Humboldt, Lander, Nye N, Pershing, Washoe, White Pine. The types of *gunderi* are of an undoubted *zerene*. The taxon *cynna* dos Passos & Grey is considered a synonym (see Grey, 1975).

140a. *Speyeria callippe nevadensis* (W. H. Edwards)—Carson City, Douglas, Elko, Humboldt, Lyon, Mineral, Storey, Washoe.

140b. *Speyeria callippe harmonia* dos Passos & Grey—Churchill, Elko, Eureka, Lander, Lincoln, Nye N, Pershing, White Pine.

141a. *Speyeria egleis egleis* (Behr)—Carson City, Douglas, Mineral, Washoe.

141b. *Speyeria egleis linda* (dos Passos & Grey)—Elko, Humboldt(?).

141c. *Speyeria egleis utahensis* (Skinner)—Elko, Eureka, White Pine.

141d. *Speyeria egleis toiyabe* Howe—Lander, Nye N.

142a. *Speyeria atlantis greyi* (Moeck)—Elko.

142b. *Speyeria atlantis elko* Austin.—Elko. Populations of the *dodgei* (Gunder) cline occur in the northern portion of the county. These have been variously referred to as near *irene* (Boisduval) or near *dodgei*. It was described by Austin (1983).

143a. *Speyeria mormonia mormonia* (Boisduval)—Carson City, Douglas, Washoe. The restriction of the type locality of *mormonia* to western Nevada (Miller & Brown, 1981) seems reasonable. This relegates *arge* (Strecker), the name previously applied to Nevada material, to synonymy. The synonym *montivaga* (Behr) has also been applied to Nevada material (Holland, 1931).

143b. *Speyeria mormonia artonis* (W. H. Edwards)—Elko, White Pine.

144. *Poladryas arachne arachne* (W. H. Edwards)—Clark, Lincoln, Nye N, Nye S, White Pine.
145a. *Chlosyne leanira cerrita* (W. G. Wright)—Clark, Esmeralda, Lincoln, Nye S. A new name might be needed for these populations as *cerrita* was named from a mixed population.
145b. *Chlosyne leanira alma* (Strecker)—Carson City, Churchill, Douglas, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.
146. *Chlosyne californica* (W. G. Wright)—Clark, Lincoln.
147. *Chlosyne lacinia crocale* (W. H. Edwards)—Clark.
148a. *Chlosyne palla* (Boisduval) ssp.—Carson City, Douglas, Storey, Washoe. This phenotype has been called *whitneyi* (Behr). Recent investigations have indicated that the insect described as *whitneyi* is actually what we have known as *damoetas* (Skinner) (*fide* J. F. Emmel). Thus the Sierra Nevada *palla* is without a name.
148b. *Chlosyne palla vallismortis* (J. W. Johnson)—Clark, Nye S. This may actually be closer to *acastus* or a valid species in itself (*fide* J. F. Emmel).
149. *Chlosyne acastus acastus* (W. H. Edwards)—Carson City, Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine.
150. *Chlosyne neumoegeni neumoegeni* (Skinner)—Clark, Esmeralda, Lincoln, Nye S.
151. *Chlosyne hoffmanni hoffmanni* (Behr)—Carson City, Washoe.
152. *Phyciodes texana texana* (W. H. Edwards)—Clark.
153. *Phyciodes phaon* (W. H. Edwards)—Clark.
154a. *Phyciodes tharos distincta* Bauer—Clark.
154b. *Phyciodes tharos* nr.(?) *pascoensis* (W. G. Wright)—Elko, White Pine.
155a. *Phyciodes pratensis pratensis* (Behr)—Elko, Esmeralda, Eureka, Humboldt, Lander, Lyon, Nye N, Pershing, Washoe.
155b. *Phyciodes pratensis montana* (Behr)—Carson City, Douglas, Lyon, Mineral, Washoe.
155c. *Phyciodes pratensis camillus* W. H. Edwards—Elko, Eureka, Lincoln, Nye N, White Pine.
155d. *Phyciodes pratensis* (Behr) ssp.—Elko, Eureka, Humboldt, Lander. This is a very pallid phenotype from the Humboldt River Valley.
156. *Phyciodes orseis herlani* Bauer—Carson City, Douglas, Washoe.
157. *Phyciodes pallida barnesi* Skinner—Clark, Elko, Eureka, Lincoln, Nye N, White Pine.
158. *Phyciodes mylitta mylitta* (W. H. Edwards)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine.
159a. *Euphydryas anicia alena* Barnes & Benjamin—Clark, Lincoln. The taxa *anicia* (Doubleday & Hewitson) and *colon* (W. H. Edwards) were synonymized with *chalcedona* (Doubleday) by Scott (1978b). I treat them as, at least, semispecies.
159b. *Euphydryas anicia macyi* Fender & Jewett—Humboldt.
159c. *Euphydryas anicia morandi* Gunder—Clark.
159d. *Euphydryas anicia veazieae* Fender & Jewett—Humboldt, Washoe.
159e. *Euphydryas anicia wheeleri* (Hy. Edwards)—Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Pershing, White Pine.
160a. *Euphydryas chalcedona kingstonensis* T. & J. Emmel—Clark.
160b. *Euphydryas chalcedona macglashanii* (Rivers)—Carson City, Douglas, Lyon, Storey, Washoe. The name *truckeensis* Gunder, ascribed to our fauna (Martin & Truxal, 1955), is synonymous.
161a. *Euphydryas colon nevadensis* Bauer—Elko.
161b. *Euphydryas colon wallacensis* Gunder—Washoe.
162a. *Euphydryas editha aurilacus* Gunder—Washoe. This population has previously been referred to *nubigena* (Behr).
162b. *Euphydryas editha hutchinsi* McDunnough—Elko.
162c. *Euphydryas editha lehmani* Gunder—Elko, Eureka, Lander, Lincoln, Nye N, White Pine. The name *caverna* Gunder is based on an aberration from Nevada.

162d. *Euphydryas editha monoensis* Gunder—Carson City, Douglas, Washoe.

162e. *Euphydryas editha koreti* Murphy & Ehrlich—Lander, White Pine. The high elevation populations of the Toiyabe, Snake and Schell Creek ranges are distinctive and were described by Murphy and Ehrlich (1983).

162f. *Euphydryas editha* (Boisduval) ssp.—Washoe. This undescribed phenotype is like certain low elevation Modoc County, California material. This may or may not be what is referred to as *edithana* (Strand) in northwestern Nevada (Bauer *in* Howe, 1975).

163. *Polygonia satyrus satyrus* (W. H. Edwards)—Carson City, Clark, Douglas, Elko, Eureka, Lander, Lincoln, Lyon, Nye N, Washoe, White Pine.

164. *Polygonia zephyrus* (W. H. Edwards)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

165. *Nymphalis californica californica* (Boisduval)—Carson City, Churchill, Clark, Douglas, Elko, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine.

166. *Nymphalis antiopa antiopa* (Linnaeus)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

167. *Nymphalis milberti furcillata* (Say)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

168. *Vanessa virginiensis* (Drury)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine.

169. *Vanessa cardui* (Linnaeus)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

170. *Vanessa annabella* (Field)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine. The name *carye* (Hübner) was previously misapplied to this taxon.

171. *Vanessa atalanta rubria* (Fruhstorfer)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

172. *Precis coenia* (Hübner)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

173a. *Limenitis archippus* nr. *archippus* (Cramer)—Elko. The Little Salmon River population is somewhat intermediate towards *lahontani* but is closest to the nominate.

173b. *Limenitis archippus obsoleta* W. H. Edwards—Clark. It appears that *hulstii* W. H. Edwards is insufficiently different to warrant recognition. If valid, the latter would apply to Nevada material.

173c. *Limenitis archippus lahontani* Herlan—Churchill, Elko, Eureka, Humboldt, Lander, Lyon, Pershing, Storey, Washoe.

174a. *Limenitis weidemeyerii latifascia* E. M. & S. F. Perkins—Churchill, Elko, Eureka, Humboldt, Lander, Mineral, Nye N, Pershing, White Pine.

174b. *Limenitis weidemeyerii nevadae* (Barnes & Benjamin)—Clark.

174c. *Limenitis weidemeyerii angustifascia* (Barnes & Benjamin)—Clark, Lincoln.

175. *Limenitis lorquini eavesii* Hy. Edwards—Carson City, Churchill, Douglas, Esmeralda, Humboldt, Lyon, Mineral, Storey, Washoe. This species hybridizes with *L. weidemeyerii latifascia* (not *nevadae*, *contra* Miller & Brown, 1981); the hybrid was named "fridayi" Gunder. These are known from Churchill, Elko, Humboldt and Mineral counties. Western Great Basin populations are distinct from nominate *lorquini* and fit the concept of *eavesii*. In the Pine Forest Range (Humboldt County), the population is largely "fridayi" and the *lorquini* appears to be of the subspecies *burrisoni* Maynard.

176. *Adelpha bredowii eulalia* (Doubleday & Hewitson)—Clark, Lincoln, White Pine.

All U.S. records (including Nevada, Holland, 1931) were once included in *californica* (Butler).

APATURIDAE

177. *Asterocampa celtis montis* (W. H. Edwards)—Clark. I have seen no evidence to maintain the multitude of monotypic species in this genus.

SATYRIDAE

178. *Cyllopsis pertepida dorothea* (Nabokov)—Clark, Lincoln. Use of *Cyllopsis* follows the review by Miller (1974).

179a. *Coenonympha ochracea mono* Burdick—Douglas, Lyon, Mineral. This, *ampelos* and *california* are members of the *tullia* (Muller) superspecies.

179b. *Coenonympha ochracea* W. H. Edwards ssp.—Clark, Elko, Eureka, Lander, Lincoln, Nye N, White Pine. The name *brenda* W. H. Edwards has often been misapplied (e.g., Brown, 1964), as has the nominate (e.g., Holland, 1931) to the heavily ocellated Great Basin phenotype; *brenda* appears synonymous with *california* (*fide* R. E. Gray; also dos Passos, 1964).

180a. *Coenonympha ampelos ampelos* W. H. Edwards—Carson City, Douglas, Elko, Eureka, Humboldt, Lander, Lyon, Nye N, Storey, Washoe.

180b. *Coenonympha ampelos elko* W. H. Edwards—Elko, Eureka, Humboldt, Lander, White Pine.

181. *Coenonympha california california* Westwood—Clark.

182a. *Cercyonis pegala gabbii* (W. H. Edwards)—Carson City, Douglas. These populations are often referred to as *ariane* (Boisduval). The latter refers to certain populations west of the Sierra Nevada. The name *gabbii* may (or may not) apply to this western Great Basin material.

182b. *Cercyonis pegala stephensi* (W. G. Wright)—Humboldt, Washoe. The name *blanca* T. Emmel & Mattoon is a synonym.

182c. *Cercyonis pegala* (Fabricius) ssp.—Elko, Eureka, Humboldt, Lander, Lyon, Mineral(?), Pershing, White Pine. The central Great Basin populations are a distinct entity. The populations in Lyon and Mineral counties are similar but may not be properly placed here.

183a. *Cercyonis sthenele paulus* (W. H. Edwards)—Carson City, Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine.

183b. *Cercyonis sthenele masoni* Cross—Clark, Lincoln, Nye N, Nye S. This phenotype, closest to *masoni,* extends into the desert areas of California and may warrant taxonomic recognition.

184a. *Cercyonis oetus oetus* (Boisduval)—Carson City, Churchill, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Pershing, Storey, Washoe, White Pine.

184b. *Cercyonis oetus pallescens* T. & J. Emmel—Lander, Nye N. This taxon, described by Emmel and Emmel (1971), was omitted in Miller and Brown (1981).

185a. *Neominois ridingsii stretchii* (W. H. Edwards)—Elko, Eureka, Humboldt, Lander, Nye N, Washoe, White Pine.

185b. *Neominois ridingsii dionysus* Scudder—Elko, Nye N, White Pine.

185c. *Neominois ridingsii* (W. H. Edwards) ssp.—Esmeralda, Lyon, Mineral. This is the pale, western Great Basin population described by Austin (in press). The occurrence of the nominate subspecies in Nevada (Emmel *in* Howe, 1975) is incorrect.

186. *Oeneis ivallda* (Mead)—Carson City, Washoe.

187. *Oeneis chryxus chryxus* (Doubleday & Hewitson)—Elko, Lincoln, White Pine.

DANAIDAE

188. *Danaus plexippus plexippus* (Linnaeus)—Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, Storey, Washoe, White Pine.

189. *Danaus gilippus strigosus* (Bates)—Carson City, Churchill, Clark, Douglas, Elko,

Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye N, Nye S, Pershing, White Pine.

DUBIOUS AND HYPOTHETICAL RECORDS

A number of taxa have been reported for Nevada which are unlikely or represent misdeterminations. Others range nearly to the borders of the state and may be expected to occur. These are commented upon below. Taxa reported but now considered synonymous with those occurring in the state are discussed above in the main species accounts.

Erynnis brizo lacustra (W. G. Wright)—The reported record (Martin & Truxal, 1955) undoubtedly refers to *burgessi*.

Hesperia comma oregonia (W. H. Edwards)—The type series was supposedly taken in Nevada and there are specimens labeled such in Edwards' collection in the Carnegie Museum, Pittsburgh, Pennsylvania (see Brown & Miller, 1977). These probably led to the subsequent listing of the taxon for Nevada (Lindsey, 1921; Lindsey et al., 1931). This subspecies does not occur in the state.

Hesperia pawnee Dodge—MacNeill (1964) mentioned seeing an, undoubtedly mislabeled, male labeled "Nevada."

Hesperia viridis (W. H. Edwards)—A specimen in the Snow Entomological Museum, University of Kansas, Lawrence, is labeled "Verdi, Nevada, July, 1903" (MacNeill, 1964; Brown & Miller, 1977). It is undoubtedly mislabeled.

Ochlodes sylvanoides pratincola (Boisduval)—A worn Nevada specimen taken to be this taxon was figured by Holland (1931). It probably is nominate *sylvanoides*.

Ochlodes agricola (Boisduval)—Specimens listed in the Nevada State Museum catalog for Clark and Elko counties are unlocatable. Undoubtedly these represent a misdetermination of some other taxon. Specimens from the W. H. Edwards collection from Nevada (Irwin, 1966) are probably mislabeled.

Poaenes taxiles (W. H. Edwards)—The taxon has been listed for the state on several occasions (e.g., Edwards, 1881; Lindsey, 1921; Lindsey et al., 1931; MacNeill *in* Howe, 1975; Pyle, 1981). Three specimens labeled Nevada are in the W. H. Edwards collection at the Carnegie Museum, Pittsburgh, Pa. (Brown & Miller, 1980). There are no recent, verifiable records for the state but it occurs into western Utah and may be found eventually in one or more of the eastern Nevada counties.

Paratrytone melane melane (W. H. Edwards)—Nevada, in error, was included as the type locality (see Brown & Miller, 1980). The species is unknown in the state.

Amblyscirtes eos (W. H. Edwards)—The one report for Clark County (1972, Lepid. Soc. Season Summary) represents a misdetermination of *Pholisora alpheus* (*fide* J. F. Lesser).

Amblyscirtes vialis (W. H. Edwards)—Holland (1931) stated the range as including Nevada. I do not know of any records for the state although it occurs not too far away in the Sierra Nevada of California (Shapiro et al., 1979).

Parnassius clodius sol Bryk & Eisner—The type locality was listed as "Nevada"; this is probably more properly the Sierra Nevada somewhere in California. This taxon is not known from Nevada.

Parnassius phoebus behrii W. H. Edwards—Brown (1975b) mentioned a total of seven specimens in the W. H. Edwards collection at the Carnegie Museum labeled Nevada. There are no recent records and the above may represent mislabeling although the taxon occurs close to the Nevada line in the Sierra Nevada.

Papilio indra fordi J. A. Comstock & Martin—Tyler's (1975) inclusion of this taxon for Nevada is erroneous (probably based on 1963, Lepid. Soc. Season Summary). The record undoubtedly refers to the *panamintinus*-like populations in the Spring Mountains.

Neophasia menapia tau (Scudder)—The Caron Range population (Herlan, 1962) is not of this subspecies but of the nominate.

Euchloe hyantis hyantis (W. H. Edwards)—The recorded occurrence (1967, Lepid. Soc. Season Summary; see also Brown, 1973) refers to *lotta*.

Anthocharis sara sara Lucas—This has been incorrectly included in the Carson Range list (Herlan, 1962) as the form "reakirtii" W. H. Edwards. Two specimens of this taxon labeled "Mineral County" are in the Nevada State Museum. They are regarded as mislabeled as they do not, in any way, resemble material from nearby.

Anthocharis sara inghami Gunder—This and *thoosa* have been confused leading to the erroneous use of the former in the Nevada literature (1969, Lepid. Soc. Season Summary).

Colias occidentalis chrysomelas Hy. Edwards—The report for the Carson Range (Herlan, 1962) is unverified and undoubtedly represents a misdetermination.

Lycaena xanthoides xanthoides (Boisduval)—This species does not occur in Nevada; the Carson Range record (Herlan, 1962) is an undoubted misdetermination.

Lycaena gorgon (Boisduval)—I do not know the basis for Holland's (1931) inclusion of this species for Nevada.

Lycaena mariposa mariposa (Reakirt)—This species is reported as occurring in Nevada by Opler (*in* Howe, 1975). I know of no records.

Satyrium acadica coolinensis (Watson & W. P. Comstock)—The supposed Nevada record (Herlan, 1962) is a misidentification of, probably, *californica*.

Satyrium sylvinus dryope (W. H. Edwards)—A pair labeled *dryope* collected in "Nevada" by Morrison are in Edwards' collection at the Carnegie Museum (Brown, 1970a). These are either mislabeled or represent tailless individuals from a normally tailed Nevada population.

Callophrys sheridanii (W. H. Edwards)—Pyle (1981) reported *sheridanii* for southern Nevada. He treated this taxon as specifically distinct from both *comstocki* and *lemberti*. In this sense, *sheridanii* is unverified for Nevada.

Callophrys mossii windi (Clench)—This butterfly is in the Sierra Nevada not far from the Nevada line (*fide* D. L. Bauer). It may occur in association with its *Sedum* foodplant in, especially, the Mt. Rose area of Washoe County.

Everes comyntas (Godart)—This was reported for Nye County (1969, Lepid. Soc. Season Summary). All Nevada *Everes* seem to be *amyntula*.

Glaucopsyche piasus sagittigera (C. & R. Felder)—Brown (1975a) placed a single Humboldt County specimen in this taxon. More extensive material from this area shows these to be *toxeuma*.

Glaucopsyche lygdamus incognitus Tilden—The Nevada occurrences (Martin & Truxal, 1955; Herlan, 1962) as *behrii* (W. H. Edwards) probably represent *columbia*.

Plebejus icarioides lycea (W. H. Edwards)—The Carson Range report (Herlan, 1962) is of *fulla*.

Plebejus icarioides icarioides (Boisduval)—Two names associated with this subspecies have been ascribed to Nevada. The first is *mintha* (W. H. Edwards) of which the types were originally stated as being from Nevada but later corrected to California (see Brown, 1970b). The other, *fulla* (W. H. Edwards), has been synonymized with nominate *icarioides* (e.g., dos Passos, 1964; Miller & Brown, 1981). This, however, is the senior synonym of the widespread Great Basin subspecies previously called *ardea*.

Speyeria nokomis nitocris (W. H. Edwards)—This taxon was erroneously reported for Nevada (Edwards, 1897; dos Passos & Grey, 1947).

Speyeria zerene conchyliatus (J. A. Comstock)—Variation among the blending *zerene* populations east of Lake Tahoe produces occasional specimens resembling this subspecies (e.g., Herlan, 1962). The variation is best referred to the nominate subspecies. The Sierran influence seen in some individuals from northwestern Washoe County is due to introgression from *conchyliatus*.

Speyeria callippe juba (Boisduval)—This taxon was included for Nevada as *inornata* (W. H. Edwards) by Holland (1931) and dos Passos and Grey (1947), both probably following Edwards (1884). I know of no records although it does occur in the Sierra Nevada not far to the west (Shapiro et al., 1979).

Speyeria callippe laura (W. H. Edwards)—The types of this subspecies were reported from Nevada (Edwards, 1879). Nothing like it has turned up in the state since. The name probably applies to something further west in California.

Speyeria atlantis irene (Boisduval)—Moeck (1957) reported *irene* on Verdi Peak north of Lake Tahoe near the Nevada line. It may occur east of here in Washoe County.

Boloria epithore sierra E. Perkins—The species occurs in the vicinity of South Lake Tahoe, Eldorado County, California (*fide* D. L. Bauer). It may occur in adjacent Douglas County.

Chlosyne leanira wrightii (W. H. Edwards)—Holland (1931) erroneously included Nevada in the range of this taxon.

Chlosyne gabbi (Behr)—Higgins (1960) reported a specimen of this species labeled "Nord Nevada." It is undoubtedly mislabeled.

Chlosyne whitneyi whitneyi (Behr)—This has been long known as *damoetas* (Skinner) (see comment under *palla* in main species accounts). The species occurs in the Sierra Nevada and Sweetwater Mountains in California. It may also be in adjacent Nevada.

Dymasia dymas chara (W. H. Edwards)—A specimen in the Allyn Museum of Entomology, Sarasota, Florida is mislabeled Elko County (*fide* E. M. Perkins). The correct data are Pima County, Arizona, and the above museum has been so notified.

Phyciodes picta (W. H. Edwards)—This species was erroneously listed for Nevada (1964, Lepid. Soc. Season Summary). There are no records for the state.

Phyciodes pallida pallida (W. H. Edwards)—This taxon was reported from Nevada as *mylitta mata* (Reakirt) (1963, Lepid. Soc. Season Summary). This undoubtedly represents *barnesi*.

Euphydryas chalcedona olancha (W. G. Wright) and *sierra* (W. G. Wright)—Holland (1931) and Scott (1978b) used these names for the variation in Nevada *macglashanii*. Comstock (1937) referred to central Nevada material (apparently *wheeleri*) as *sierra*.

Polygonia faunus rusticus (W. H. Edwards)—This species has been taken a very short distance from the Nevada line near South Lake Tahoe, Eldorado County, California (*fide* D. L. Bauer) and will probably eventually be recorded in Douglas County.

Polygonia oreas silenus (W. H. Edwards)—Ferris and Brown (1981) showed an unverified record for Elko County. This represents a misdetermined *zephyrus* (*fide* R. L. Langston).

Precis evarete (Cramer)—The report for Nevada (Herlan, 1962 as *orithya evarete*) refers to *coenia*.

Coenonympha ampelos columbiana McDunnough—Nevada nominate *ampelos* have been erroneously referred to this taxon (Herlan, 1962; 1964, Lepid. Soc. Season Summary).

Cercyonis pegala wheeleri (W. H. Edwards)—The types for the synonymous *hoffmani* (Strecker) were reported as from "Owens Lake, Nevada." This locality is actually in California.

Cercyonis sthenele silvestris (W. H. Edwards)—The occurrence in Nevada (Herlan, 1962) refers to *paulus*.

Oeneis nevadensis nevadensis (C. & R. Felder)—Martin and Truxal (1955) and Emmel (*in* Howe, 1975) reported this species for Nevada. I know of no definite records.

I have been unable to verify a number of possible county records listed in the Harjes (1980) checklist. These are listed below. Some are unlikely or are known misdeterminations and, the county is set in italics, and many are commented upon. Others are probable and are listed mostly without comment.

Hesperia nevada—*Esmeralda* (misdetermined *uncas*, NSM).
Heliopetes ericetorum—Washoe.
Pyrgus ruralis—Carson City.
Erynnis propertius—*Lyon* (misdetermined *pacuvius*, NSM).
Thorybes mexicana—*White Pine* (misdetermined *Erynnis telemachus*, NSM).
Papilio bairdii—*Washoe* (misdetermined *zelicaon*, NSM).
Nathalis iole—Douglas.
Lycaena nivalis—*Churchill* (misdetermined *helloides*, NSM).

Habrodais grunus—Clark (typographical error, should be Douglas).
Callophrys spinetorum—Storey.
Callophrys nelsoni—Elko, Lyon, Nye (misdetermined *siva,* NSM, etc.).
Callophrys dumetorum—Storey (misdetermined *lemberti,* Bauer).
Plebejus idas—Mineral (misdetermined *melissa,* NSM).
Libytheana bachmanii—Storey.
Limenitis weidemeyerii—Carson City, Washoe.
Limenitis lorquini—White Pine.
Polygonia satyrus—Storey (misdetermined *zephyrus,* NSM).
Chlosyne lacinia—Lander.
Euphydryas chalcedona—Churchill, Elko, Eureka, Lander, Nye (correct only if *anicia* is considered a *Chalcedona,* see Scott, 1978b).
Euphydryas editha—Churchill.
Danaus gilippus—Washoe.
Coenonympha california—Humboldt (partially mislabeled California specimen, NSM).
Neominois ridingsii—Douglas.

There are an additional five county records that are erroneous or unverified in any way:

Hesperia pahaska—White Pine (Ferris & Brown, 1981). This is possible, but there are no verified records to date.
Chlosyne palla—Elko (Ferris & Brown, 1981). Unverified and probably refers to *acastus.*
Limenitis lorquini—Elko, White Pine (Ferris & Brown, 1981). The White Pine record is totally erroneous; the Elko record undoubtedly refers to "fridayi" specimens which occasionally turn up.
Cercyonis oetus—Clark (1974, Lepid. Soc. Season Summary). Undoubtedly this refers to *sthenele.*

Other Clark County *dubia* are listed in Austin and Austin (1980).

DISCUSSION

To date, 189 species and some 300 total taxa of butterflies are known from the state of Nevada (Table 1). In general, counties with a portion of the Sierra Nevada in western Nevada, the four counties on the eastern border and the huge Nye County show the greatest diversity. Some of this is real; some is undoubtedly due to insufficient collecting. In addition, there are a number of areas within the state that have received little or no study. These include, but are not limited to, the following:

1) the northeastern and southeastern portions of Elko County.
2) Elko and Humboldt counties between the Independence and Santa Rosa ranges.
3) western Humboldt County west of the Santa Rosa Range.
4) eastern and western Pershing County.
5) extreme northern Washoe County.
6) much of Churchill County outside the Clan Alpine Range and the Fallon area.
7) Lander County between U.S. 50 and I-80.
8) northwestern quarter of White Pine County.
9) northern Nye County except the region from the Toiyabe Range to the Monitor Range.

10) southern Nye County (most of this is due to the presence of the Nevada Test Site which is off limits to the average collector; there are still fringe areas which can be studied).
11) western half of Lincoln County.
12) Mineral County except the Wassuk Range.
13) Esmeralda County except the White Mountains.

Some of these areas appear important as blend zones between taxa or may represent the distributional limits of others.

What is as important as filling in the distributional holes in Nevada is a more thorough knowledge of the fauna of adjacent regions. A start on this is Dornfeld's (1980) work on Oregon butterflies. The distribution and taxonomy of the butterflies of the other bordering states (Arizona, California, Idaho, Utah) are in various stages of study and updating. Once completed, we should have a picture of the influence of surrounding regions on the butterflies of Nevada specifically and the Great Basin in general.

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MITOURA MILLERORUM (CLENCH) AND ITS OCCURRENCE IN THE UNITED STATES (LYCAENIDAE)

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ABSTRACT. The male imago is illustrated and the male genitalia described and illustrated for the first time. A new Mexican and a thus-far unique southwestern United States collection record are documented along with clarifications concerning the original description of *millerorum*, specimens which represent it, and its inter-specific diagnosis. A larval specimen collected on *Arceuthobium globosum* Hawksworth and Wiens (Loranthaceae) is discussed relative to its possibly representing *millerorum* and, if so, the importance of any apparent monophagy in defining the species.

Mitoura millerorum (Clench) was described from a holotype female collected in the vicinity of El Encarnacion, Hidalgo State, Mexico, with a male paratype (not personally examined by Clench) designated from Palos Colorados, Durango State, Mexico (Clench, 1981). The purposes of this brief paper are to: (1) illustrate the male imago and describe and illustrate the male genitalia of the hitherto undescribed male of *millerorum*; (2) document further collection records of the species, including one in the United States; (3) clarify the comments of Clench (loc. cit.) concerning the species and specimens representing it; (4) summarize the present knowledge of its biology and (5) thereby encourage lepidopterists in the United States to pursue larger samples of this apparently rare hairstreak butterfly.

Circumstances Surrounding the Description of *M. millerorum*

The description of *M. millerorum* was published posthumously. Its description and associated type designations were complicated, therefore, by the assembling of Clench's unfinished manuscripts and the apparently related type series. This effort, made by Drs. Lee D. and Jacqueline Y. Miller was hampered in regard to *millerorum* by several circumstances. Firstly, Clench had not seen and had, therefore, not dissected the male paratype specimen from the American Museum of Natural History. Its existence had been called to his attention earlier by me. A description of the species had been prepared in manuscript by me, using the aforementioned specimen and a female in the British Museum (Natural History) collected in July at Bolanos, Jalisco State, Mexico. In 1979, I deferred description of the species to Clench, sending him information concerning both of the above specimens (the latter of which had also been listed by Shields, 1965, as *M. spinetorum* (Hewitson)). In turn, Clench forwarded for my examination the unique specimen from Otero County, New Mexico, noted by him (loc. cit., pp. 22–23) as collected "3 mi. N. Weed, ca. 6700 ft., 12 June 1977," by H. K. and M. Clench. This specimen had the undersurface hindwing postbasal stripes characteristic of *millerorum* but was identified by Clench (loc. cit.) as an aberration of *spinetorum*. By the time of his death, Clench had not dissected the eventual holotype of *millerorum*, though I had returned my dissection of the Otero County specimen to him for comparison.

When the Millers assembled the material for Clench (loc. cit.) none of the above material or information was located. Hence, when the original description was published, the Otero County specimen had still not been found, and although I possessed a drawing of its genitalia, I had not been able to compare it to either the eventual type or the Bolanos, Mexico, specimen. As a result there was no standard of comparison to identify the Otero County specimen properly. Further, the male of *millerorum* remained undescribed; the treatment of *millerorum* was ultimately limited to comments in the remaining unfinished manuscript of Clench, and information concerning *millerorum* cullable from Shields (loc. cit.) was not integrated into the original description. In subsequent years all of the above problems have been clarified.

Clarifications Concerning *M. millerorum*, Its Biology and Occurrence

Fig. 1 illustrates the features of the male and female genitalia of all known *Arceuthobium* (Loranthaceae)-feeding *Mitoura* taxa.[1] Shorter, hairlike spines on the cephalo-ventrad surface of the valvae ("bilobed configuration" *sensu* Johnson, 1976, 1978, and in press[2] are emphasized, while long hairlike spines not figured. The former, along with overall opaqueness in this valval region, characterize *Arceuthobium*-feeders contrasted to Cupressaceae-feeders (see Johnson, 1976, and in press) along with numerous other characters. Among *Arceuthobium*-feeders, the male genitalia of *M. millerorum* are distinctive as follows: (1) bilobed area markedly larger as contrasted to caudal length of valvae; (2) saccus widely parabolic; (3) cephalad cornutus at aedeagal terminus bifurcate; and (4) (not illustrated) caudal one-third of aedeagus distinctly curved (60° angle) in known specimen. This latter trait occurs in no other known *Mitoura* though its generality in *millerorum* cannot be certain from the single known specimen. Differences in the female genital plate of *Arceuthobium*-feeders are most apparent in the nature

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[1] The life histories of *M. spinetorum* and *johnsoni* (Skinner) have been well documented (see Shields, loc. cit.). That of *millerorum* is known only from the circumstantial data presented in this paper or inferred from the overall unity of morphological characters shared by taxa of Fig. 1 as compared to *Mitoura* taxa known to feed on Cupressaceae (see Johnson, 1976, 1978, and in press) [in press]. Revision of the Callophryina of the world with phylogenetic and biogeographic analyses (Lepidoptera: Lycaenidae). Ms. (in part) as Ph.D. dissertation, Graduate Center, City University of New York (1981). 902 pp.

[2] In press. Revision of the Callophryina of the world with phylogenetic and biogeographic analyses (Lepidoptera: Lycaenidae). Ms (in part) as Ph.D. dissertation, Graduate Center, City University of New York (1981). 902 pp.

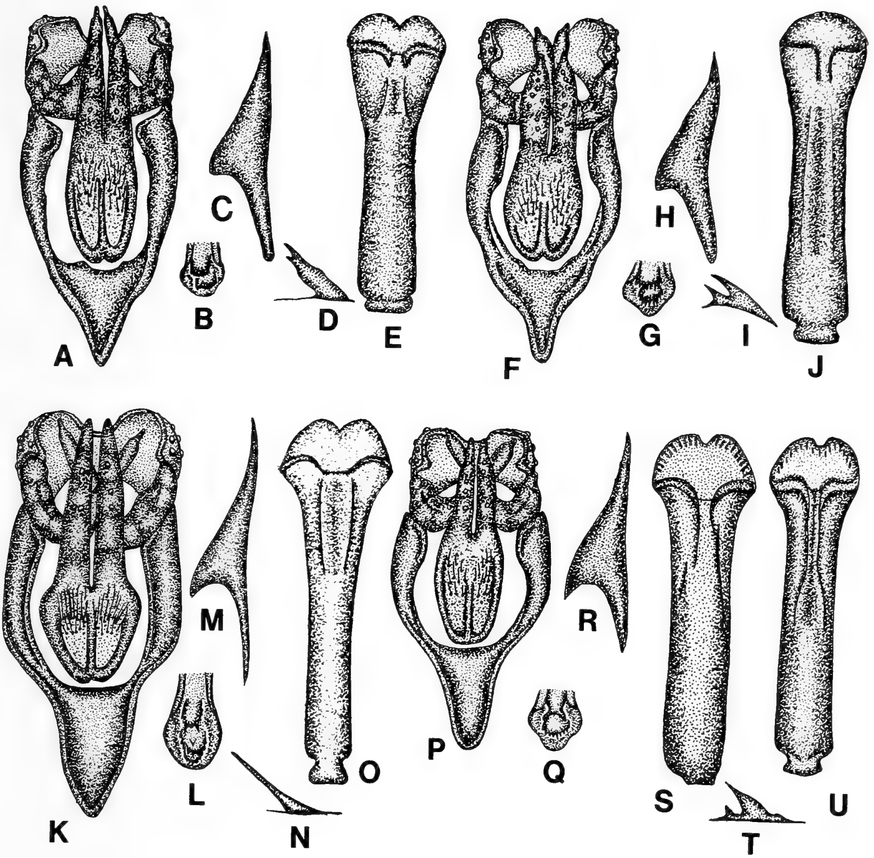

FIG. 1. Male and female genitalia of *Arceuthobium*-feeding *Mitoura* taxa—**A, B, C:** topotypical *M. johnsoni* male, ventral view of genitalia, caudal tip of aedeagus, and lateral view of valvae, respectively; **D, E:** topotypical *M. johnsoni* female, signum and genital plate, respectively. Using same display format—**F, G, H** (male); **I, J** (female): topotypical *M. spinetorum*; **K, L, M** (male): holotype *M. estela*; **N, O** (female): paratype *M. estela*; **P, Q, R** (male): paratype *M. millerorum*. Entry **S** (female): holotype *M. millerorum*; **T, U** (female): *M. millerorum,* Otero County, New Mexico. So as not to obscure other features, the male genitalia are drawn without the long, hairlike spines which protrude from the caudad portion of the valvae and ventrad surface of the uncus.

of the lamellal lips caudad on the ductus bursae, the nature of the sclerotizations surrounding these lips, and the shape of the sculpturing caudo-ventrad on the ductus bursae. Readers familiar with genitalia of Cupressaceae-feeding *Mitoura* will note the overall differences apparent in these as compared to taxa in Fig. 1 (see Johnson, 1976, in press). Johnson (in press) attributes this hiatus to the relatively more primitive (plesiotypic) nature of the characters in genitalia of *Arceuthobium*-feeders. Variation possible in the rather simplified struc-

FIG. 2. Undersurfaces of the wings of (**A, left**) *M. millerorum*, paratype male and (**B, right**) *M. spinetorum* (Fort Wingate, New Mexico, AMNH) chosen for its resemblance to *millerorum*, having nearly all apparent wing characters except the postbasal stripes (see text for discussion).

tural components of these is less than that in more highly specialized genitalic structures characteristic of Cupressaceae-feeders. As a result, relative significance of interspecific differences among taxa in Fig. 1 must be viewed with reference to *Mitoura* taxa as a whole (particularly these seen as a primitive to derived hierarchy) rather than in terms of the few apparent differences within the *Arceuthobium*-feeders alone. With such a view, *M. millerorum* is clearly a sister species of *spinetorum* and not to be viewed as a subspecies.

Only one of the illustrated species, *M. estela* (Clench), is not known to occur in the United States. In Fig. 1, item S illustrates the holotype of *millerorum* while T and U illustrate the Otero County, New Mexico, specimen. It is apparent from these comparisons (see figure explanation for details), along with the distinct wing characters mentioned by Clench and confirmed by my examination, that the latter represents *millerorum*. The specimen has subsequently been located by Dr. John Rawlins at the Carnegie Museum of Natural History and recurated in that collection. Genitalic features of the Bolanos, Mexico, specimen are similar to both of the above mentioned specimens.

Figure 2 illustrates the wing undersurfaces of the paratype male of *millerorum* (left, A; genitalia, Fig. 1 P–R) and a specimen of *spine-*

torum (right, B) selected for its overall resemblance to *millerorum* except for the postbasal stripes. The latter selection is relevant to Clench's apparent reason for associating the Otero County specimen with *spinetorum*. Postbasal stripes in *millerorum* are usually more apparent than indicated by the photo and vary slightly from two distinct slashes, generally in the same plane, to a single, long, straight stripe. The square shape of the distad extensions of the median line near the *Thecla*-spot also seems characteristic of *millerorum* as opposed to the more w-shaped distad extensions of the median line in *spinetorum*. Clench reasoned that the Otero County specimen was more like *spinetorum* in all characters except the postbasal stripes. Undoubtedly this was because the limbal area of the hindwing undersurface on many *spinetorum* was like that on the Otero County specimen: brighter and more flushed with gray-blue and with only small and obsolescent black spots along the submargin. The opposite tendency, however, also occurs as noted in Fig. 2. As a result it is important to summarize that the best overall superficial character for recognizing *millerorum* is its postbasal stripes. Comparatively, *M. johnsoni* is brown on the upper surface of the wings (not steel blue as on the remaining taxa in Fig. 1), while on *estela* the limbal area of the hindwing undersurface is accented by bright orange-red across the entire submargin (making it unmistakable). The association of *M. dospassosi* (Clench) with the above taxa (Clench, loc. cit.) was incorrect. It is clear from the morphology of *dospassosi* that it is most likely a Cupressaceae-feeder (see Johnson, in press). Clench's assessment that the upper surface of *dospassosi* appeared blue (Clench, loc. cit., p. 32: his apparent reason for the clustering) is questionable. Most specimens of *dospassosi* appear black or no more blue-tinted than specimens of *M. sweadneri* Chermock, a taxon with which *dospassosi* shares numerous genitalic characters and which feeds on *Juniperus* (Cupressaceae) (Johnson, 1978, in press).

Clench (loc. cit.) mentioned the possibility that all Mexican specimens listed by Shields (loc. cit.) might represent *millerorum*. He was correct except, perhaps, for the specimen from Baja California Norte. Except for the latter, all of the above specimens have been seen by me and represent *millerorum*. The specimen from Baja California (for which Patterson & Powell, 1959, mention no unusual features) is well within the zoogeographical region characterized by the distribution of *spinetorum* (and the tendency of numerous populations of butterflies in southern California to have associations southward into northern Baja). A larval specimen of *Mitoura*, perhaps referable to *millerorum* and located in the Peabody Museum (Yale University), is of great interest. It is from "6 mi. E. of the Mexico-Michoacan boundary on

Hi. 45, leg. Hawksworth and Wiens" (Shields, loc. cit., and Peabody Museum). No adult was reared from this larva and, therefore, its specific identity as either of the Mexican taxa *millerorum* or *estela* cannot be ascertained with certainty. However, it was collected on *Arceuthobium globosum* Hawksworth and Wiens growing on *Pinus michoacana* Martinez (Pinaceae) and is identifiable as a *Mitoura.* If the specimen represents either of the taxa *millerorum* or *estela,* this apparent unique monophagy would be a character equivalent to that which, among others, distinguishes the specificity of *M. johnsoni* (considered monophagous on *A. douglassi* Engelm., Shields, loc. cit.; Johnson, 1976, and in press).

Conclusions

Four specimens are presently known of *M. millerorum,* three from Mexico and one from the United States. A larval specimen may represent the species and provides possible clues concerning its biology. The species distribution, relative to congeners and other related Eumaeini lycaenids, is characteristic of segregations occurring from montane central Mexico north to the isolated mountain ranges of southern Arizona and New Mexico (Johnson, in press; Rosen, 1975). This, along with its relative ease of identification, makes it a taxon which should be pursued by North American lepidopterists, particularly in regard to elucidation of its biology. As is well known, all of the hitherto mentioned species of *Mitoura* occur in highly local populations of low density (Brown, Eff & Rotger, 1957; Ferris & Brown, 1981). In the case of *millerorum,* however, its occurrence in the southwestern United States demonstrates that one should not assume that *spinetorum* will be the only species collectable by concerted fieldwork.

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TECHNIQUES FOR MAINTAINING A CULTURE OF THE BLACK SWALLOWTAIL BUTTERFLY, *PAPILIO POLYXENES ASTERIUS* STOLL (PAPILIONIDAE)

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ABSTRACT. A culture of the black swallowtail butterfly, *Papilio polyxenes asterius* Stoll (Papilionidae) is initiated from field-collected females. One hundred to two hundred larvae are reared on potted plants in a greenhouse. Adults are housed in an environmental growth chamber with a 16 L/8 D photoperiod, day and night temperatures of 27°C and 15.5°C, respectively, and with a relative humidity at 70 ± 15%. Adults are hand-fed and hand-paired.

Successful rearing techniques are often a prerequisite for experimental success, yet they are seldom discussed in scientific articles. Our study of the behavior of the black swallowtail butterfly (*Papilio polyxenes asterius* Stoll) has required the maintenance of a year-round culture of this butterfly. Here we describe techniques that may be useful to other researchers who would like to rear this or related butterfly species. We do not claim originality for many of these techniques; some are scattered in the literature, while others have been developed by staff and graduate students in our research group or suggested to us by lepidopterists elsewhere.

Initiating a Culture

Collecting. A stock of wild female butterflies is collected locally. In central New York, peak collecting is generally during the second annual brood, from early July to late August (Lederhouse, 1978). Lederhouse (1981) found only 2.3% of field-caught females to be virgins, and we assume that our wild-collected females have already been fertilized. Captured butterflies are placed in 3½″ square, glazed paper envelopes[1] and transported back to the laboratory in a cool, shady place in the vehicle. In the laboratory, they are housed in a walk-in environmental growth chamber[2] under a 16 L/8 D photoperiod, day and night temperatures of 27°C and 15.5°C, respectively, and at a relative humidity of 70 ± 15%.

Feeding. Butterflies are immediately fed a 10% solution of honey in water, poured into the inverted top of a small petri dish, the inverted bottom of which floats on the solution (Fig. 1). Each butterfly is held close to the dish and its proboscis is unrolled with an insect pin; the

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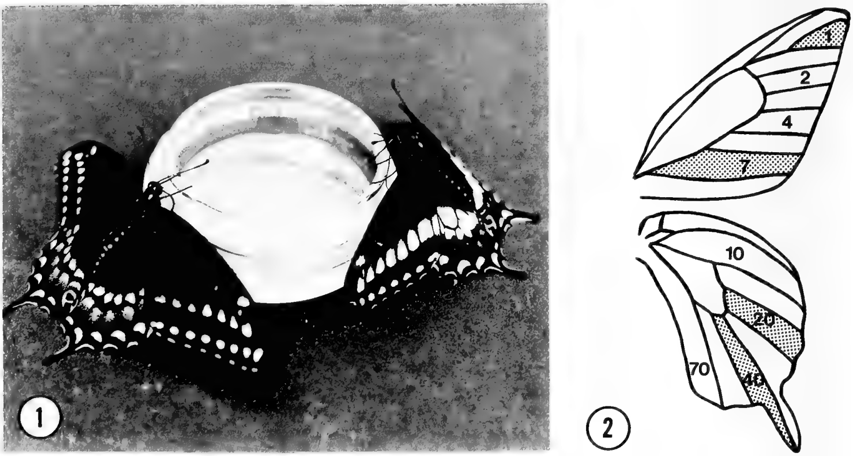
[1] Ward's Natural Science Establishment Inc., P.O. Box 92912, 5100 West Henrietta Road, Rochester, NY 14692-9012.

[2] Environmental Growth Chambers, P.O. Box 407, Chagrin Falls, OH 44022.



FIGS. 1 & 2. **1,** butterflies at honey-water feeding station; **2,** undersides of butterfly wings illustrating markings for number 68.

tip of the proboscis is placed into the honey-water. If feeding occurs, it will continue for 1–5 minutes. This technique allows butterflies to feed with minimal contamination of the legs, abdomens and wings. We have been unable to persuade *P. polyxenes* adults to initiate feeding in the laboratory without assistance.

Numbering. We use a 1-2-4-7 marking system (Ehrlich & Davidson, 1960; Brussard, 1971; Southwood, 1978) as illustrated in Fig. 2. This technique was first used in our black swallowtail culture by Lederhouse (1978). Butterflies can be numbered from 1 to 99; additional numbers are available by changing marker color.

Oviposition. After numbering and feeding, each female butterfly is caged with a potted host plant. Cages are wood-framed, 34 cm × 46 cm, and covered on five sides with organdy mesh or "no-see-um" netting. We do not use wire mesh, because the resistance produced by gripping butterfly tarsi can cause them to break off in handling. Old or worn specimens are placed in plastic shoe boxes[3] lined with paper towels and containing sprigs of host plant fitted with water-filled "Aquapics"®,[4] as shown in Fig. 3. Lids are left ajar or the center is cut out and replaced with wire mesh for ventilation. Because host plant sprigs will desiccate before eggs hatch, the eggs are removed by light nudging with a fingernail and are placed in a plastic petri dish,[5] 15 cm in diameter, lined with moist filter paper.

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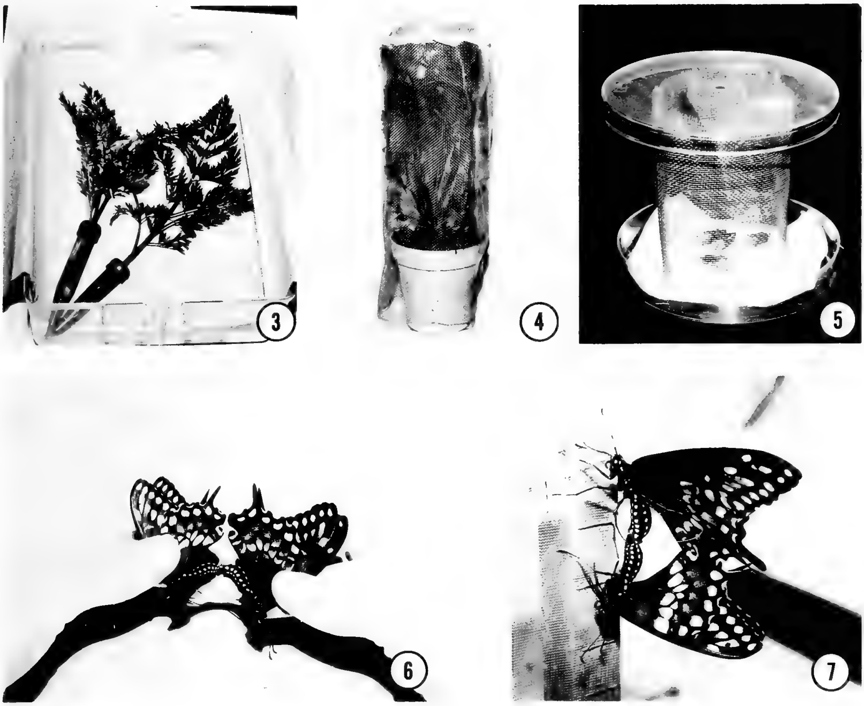
[3] Tri-State Molded Plastics, Inc., P.O. Box 6, Dixon, KY 42409.

[4] Cleveland Plant and Flower Co., Wholesale Florists, 262–272 Clinton Street, Binghamton, NY 13905.

[5] VWR Scientific Inc., P.O. Box 1050, Rochester, NY 14603.



FIGS. 3–7. **3,** plastic shoe box with host plant sprigs in "Aquapics"® for oviposition or larval feeding; **4,** individual larval rearing cage; **5,** butterfly emergence cage; **6,** hand-pairing of butterflies; **7,** butterflies *in copula*.

Rearing Immature Stages

We have relied on two methods of rearing larvae: (1) on potted plants, and (2) on excised leaves in closed containers.

Rearing on potted plants. Egg-laden plants are kept on a cart in the greenhouse, under a 16-hour light cycle provided by 400 and 1000 watt metal halide lamps.[6] Egg-laden plants are watered daily. Depending on temperature, eggs hatch in 3–5 days. In the greenhouse, when larvae are present, temperatures are maintained between 24 and 27°C. Automatic misting systems should not be used for watering plants containing larvae younger than the fourth instar, due to high mortality from drowning.

As larvae grow, fresh pots of food plant are placed around them. The larvae will remain on the plants if an ample supply of food is available. Frass is swept out daily. Because larval feeding is minimal

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[6] General Electric Company, Hendersonville, NC.

during the first three instars, an abundance of larvae can be maintained. At the fourth instar, the number of larvae is decreased to the number of adults needed, plus 15% to allow for accidental deaths and abnormal specimens. Culture larvae are transferred directly to potted food plants on a greenhouse bench, where they range freely until the end of the fifth instar. If unconfined, they will wander extensively to find a pupation site. To prevent such larval wandering, we confine the late fifth instar larvae with their potted food plants under metal-framed wire cages, 71 cm × 71 cm, or under cylinders of wire with organdy tops that fit over a single pot (Fig. 4). After completing their feeding and voiding their guts, larvae pupate on the roof or walls of the cage and can easily be collected for transfer to emergence cages.

When fresh food plants are available in the field, larvae are reared on potted plants in the greenhouse until the fourth instar and then on excised stems placed in water-filled jars or Erlenmeyer flasks. Food plant is changed every second day, but water is changed daily. Wire cages cover these containers.

Rearing in closed containers. Larvae can be reared in different types of closed containers. Eggs are removed from plants and transferred to petri dishes kept in our growth chamber. With a fine camel-hair brush or a broken boiling stick, newly-hatched first-instar larvae are moved to excised sprigs of food plant fitted with "Aquapics"® (Scriber, 1977). The food plant is placed in a plastic shoe box lined with paper towels. Because of heavy condensation, paper towels must be changed daily and boxes wiped out. Individual larvae can also be reared in small glass petri dishes or plastic containers with tight-fitting lids and moist filter-paper bottoms. Cut leaves are placed in these without any reservoir. The idea is to keep the leaves from drying out without drowning the larvae. Small rearing dishes must be wiped out every 1–2 days. This method is used frequently by researchers feeding weighed or treated leaf material. Food plant in closed containers can be consumed for two days, but water reservoirs must be filled and liners misted daily. A small twig added to the container is a preferred pupation site. Containers are sterilized routinely in 5% sodium hypochlorite solution. Rearing a large number of larvae in closed containers is extremely time-consuming.

Pupae. Larvae pupate on plant stems and pots or the frame or wire of cages. Prepupae shed their ultimate larval skin in 24–48 hours. Prepupae and new pupae are easily damaged. They are removed from pupation sites by misting the silk pad with water and pulling gently at the silk. Pupae are moved to emergence cages in the growth chamber, 5–6 per cage. Each emergence cage is a plastic petri dish, with

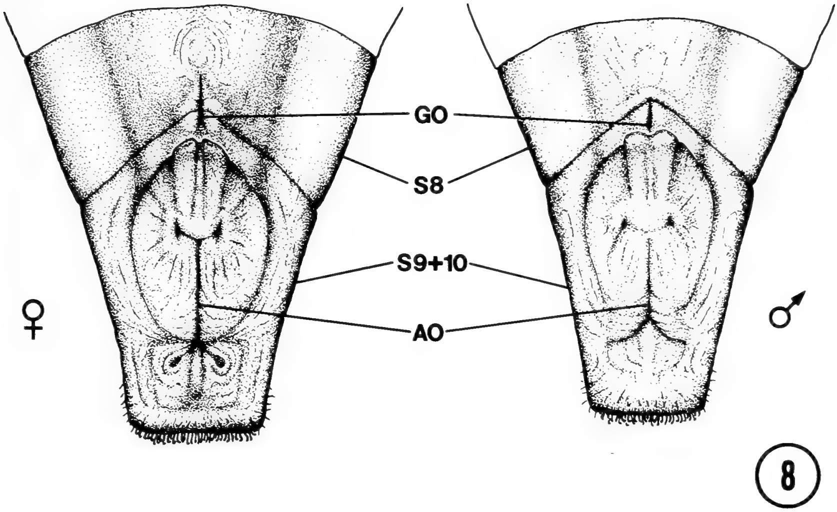

FIG. 8. Abdominal apices of female and male pupae (GO, genital opening; S8, segment 8; S9–10, segments 9 and 10; AO, anal opening).

a "Kimwipe"® liner on the bottom and a 6″ cylinder of wire mesh (Fig. 5).

During June a group of larvae is reared under a short day photoperiod (8 L/16 D) to obtain diapausing pupae. They are stored in a cold environment (0°C) until needed to initiate a new culture, if necessary, during the winter.

Sex of pupae can be accurately determined by close examination of the sutures on the genital plates (Jackson, 1890; Poulton, 1890; Mosher, 1916). The male genital opening is on the mid-ventral surface of segments 9+10 (Fig. 8, GO); while in the female, two genital openings are confluent forming a single slit across the boundaries of segments 8 and 9+10. The genital opening is surrounded by a raised area in both sexes (but more prominently in the female).

Adults

In the laboratory, the adult emergence pattern is protandrous, with eclosion following pupation by 13–20 days (Lederhouse et al., 1982). Eclosing butterflies dry for 24 hours. One day after emergence, each female is marked, fed and bred by the hand-pairing technique developed by Clarke and Sheppard (1956) as illustrated in Fig. 6. Males are fed but not marked. Because Sims (1979) found spermatozoa counts to be low in young males of a closely related species, *Papilio zelicaon* Lucas, males are not mated for 48 hours after eclosing. Each mated pair of butterflies (Fig. 7) is placed on the inside of a tilted cage. They crawl to the top and hang for 51.3 ± 8.6 minutes (Lederhouse, 1981). Male butterflies can be discarded after the initial mating. If not, they can be remated if rested 48 hours, but spermatophore size will probably be decreased (see Sims, 1979) and copulation time will be longer (Lederhouse, 1981). When the majority of eclosing females have mated, new pots of host plants are introduced to collect 300–400 eggs for the next generation of the culture. Additional heat has been provided to increase oviposition activity. Sixty-watt incandescent or infrared reflector lamps are suspended a minimum of 46 cm above the cages for a period of 3–4 hours. Because egg fertility decreases with time from initial mating (Lederhouse, 1981), we discard mated females after 7–10 days.

During periods of absence, pupae and adults can be stored. Pupae are packed in moist paper towels (see Stone & Midwinter, 1975) and placed in a small insulated cooler. The cooler is stored in a cold environment (0°C) which halts adult emergence. They can stay there for up to two weeks. Adults can be safely refrigerated for 2–3 days. They are put into glazed paper envelopes and placed upright in a cooler after feeding. Butterflies emerging that day are allowed to dry until late afternoon before storage. After removal from the cold environment, they need 2–3 hours to warm up before feeding, the first hour in the envelopes.

Unfortunately, larvae cannot go unattended, even for 24 hours. Potted plants with larvae feeding on them must be watered daily.

Providing Food Plant

Greenhouse plants. Prerequisites for maintaining a culture of this butterfly are a large amount of greenhouse space, readily available food plant in the field, or some combination of the two. We need 325 square feet of greenhouse bench space, supplemented by field-collected plants from June through August, to produce two broods of adults (100–200 individuals each) emerging every six-week period.

Our supply of greenhouse plants for each coming year is started from seed in the spring. Seeds are sown 10–20 per 6″ pot, in sterilized soil or artificial mix. We routinely plant seeds of carrot (*Daucus carota* L.) and parsley (*Petroselinum crispum* (Mill.) Mansfeld). Other food plant species can be planted from commercial or field-collected seeds (Tietz, 1972; Rehr, 1973; Tyler, 1975; Berenbaum, 1978; Scriber & Finke, 1978). Seedlings emerge in two weeks and are thinned before plants are ready for use two months later. Because these plant species are cold weather crops, temperatures in the greenhouse (when larvae are not present) are kept at 21°C. Evaporative cooling units keep greenhouse temperatures down in the summer.

Plants are routinely watered and fertilized, depending on soil type and climatic conditions. Fertilizing is especially important to promote new growth after the stress of larval feeding. The metal halide lamps, providing a 16-hour photoperiod for larvae, also enhance plant growth in winter. All plants are treated to combat the usual greenhouse pests. We avoid broad-spectrum insecticides and use only those specific for target pest organisms.

After larval feeding, plant stems are cut short to facilitate new growth and provide optimal coverage for pesticide applications. At any one time, ⅓ of our plants are usable for feeding, ⅓ are waiting out twice the residual time of the last pesticide application and ⅓ are just starting to put out new growth. Destruction of some plants by larvae, pruning and pest attacks necessitate having more than one plant per pot. New plants are potted each year, because plants carried over from one year to the next send out flowering stalks and regenerate little new leaf material.

Field-collected leaves. To support larvae in the summer when new greenhouse plants are still maturing, cuttings are collected from wild plants in the field or from plants cultivated in a garden plot. Cuttings are taken in early morning. Cut stems are placed in a bucket of water that is surrounded by ice in a cooler. By taking these precautions, cuttings need only be changed every other day. Cuttings taken during the heat of the day and not adequately protected from dehydration do not remain turgid. New leaves, flower and seed heads are collected. New growth of biennial species can be found in spring and again in late summer.

Morbidity and Mortality

Disease suppression in insects is dependent upon the maintenance of optimal living and rearing conditions (Steinhaus, 1963). These optimal conditions include freedom from stress such as that induced by crowding, toxic chemicals, adverse conditions of light and radiation, inadequate nutrition or lack of oxygen (Steinhaus, 1958, 1963; Burges, 1973). Our rearing method, using potted plants in the greenhouse, provides maximum radiation, air circulation, humidity and space, and optimal food plant quality. Although growth chambers allow more precise control of temperature, humidity and light cycle fluctuations, the incidence of disease in such environments is higher.

Our culture techniques have eliminated epizootic infections to immature stages. However, some enzootic diseases are encountered, and as Burges (1973) points out most species of leaf-feeding Lepidoptera probably possess a nuclear polyhedrosis virus, a cytoplasmic polyhedrosis virus, a granulosis virus and microsporidians. The small percentage of mortality seen every culture cycle is symptomatic of a fatal bacterial septicemia (Bucher, 1960). Affected larvae discontinue to feed or grow and eventually die; dead larvae hang limp and flaccid, a certain sign of extensive tissue destruction and putrefaction of body contents. The invading bacteria are probably in a class defined by Bucher (1960) as "potential pathogens." These pathogens invade and multiply in the susceptible hemocoele after a variety of stress factors has made the gut more permeable.

No epizootic infections have occurred in the imagos of our culture, although we do see some malformations such as missing or shortened appendages, deformed tarsi, deformed claspers of males, and very small or oversized individuals. One environmental aberration that was once a persistent problem is the condition of a split proboscis. Providing high humidity in the local environment of pupae, either by resting them on a damp substrate (see Stone & Midwinter, 1975) or misting daily (Lederhouse, 1978), can minimize its occurrence. All malformed pupae and adults are eliminated routinely from the culture.

From June to October, prepupae and pupae in the greenhouse must be protected from attack by the hymenopterous parasitoid *Pteromalus puparum* (L.) (Pteromalidae). Cages can be covered with "no-see-um" netting to keep these parasites out.

Maintaining Genetic Variability

Heterozygosity in a domesticated laboratory culture can be lost quickly, especially if the culture is initiated from a few individuals (Benz, 1963). An increase in homozygosity is believed to contribute to a decline in fitness. To maintain genetic variability, we collect many female butterflies from the local wild population to initiate a new culture or add genetic material to an existing one. To avoid inbreeding depression (Mayr, 1970), during the winter months we rear two groups of larvae every six weeks, each with 100–200 individuals. This gives us 50–100 mated females to generate the next cycle.

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THE BUTTERFLIES OF MISSISSIPPI—SUPPLEMENT NO. 3[1]

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ABSTRACT. An annotated list of Mississippi butterflies is presented. This updated version is the fifth such list published. Six names additional to the previous lists have been included.

Of the five published lists of Mississippi butterflies, this is the first to use the names and arrangement of Miller and Brown (1981) as amended by them in Hodges (Editor) (1983). It includes six names not included in the fourth list (Mather & Mather, 1976). The growth rate has dropped to fewer than one per year as indicated in Table 1 below:

TABLE 1. Published lists of Mississippi butterflies, showing rate of increase in the addition of names previously unrecorded from the state.

List	Reference	Names	Time interval	Names added	Names added per year
1	Weed (1894)	53	—	—	—
2	Hutchins (1933)	73	39	20	0.5
3	M. & M. (1958)	122	25	49	1.9
4	M. & M. (1976)	144	18	22	1.2
5	M. & M. (1984)	150	8	6	0.75

In 1958 we expressed the opinion that the list would grow to include about 160 names. We also said, "there may be cases in which the Mississippi representatives of a given species represent more than one population; if so, we do not believe that we as yet have adequate data to support such a conclusion." Now we do. Our reasons for adding the six names are summarized below.

1. *Papilio glaucus australis* Maynard. In 1958, we noted that Professor R. L. Chermock had told us that the south Alabama *glaucus* population was referable to *australis.* We now have sufficient material from south Mississippi to come to the same conclusion about the population there.

2. *Papilio troilus ilioneus* J. E. Smith. In 1958, on the advice of Mr. Cyril F. dos Passos, we referred the Mississippi population to the subspecies. Before 1976, Mr. Harry K. Clench examined a long series and concluded that the correct referral was to the nominate subspecies. We

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therefore used that name in the 1976 list. We are now of the opinion that both subspecies are present. This view tends to be supported by the treatment of *texanus* Ehrmann, type locality Houston, Texas as a synonym of *ilioneus* J. E. Smith, type locality Georgia.

3. *Basilarchia archippus floridensis* (Strecker). In 1958 we assigned the Mississippi population to *B. a. watsoni* (dos Passos) on the advice of Mr. dos Passos. We also noted that a specimen from Harrison Co. in the collection at the University of Missouri at Columbia had been determined as *B. a. floridensis* by Harold I. O'Byrne, while another, from Tishomingo Co., in the Los Angeles County Museum had been determined as *B. a. archippus* by J. A. Comstock. We now believe that both *B. a. watsoni* and *B. a. floridensis* populations are present in Mississippi.

4. *Asterocampa alicia* (W. H. Edwards). In 1958 we assigned the Mississippi population to *A. celtis alicia,* type locality New Orleans, La., on the advice of Mr. dos Passos, in spite of the fact it was recognized by him that the majority of the specimens in the sample he had seen resembled *A. c. celtis,* type locality Georgia. In 1975, Howe elevated *alicia* to species status based on unpublished work by W. J. Reinthal. If *celtis* and *alicia* are not conspecific, then the population in Mississippi nearest to New Orleans must be assigned to *alicia* and the remainder (superficially indistinguishable from *celtis*) assigned to it.

5. *Asterocampa flora* (W. H. Edwards). Although in 1958 our Mississippi sample included material resembling *flora,* type locality Palatka, Florida, we called the population *A. c. clyton,* type locality Georgia, on the advice of Mr. dos Passos, who expressed the view that the name *flora* should be restricted to the Florida population. Howe (1975) also elevated *flora* to species status, based on unpublished work by Reinthal and gave its distribution as "Southern Georgia, Florida, Gulf States, and Texas." We thus assign the material that resembles *flora* (coming from the southern third of Mississippi) to *flora* and that resembling *clyton* (coming from north of there) to *clyton.*

6. *Cercyonis pegala alope* (Fabricius). In 1958, only a few records were known, primarily from the southern part of the state. In 1976, it was clear that this material belonged to the subspecies named *abbotti* by F. M. Brown in 1969. In 1979, David Hess examined all available Mississippi material and determined a series from northern Mississippi (Tippah Co.) as *C. p. alope,* while those from the southern part of the state remained *C. p. abbotti.*

The revised check list, including the six additional names, using the names and sequence as given by Miller and Brown (1981) as amended by them in Hodges et al. (1983) follows:

1. 3870. *Epargyreus clarus clarus* (Cramer)
2. 3886. *Urbanus proteus* (Linnaeus)
3. 3889. *Urbanus dorantes dorantes* (Stoll)
4. 3902. *Autochton cellus* (Boisduval and Leconte)
5. 3904. *Achalarus lyciades* (Geyer)
6. 3909. *Thorybes bathyllus* (J. E. Smith)
7. 3910. *Thorybes pylades* (Scudder)
8. 3913. *Thorybes confusis* Bell
9. 3932. *Staphylus hayhurstii* (W. H. Edwards)
10. 3946. *Erynnis brizo brizo* (Boisduval and Leconte)
11. 3947. *Erynnis juvenalis juvenalis* (Fabricius)
12. 3952. *Erynnis horatius* (Scudder and Burgess)
13. 3954. *Erynnis martialis* (Scudder)
14. 3956. *Erynnis zarucco* (Lucas)
15. 3957. *Erynnis funeralis* (Scudder and Burgess)
16. 3959. *Erynnis baptisiae* (Forbes)
17. 3966. *Pyrgus communis* (Grote)
18. 3968. *Pyrgus oileus* (Linnaeus)
19. 3977. *Pholisora catullus* (Fabricius)
20. 3993. *Nastra lherminier* (Latreille)
21. 3995. *Nastra neamathla* (Skinner and R. C. Williams)
22. 3998. *Lerema accius* (J. E. Smith)
23. 4004. *Ancyloxypha numitor* (Fabricius)
24. 4010. *Copaeodes minimus* (W. H. Edwards)
25. 4013. *Hylephila phyleus* (Drury)
26. 4027a. *Hesperia metea licinus* (W. H. Edwards)
27. 4029. *Hesperia attalus attalus* (W. H. Edwards)
28. 4041. *Polites themistocles* (Latreille)
29. 4042. *Polites origenes origenes* (Fabricius)
30. 4045. *Polites vibex vibex* (Geyer)
31. 4046. *Wallengrenia otho* (J. E. Smith)
32. 4047. *Wallengrenia egeremet* (Scudder)
33. 4048. *Pompeius verna* (W. H. Edwards)
34. 4049a. *Atalopedes campestris huron* (W. H. Edwards)
35. 4050. *Atrytone arogos arogos* (Boisduval and Leconte)
36. 4051. *Atrytone delaware delaware* (W. H. Edwards)
37. 4052. *Problema byssus byssus* (W. H. Edwards)
38. 4059. *Poanes hobomok* (Harris)
39. 4060. *Poanes zabulon* (Boisduval and Leconte)
40. 4063. *Poanes yehl* (Skinner)
41. 4064a. *Poanes viator zizaniae* Shapiro
42. 4070. *Euphyes arpa* (Boisduval and Leconte)
43. 4071. *Euphyes pilatka* (W. H. Edwards)
44. 4073. *Euphyes alabamae* (Lindsey)
45. 4074. *Euphyes dukesi* (Lindsey)
46. 4078a. *Euphyes ruricola metacomet* (Harris)
47. 4080. *Atrytonopsis hianna hianna* (Scudder)
48. 4084. *Atrytonopsis loammi* (Whitney)
49. 4096. *Amblyscirtes hegon* (Scudder)
50. 4099. *Amblyscirtes aesculapius* (Fabricius)
51. 4100. *Amblyscirtes carolina* (Skinner)
52. 4101. *Amblyscirtes reversa* (F. M. Jones)
53. 4105. *Amblyscirtes vialis* (W. H. Edwards)
54. 4107. *Amblyscirtes belli* H. A. Freeman
55. 4108. *Amblyscirtes alternata* (Grote and Robinson)
56. 4111. *Lerodea eufala* (W. H. Edwards)
57. 4114. *Oligoria maculata* (W. H. Edwards)

58. 4115. *Calpodes ethlius* (Stoll)
59. 4116. *Panoquina panoquin* (Scudder)
60. 4119. *Panoquina ocola* (W. H. Edwards)
61. 4145. *Megathymus yuccae yuccae* (Boisduval and Leconte)
62. 4157. *Battus philenor philenor* (Linnaeus)
63. 4159a. *Papilio polyxenes asterius* Stoll
64. 4170. *Papilio cresphontes cresphontes* Cramer
65. 4176. *Papilio glaucus glaucus* Linnaeus
66. 4176b. *Papilio glaucus australis* Maynard
67. 4181. *Papilio troilus troilus* Linnaeus
68. 4181a. *Papilio troilus ilioneus* J. E. Smith
69. 4182. *Papilio palamedes* Drury
70. 4184. *Eurytides marcellus* Cramer
71. 4193. *Pontia protodice* (Boisduval and Leconte)
72. 4197. *Artogeia rapae* (Linnaeus)
73. 4198a. *Ascia monuste phileta* (Fabricius)
74. 4207. *Falcapica midea midea* (Hübner)
75. 4209. *Colias philodice philodice* Godart
76. 4210. *Colias eurytheme* Boisduval
77. 4224. *Zerene cesonia* (Stoll)
78. 4227a. *Anteos maerula lacordairei* (Boisduval)
79. 4228a. *Phoebis sennae eubule* (Linnaeus)
80. 4229. *Phoebis philea* (Johansson)
81. 4237. *Eurema lisa* Boisduval and Leconte
82. 4242. *Eurema nicippe* (Cramer)
83. 4243. *Eurema daira* (Godart)
84. 4246. *Eurema mexicanum* (Boisduval)
85. 4248. *Nathalis iole* Boisduval
86. 4249. *Feniseca tarquinius tarquinius* (Fabricius)
87. 4256. *Hyllolycaena hyllus* (Cramer)
88. 4268a. *Eumaeus atala florida* Röber
89. 4270. *Atlides halesus halesus* (Cramer)
90. 4275a. *Harkenclenus titus mopsus* (Hübner)
91. 4282a. *Satyrium calanus falacer* (Godart)
92. 4284. *Satyrium kingi* (Klots and Clench)
93. 4285a. *Satyrium liparops strigosum* (Harris)
94. 4299. *Calycopis cecrops* (Fabricius)
95. 4300. *Calycopis isobeon* (Butler and Druce)
96. 4318. *Mitoura grynea grynea* (Hübner)
97. 4322b. *Incisalia augustus croesioides* (Scudder)
98. 4326c. *Incisalia henrici turneri* Clench
99. 4328. *Incisalia niphon niphon* (Hübner)
100. 4332. *Eurystrymon ontario ontario* (W. H. Edwards)
101. 4335. *Parrhasius m-album* (Boisduval and Leconte)
102. 4336. *Strymon melinus melinus* Hübner
103. 4354a. *Brephidium isophthalma pseudofea* (Morrison)
104. 4357. *Leptotes marina* (Reakirt)
105. 4359a. *Hemiargus ceraunus antibubastus* Hübner
106. 4360a. *Hemiargus isola alce* (W. H. Edwards)
107. 4361. *Everes comyntas comyntas* (Godart)
108. 4363. *Celastrina ladon ladon* (Cramer)
109. 4386. *Calephelis virginiensis* (Guérin-Méneville)
110. 4410. *Libytheana bachmanii bachmanii* (Kirtland)
111. 4413a. *Agraulis vanillae nigrior* Michener
112. 4418a. *Heliconius charitonius tuckeri* W. P. Comstock and F. M. Brown
113. 4420. *Polygonia interrogationis* (Fabricius)
114. 4421. *Polygonia comma* (Harris)

115. 4432. *Nymphalis antiopa antiopa* (Linnaeus)
116. 4434. *Vanessa virginiensis* (Drury)
117. 4435. *Vanessa cardui* (Linnaeus)
118. 4437a. *Vanessa atalanta rubria* (Fruhstorfer)
119. 4439. *Hypolimnas misippus* (Linnaeus)
120. 4440. *Junonia coenia* (Hübner)
121. 4443a. *Anartia jatrophae guantanamo* Munroe
122. 4447. *Euptoieta claudia* (Cramer)
123. 4449. *Speyeria diana* (Cramer)
124. 4450. *Speyeria cybele cybele* (Fabricius)
125. 4476a. *Anthanassa texana seminole* (Skinner)
126. 4480. *Phyciodes phaon* (W. H. Edwards)
127. 4481. *Phyciodes tharos tharos* (Drury)
128. 4489. *Charidryas gorgone gorgone* (Hübner)
129. 4490. *Charidryas nycteis nycteis* (Doubleday)
130. 4516a. *Euphydryas phaeton ozarkae* Masters
131. 4522b. *Basilarchia arthemis astyanax* (Fabricius)
132. 5423a. *Basilarchia archippus floridensis* (Strecker)
133. 5423b. *Basilarchia archippus watsoni* dos Passos
134. 4554. *Anaea andria* Scudder
135. 4557. *Asterocampa celtis* (Boisduval and Leconte)
136. 4562. *Asterocampa alicia* (W. H. Edwards)
137. 4562.1. *Asterocampa clyton* (Boisduval and Leconte)
138. 4563. *Asterocampa flora* (W. H. Edwards)
139. 4568b. *Enodia portlandia missarkae* J. R. Heitzman and dos Passos
140. 4568.1. *Enodia anthedon anthedon* A. H. Clark
141. 4568.2 *Enodia creola* (Skinner)
142. 4569. *Satyrodes appalachia* (R. Chermock)
143. 4573. *Cyllopsis gemma gemma* (Hübner)
144. 4575. *Hermeuptychia sosybius* (Fabricius)
145. 4576. *Neonympha areolata areolata* (J. E. Smith)
146. 4578. *Megisto cymela cymela* (Cramer)
147. 4587a. *Cercyonis pegala abbotti* F. M. Brown
148. 4587b. *Cercyonis pegala alope* (Fabricius)
149. 4614. *Danaus plexippus* (Linnaeus)
150. 4615a. *Danaus gilippus berenice* (Cramer)

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A NEW SPECIES OF *EXOTELEIA* (GELECHIIDAE) REARED FROM PONDEROSA PINE

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ABSTRACT. *Exoteleia anomala*, new species, is described from New Mexico and Arizona. The larvae are needle miners on ponderosa pine. Problems with recognition of North American species of *Exoteleia* are discussed.

A new species of *Exoteleia* was reared by R. E. Stevens from needles of ponderosa pine, *Pinus ponderosa* Douglas *ex* Lawson, near Silver City, Grant County, New Mexico. Reared adults were sent to me for identification. The moths proved to be an undescribed species that is most closely related to *Exoteleia pinifoliella* (Chambers). *Exoteleia anomala* Hodges is described to permit discussion of it and related species.

Exoteleia anomala, new species

A small dark-brown to black and pale-gray banded moth (Fig. 1). Most scales have shining yellowish reflections depending on angle of light incidence.

Description. Head: haustellum white, several gray-tipped scales basally; labial palpus mainly white, lateral surface of first and second segments with many dark brown-tipped scales, inner surface of second segment with a few dark brown-tipped scales near apex, apex of second segment white, third segment with a partial ring of dark brown-tipped scales at ⅓ length and a well-developed ring of dark brown-tipped scales at ¾ length; antenna, ventral surface mainly gray, scape off white ventrally and on anterior margin, dorsal surface dark brown, individual scales off white basally; shaft dark, alternate scale rows dark brown and gray; sensory cilia of male very short, scarcely visible at base of each segment at 100× magnification; frons, vertex, and occiput white, a narrow band of dark brown-tipped scales on anterior margin of eye, dark gray scales on posterior margin of eye. **Foreleg:** coxa and trochanter mottled pale and medium gray; femur darker gray; tibia dark gray, a few white scales at ⅕ length, ⅗ length, and apex; tarsus dark gray, base and apex of some scales paler; base and apex of 1st tarsomere with white scales, apex of 2nd and 5th tarsomeres with off-white scales. **Midleg:** similar to foreleg, apex of each tarsomere with white scales. **Hindleg:** coxa and trochanter off white; femur mottled pale and dark gray; tibia mottled pale and dark gray, dorsal tuft of long scales off white, outer spurs mainly off white; tarsus mottled off white and dark gray, base and apex of 1st tarsomere and apex of other tarsomeres white. Thorax mottled dark and pale gray-brown, individual scales with pale apexes and pale ridges. **Wings:** upper surface as illustrated; forewing mottled dark gray brown to black and pale gray to white; patches of upturned scales at approximately ⅕, ⅖, and ⅗ length; ventral surface of forewing with linear zone of dark brown scales (male only) that have the scale apexes directed toward the posterior margin, zone extending from before ½ length of wing nearly to posterior margin behind apex. **Wing length:** 4.9 mm (4.0–5.0 mm). **Abdomen:** dorsal and ventral surface of segments dark brown medially, off white laterally and distally. **Male genitalia:** as in Figs. 2 and 4. **Female genitalia:** as in Fig. 3.

Types. Holotype: male, New Mexico, 40 km NE Silver City; *Pinus ponderosa*, vi.1977;

FIG. 1. *Exoteleia anomala,* new species, holotype male.

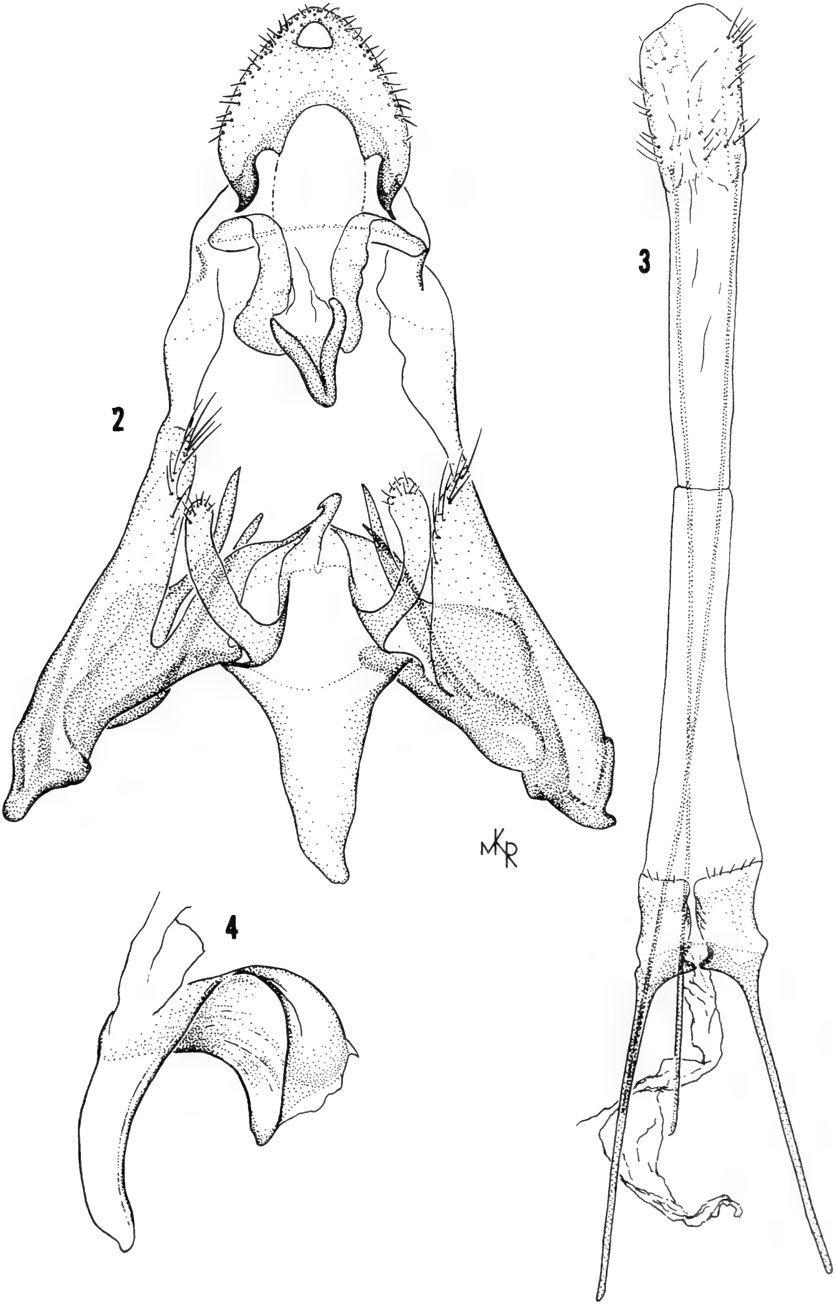
R. Stevens; Hopkins U.S. #36961. **Paratypes:** 11 males, 8 females; same data as for holotype; USNM genitalia slides #10893–10902. 2 males, 4 females; Arizona, 10 km N Fort Apache; *Pinus ponderosa,* J. M. Schmid; Hopkins U.S. #66729, reared 8/82; USNM genitalia slides 11745–11748. In collection U.S. National Museum of Natural History.

Host plant. *Pinus ponderosa* Douglas *ex* Lawson.

Variation. The description is based on the holotype. Major variation occurs in the color of the transverse dark fasciae on the forewing that may be dark gray brown to shining red orange brown. Some specimens have gray-marked scales on the vertex and occiput.

Discussion. Males of *Exoteleia anomala* can be recognized to genus by the series of dark brown raised scales on the under surface of the forewing. These scales are directed somewhat transversely with the long axis of the wing. *Exoteleia anomala* is nearest *pinifoliella* (Chambers) in genital characters; perhaps neither sex can be separated from *pinifoliella* consistently on them; males definitely cannot. The general coloration of the upper surface of the forewings and thorax of *anomala* is gray brown as viewed with the eye as contrasted with the warm red brown or brown of *pinifoliella. Pinifoliella* is known from southern Ontario and the New Jersey Pine Barrens, south along the Appalachian Mountains to Georgia, and from the Boston Mountains in northwestern Arkansas. *Anomala* occurs in New Mexico and Arizona.

When specimens of *anomala* were sent to me for identification, I anticipated writing a key to adults of species of *Exoteleia*; however, I have been utterly frustrated in an attempt to do so. In addition to the introduced *dodecella* (Linnaeus), *pinifoliella, burkei* Keifer, *chillcotti* Freeman, and *nepheos* Freeman occur in North America. *Exoteleia*



FIGS. 2–4. *Exoteleia anomala*, genitalia: **2, 4,** male; **3,** female.

graphicella (Busck) and *californica* (Busck) are not congeneric with *dodecella* and will be transferred at a future date. *Dodecella* is a large species (4.8–5.7 mm wing length) and is distinctly gray. It occurs in southern Ontario, Maine, and New York. Martin (1959) published on its bionomics for southern Ontario.

Study of genitalia of 80 specimens from populations throughout the range of the native species has shown that none of the genital characters cited by previous authors is significant to discriminate among species. In males the margin of the lightly sclerotized part of the uncus, the size and shape of the mediolateral lobes from the saccus, the relative length and shapes of the valvae and lobe from the posterior margin of the saccus all vary independently of other characters. In females the length of the extended external genitalia from the apex of the ovipositor to the anterior apex of the apophyses anteriores relative to the length of the first seven abdominal segments seems to allow for some grouping of entities. The genitalia cluster in groups from ⅔ to nearly equal to the length of the first seven segments of the abdomen. *Pinifoliella* and *anomala* have relatively long female genitalia, with *pinifoliella* having slightly the longer genitalia. Forewing coloration, host plants, and geographic distribution separate *pinifoliella* and *anomala*. What appears to be an undescribed species is small, dark, and has the shortest female genitalia relative to the first seven abdominal segments of the native species. It occurs in eastern North America from Lakehurst, New Jersey and Ithaca, New York, south to McClellanville, South Carolina, the southern Appalachian Mountains, and Hartford, Arkansas. The female genital group that includes *nepheos* has three very different looking moths: 1) the "large" dark brown forewinged, dark gray-brown hindwinged *nepheos*; 2) an undescribed entity from the type series of *pinifoliella* (Ithaca, New York) that has relatively dark brown forewings and medium gray hindwings; and 3) a series of populations from South Carolina, Florida, and Louisiana that has relatively light orange-brown and off-white banded forewings and pale gray-brown hindwings. These populations are unlikely to represent one species. The fifth group includes *burkei* and what probably is *chillcotti* from eastern Texas and Louisiana. The forewings of *burkei* are dark red brown, and the hindwings are dark gray brown; the forewings of the Texas specimens are pale orange brown and off-white banded, and the hindwings are very pale gray.

On the basis of the material that I have studied I can defend and define four species, *anomala*, *pinifoliella*, *dodecella*, and an undescribed species from the eastern United States. I have been unable to define *nepheos*, *burkei*, *chillcotti*, and potentially two other entities on adult characters.

It would appear that pupal characters may be useful to define species; however, because voucher material is not available to support some published observations, I am unable to associate the differences noted in the literature with the moths that I have studied. The type series of *pinifoliella* contains three species: *pinifoliella*; the small, dark species; and one very much like *pinifoliella* but that is associated with *nepheos* by the female genitalia. Bennet (1966) illustrated the pupa of *chillcotti*, showing that it lacks the cutting plate of the pupa of what may be *pinifoliella* (Bennett, 1954). Because any of three very similar species probably occur in the Syracuse, New York area, it is not possible to state with certainty the species that he studied and called *pinifoliella*. This uncertainty points to the need for well-prepared voucher material to be deposited in permanent collections to document publications on life history studies of insects. Subsequent, finer or different, taxonomic conclusions could then be associated with previous literature.

Larval behavior differs among the species. Burdick and Powell (1960) reported *burkei* as feeding on the needles of *Pinus radiata* D. Don. and *P. sabiniana* Dougl. into the fourth larval instar. Subsequently, the larva attacks the male staminate cones and rarely the developing buds. Stevens (1969), reporting on *burkei* (potentially) from Placerville, California, indicated that the species fed on *Pinus attenuata* Lemm. In this infestation the last instar larvae attacked developing shoots and not staminate cones. Also, pupation occurred in the last larval habitat as contrasted with the larva usually leaving the last larval habitat to pupate as reported by Burdick and Powell (1960). Lindquist and Trinnell (1967) found that the last instar larvae of *nepheos* fed on staminate cones and developing buds of *Pinus resinosa* Ait. and *P. sylvestris* L. and that pupation occurred in the last larval site. Freeman (1963) reported that *chillcotti* fed exclusively in needles of *Pinus palustris* Mill. and that pupation occurs there. Finnegan (1965) found the larva of *pinifoliella* feeding in the needles of *Pinus banksiana* Lamb.; and Bennett (1954) recorded *P. rigida* Mill., *P. resinosa* Ait., *P. virginiana* Mill., *P. echinata* Mill., *P. palustris* Mill., and *P. pungens* Lamb. as hosts.

On the basis of available material I have been unable to resolve the question of separation of species in nearctic *Exoteleia*. I strongly urge that anyone who has the opportunity rear and preserve samples of the immature stages and adults of the local species. In New Jersey a light, larger species and a dark, smaller species are present. In the coastal plain of the Southeast two species may be sympatric. In Louisiana and Texas one, two, or three species occur.

A generalized life history for all the species is that the moths appear to be univoltine with adults emerging from late spring to midsummer.

The adult female lays eggs in the entrance of an abandoned mine. Upon hatching, the larvae leave that site and attack other needles. Overwintering is in the larval stage, and the following spring the last instar larva may attack additional needles, staminate cones, or buds, apparently depending upon the species. Pupation usually occurs in the last instar larval feeding site; for *burkei* it may occur there or on or in the ground.

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GENERAL NOTES

A GENERIC REPLACEMENT NAME IN THE NACOPHORINI (GEOMETRIDAE)

One of the twenty new generic names proposed in "A Generic Revision of the New World Nacophorini (Lepidoptera, Geometridae)" (Rindge, 1983, Bull. Amer. Mus. Nat. Hist. 175:147–262) was *Azuayia*. D. S. Fletcher of the British Museum (Natural History) was kind enough to remind me that this name had already been published by Dodge (1967, Pacific Insects 9:681). I hereby propose the replacement name *Postazuayia* for *Azuayia* Rindge, 1983, op. cit., p. 199; the type species remains *Cidariophanes stigmatalis* Dognin, and the gender is feminine.

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THE CORRECT NAME FOR WHAT HAS BEEN CALLED *LYCAEIDES ARGYROGNOMON* IN NORTH AMERICA

I have been asked by the Chairman of the Committee to Review/Update Memoir No. 2 of the Lepidopterists' Society to explain briefly the confusion that has arisen in North America over the name *Lycaeides argyrognomon* as used by various authors. I think the situation is sometimes misunderstood; so I shall review the circumstances in which the name has been used during the last 150 years and of the final identification of Bergsträsser's butterfly, *Lycaeides argyrognomon*. Before doing so I must emphasize, to avoid confusion, the importance of using the correct, valid names for all animals. Rules for the formation and use of names have been the concern of zoologists at least since 1842, with rules and codes of practice usually agreed upon by committees of eminent specialists. The last *International Code of Zoological Nomenclature* was published in 1964 including Rules and Recommendations accepted by all countries. Its most important objectives are to maintain the Law of Priority and the Law of Homonymy.

Turning now to the name *argyrognomon*, this was introduced into general butterfly nomenclature as *Cupido argyrognomon* in 1871 by W. F. Kirby in his *Synonymic Catalogue of Diurnal Lepidoptera*. From that time most European authors applied this name, as used by Kirby, to cover the European species of *Lycaeides*, before, of course, the presence of a second European species was discovered. In the early years of the present century the well-known French entomologist Charles Oberthür became interested in the group. The importance of genitalic structure in butterfly taxonomy was just becoming known, and Oberthür realized the presence in Europe of two species of *Lycaeides*, one of them a local insect, its male genitalia with long falces, which he named in 1910 as *Lycaena argus ligurica*. At the same time he wrote to two well-known specialists, Prof. Courvoisier and Dr. Chapman in England, asking them to investigate "*Lycaena argus* and its forms, Races and Species." Material for this investigation was obtained from many localities in Europe and Asia. The two entomologists selected by Oberthür made independent reports which were included by Oberthür in his private publication in 1917 (Lep. Comp. XIV:2–70), including a note from Dr. Reverdin about the genitalic structure in *Lycaeides* and numerous photographic plates. Both men agreed that two species were present in Europe. Prof. Courvoisier accepted Oberthür's name *ligurica* for the species with long falces so newly identified. Chapman described it as a "New European *Lycaena*" under the name *argus* sp. nov.

As the years passed more names were published, difficulties arose, and the International Commission for Zoological Nomenclature (I.C.Z.N.) was asked to help with the situation reported by Courvoisier and Chapman. They were asked especially to select suitable names for those species recently identified by examination of the genitalia and to select a type species for the genus *Lycaeides*. All of this proved to be extremely difficult. It involved examination of a large number of specimens. In many cases no obvious scientific name existed, and finding one often called for considerable ingenuity; so, not surprisingly, the work took several decades. The first results were promulgated by the Commission in 1945 (Opinion 169) and finally in 1954 (Opinion 269). Among the important decisions was the selection of the Linnean name *idas* 1761 for the commoner species of *Lycaeides*. This was made possible by suppressing the earlier appearance of the name for a species so badly described as to be impossible to interpret. In dealing with the second species, recently identified and with specific characters in the male genitalia, the Commission was fortunate when it was found and announced in Opinion 269 that these characters were actually present in specimens of *Lycaeides* from the Bruchköbler Wald in northern Germany as recorded by Bergsträsser in his original description. *Lycaeides argyrognomon*, therefore, must become the valid specific name for this species, with impressive priority to 1779, taking precedence before all others.

During the long interval after the Commission began its work and the final Opinion in 1954, entomologists naturally continued to use the butterfly names with which they were familiar. It was during these years that V. Nabokov made many contributions, especially concerning the *Lycaeides* distributed in North America.

When discussing what should now be called *L. idas*, he used the name "*argyrognomon*," not invalid for much of that time, but after the announcement of Opinion 269 in 1954 the position changed radically. This name was restricted to a newly identified European butterfly. Applied to any other species (e.g., *L. idas*) would be to create a misidentification, and to use it so must be entirely against the Rules. The correct use of the name *Lycaeides idas* L. proposed by the Commission has been accepted everywhere in Europe and Asia. I cannot understand why it has not been accepted in North America.

Catalogue headings for Europe and America should be as follows:

Lycaeides argyrognomon Bergsträsser 1779 (*Papilio*). Europe.
  syn: *ligurica* Oberthür 1910 (*Lycaena*); syn: *aegus* Chapman 1917 (*Plebejus*).
Lycaeides idas Linnaeus 1761 (*Papilio*). Palaearctic Region & North America.
  syn: *scudderi* W. H. Edwards 1861 (*Lycaena*); syn: *anna* W. H. Edwards 1861 (*Lycaena*); syn: *argyrognomon sensu* Kirby *et Auctorum, nec* Bergsträsser [misidentification].
Lycaeides melissa W. H. Edwards 1875 (*Lycaena*). North America, ?E. Siberia, ?Japan.

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TIGRIDIA ASESTA (LINNAEUS) (NYMPHALIDAE) IS NOT ASSOCIATED WITH *THEOBROMA CACAO* L. (STERCULIACEAE)

The medium-sized (spread wingspan, tip-to-tip, 4.5 cm) orange, brown and white nymphalid butterfly, *Tigridia asesta* (Linnaeus), is broadly distributed in moist-to-wet tropical forests of Central and South America (Seitz, 1904, Macrolepidoptera of the World, Vol. 5: The American Rhopalocera, A. Kernan, Stuttgart). A general description of the larva has been given, and the larval food plant reported to be "cocoa (*Theobroma*)" in the Upper Amazon (Seitz, op. cit.). In this note I report that the larval food plant of this butterfly in eastern Costa Rica is *Pourouma* sp. (Moraceae) and that the larva will also feed successfully on *Cecropia* sp. in the same family. My description of the larval stages also differs from that reported in Seitz (op. cit.). Based upon these preliminary natural history observations in Costa Rica, I conclude tentatively that the larval food plant record in Seitz (op. cit.), the only known food plant record for this species, is erroneous. Based upon the leaf size and shape in moraceous plants, it is easy to understand the mistaken identity of the food plants as being *Theobroma* (Sterculiaceae).

On 29 February 1984 two spinose, nymphalid-like larvae were discovered on a 0.5 m tall moraceous seedling along a weedy roadside at "Finca La Tirimbina," near La Virgen (10°23'N, 84°07'W; 220 m elev.), Heredia Province. The locality is within the "premontane tropical wet forest" zone of the Atlantic watershed and Sarapiqui District. The entire seedling was uprooted and placed in an airtight, clear-plastic bag. In this manner both larvae were reared, one to adulthood. The bottom of the bag was lined with a few layers of soft paper to absorb excess moisture and fecal material, and this paper was removed and replaced every 2–3 days. The larval "culture" was transported from this locality to other points in Costa Rica during the rearing period. The single adult obtained, along with its pupal shell and two larval head capsules, are deposited in the entomological collections of the Milwaukee Public Museum. During the rearing period, the one larva that eventually pupated was transferred from the original food plant to fresh meristems of *Cecropia* sp. (Moraceae) collected near Turrialba, Cartago Province, Costa Rica.

The third, fourth, and fifth larval instars, and the pupa, of *T. asesta* are shown in Fig. 1. Information on earlier life stages was not available. What follows is an overall composite description of larval and pupal stages based upon this material. Chaetotaxy is not given since I am not erecting a key to related species or genera. The larval descriptions are consistent with the format and depth of such information as presented on recent pages of this journal.

Third instar. 10–18 mm long (Fig. 1) with glossy black head capsule. Head capsule with one pair of 4 mm long scoli curved slightly posteriorly. Each head scolus with extensive number of short black spines along entire length. Body coloration generally brownish orange and all segments with black spines. Spine distribution the same as to be described below for the fifth instar. The anterior edge of each trunk segment bears a pair of small white dots dorso-laterally. All feet black.

Fourth instar. Very similar to third instar except body coloration now velvety black (Fig. 1). This instar attains a body length of about 25 mm prior to molting to the fifth (final instar).

Fifth instar. Attains a final length of 40 mm before pupation. Head capsule glossy dark red and notably bilobed vertically into two halves. Each head scolus about 7 mm long, curved slightly posteriorly, and arising from the apex of each head capsule "lobe." Head scolus with white tip and many black spines of varying lengths. Coloration of trunk region now a dull reddish brown, almost a pale maroon hue. Body with many small white spots, each ringed in black, and giving the trunk region a speckled appearance (Fig. 1). Head capsule width now 2.2 mm and entire structure adorned with many small black spines. First thoracic segment with dorsal raised rectangular black "plate" bearing one pair of setae curved anteriorly. Pair of latero-ventrally located white spots ringed in black and with tiny black seta arising near each. Posterior edge of segment with a few small white dots ("flecks"). Second thoracic segment with two pairs (one dorsal and one lateral) of long, branched black spines; each of these spines with four small branches or spinelets. Immediately anterior to the spines one pair of dorsally located white dots ringed in black; posteriorly with dorso-lateral doublet of these spots and with a very small white dot immediately behind each of the dorsal-most members of the two doublets. Additional ringed white spot located latero-ventrally on each side. Third thoracic segment identical to the second. All thoracic spines about 4 mm long and all with the four spinelets about ⅓ the way down from tips.

First abdominal segment bears markings similar to thoracic segments 2 and 3, but now with three pairs of black spines, all the same length. Same arrangement of spines repeated

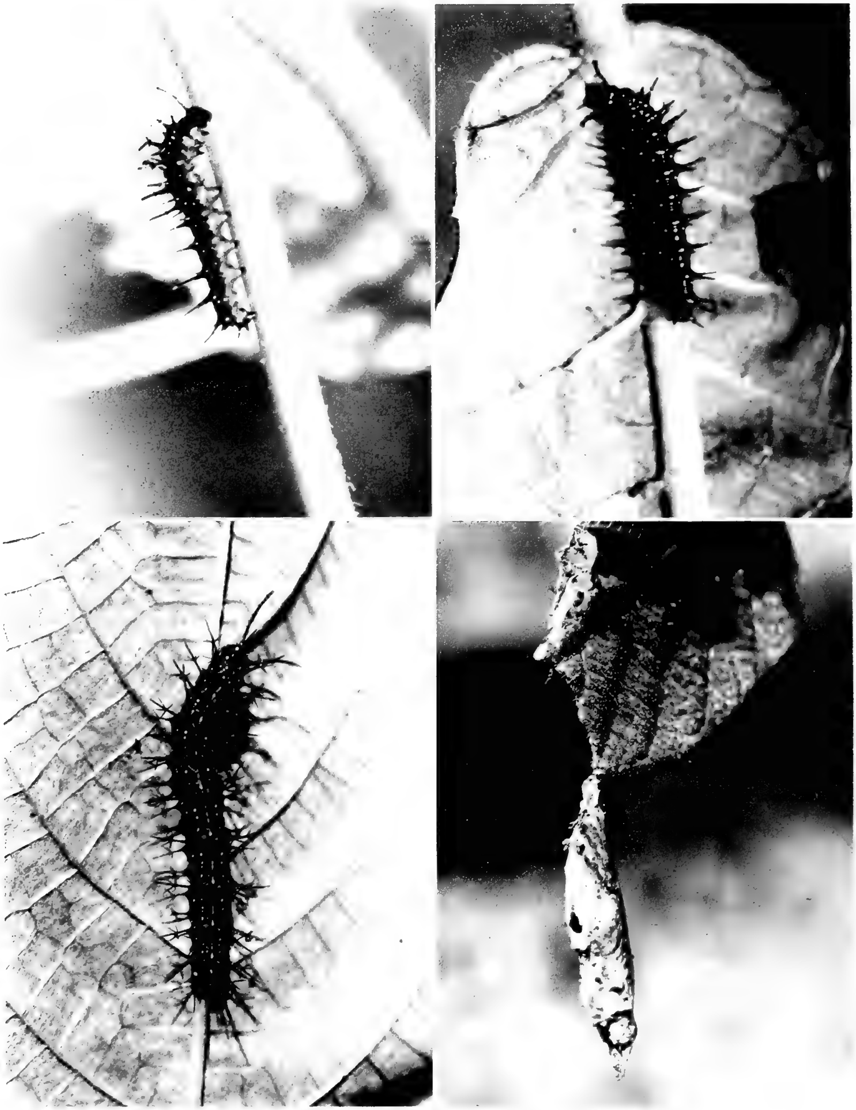

FIG. 1. Clockwise, from upper left photograph: third, fourth, and fifth larval instars, and pupa, all *in situ*, for *Tigridia asesta* (Linnaeus) (Nymphalidae) from the Sarapiqui District of Costa Rica.

on all remaining abdominal segments, except on the ninth in which white spots are absent and only one pair of reduced black spines is present. Anal plate is brownish and clasper black. The most conspicuous difference between the fifth instar and the two earlier instars is the presence of orderly arranged white spots on the trunk segments in the former.

Pupa. The pupa is 27 mm long by 6 mm wide (dorso-ventral axis) by 5 mm thick (laterally) and hangs from the edge of a partly eaten leaf of the food plant (Fig. 1). Overall, the pupa resembles an irregularly shaped wood chip slightly tinged with green meant to mimic moss. The head capsule area is adorned with one pair of 3 mm long "horns," and most of the cuticle surface of the pupa has a rough texture. Head, thorax, and wing pad areas light brown; abdomen ventrally with a moss-like green color and anteriorly with an irregular blotch (somewhat oval in shape) of dark brown. Abdomen ventrally with three pairs of knob-like projections on posterior segments. Approximately half-way along the distal edge of each wing pad a small "flange" of cuticle directed outwards, both together resembling tiny paddles directed downward. Dorsally, thoracic area adorned with a pair of knob-like projections, dark brown in color. Virtually entire length dorsally along anterior–posterior axis shaded with dark brown resembling a thick stripe. Cremaster strongly flattened, concave in ventral perspective and light brown. Pupa readily makes quick, whip-like movements of abdominal area when touched. Eclosion takes place in 10 days under the rearing conditions employed here. In the single instance observed, the butterfly emerged at 1000 h, with wings fully expanded within 15 minutes.

Larval behavior and food plant. The two larvae discovered on the *Pourouma* seedling (one early third instar and one fourth instar) occupied separate leaves. Both larvae rested on the ventral surfaces of leaves. Feeding occurred at the edge of a leaf, the larva remaining concealed from above on the ventral leaf surface. The larva does not construct silken pathways or nests on leaves. All of the six leaves of the food plant seedling appeared to be meristem or very fresh, and the two larvae were initially discovered on the largest leaves (each one about 19.5 × 7.5 cm, the latter for the greatest width). The larvae also readily accepted meristem leaves of *Cecropia*. With the roots kept moist in water-drenched paper towels and moss, the *Pourouma* seedling remained "lush" for almost three weeks in the plastic bag, facilitating the rearing of the larvae.

Seitz (op. cit.) reports the larva (instar not mentioned) as being "light green, often tinged yellowish, with light green lateral stripe, beneath darker coloured, head and spines black; on cocoa (*Theobroma*)." He describes the pupa as being "greenish-yellow, red-toned with branched wing-like continuations on the head; small white points, green spikes and black markings." My observations clearly differ from those of Seitz for *T. asesta* in Costa Rica, including the larval food plant. Meristem leaves of *Pourouma* bear a superficial resemblance to seedling leaves of *Theobroma cacao* L., particularly in terms of the pattern of venation and general oblongate shape of leaves. It is therefore not difficult to understand how the food plant could be misidentified without verification from a botanist knowledgeable about tropical vegetation. The leaves of an adult *Pourouma* tree take on a "stellate" appearance, markedly distinct from seedling leaves. The Seitz description of the larva and pupa presents a greater challenge. Three different alternatives are: (1) the descriptions are based upon newly molted individuals prior to cuticular-hardening; (2) a distinctly different subspecies or local variety of *T. asesta* is involved; and (3) a different species was being described. Based upon my limited data and the very limited amount of published information on *T. asesta* life cycle and natural history to date, it is not possible to determine which of the above alternatives is correct. I do conclude, however, that the Seitz food plant record is incorrect. As an evolutionary unit, the Moraceae are systematically far removed from the Sterculiaceae (e.g., Cronquist, 1981, An Integrated System of Classification of Flowering Plants, Columbia, New York, 1262 pp.). However, systematically unrelated groups of plants may have independently evolved chemical features rendering some members of each group to be acceptable as both oviposition sites and larval food plants for a particular species of butterfly (A. M. Young, unpub. data).

While I did not test for larval feeding on older, mature leaves of the food plant or *Cecropia*, larvae readily accepted meristem or young leaves. However, *Cecropia* saplings in nature have the highest levels of herbivore damage to mature leaves (Coley, 1983, Ecology 64:426–433). *Tigridia asesta* might be a herbivore specialized for feeding on young leaves of Moraceae in tropical forests. Brown and Heineman (1972, Jamaica and Its Butterflies, Classey, London) point out that the accuracy of the systematic position of *Tigridia* (formerly *Callizona*, as in Seitz, op. cit. also) in the tribe Coloburini depends in part upon determination of natural history information, including larval food plant records. Species within this tribe such as *Colobura dirce* Linnaeus exploit moraceous plants such as *Cecropia* as larval food plants (Brown & Heineman, op. cit.). Thus, my record of *T. asesta* on *Pourouma* and its acceptance of *Cecropia* as well point to confirmation of this genus within the Coloburini. A significant departure in the natural history between *Tigridia* and *Colobura,* however, is the clustered oviposition and larval gregariousness in the latter genus (Brown & Heineman, op. cit.) and the solitary early stages in the former as reported for the first time in this note.

Susan Sullivan Borkin and Joan P. Jass discovered the larvae on the food plant, and Luis Poveda assisted with food plant determinations.

ALLEN M. YOUNG, *Invertebrate Zoology Section, Milwaukee Public Museum, Milwaukee, Wisconsin 53233.*

ERRATUM

In my recently published note appearing in this journal (J. Lepid. Soc. 38:237–242), *Papilio birchalli* in the three figure captions should be deleted and replaced with *Papilio victorinus*. During the preparation of revisions of this paper, I forgot to make these changes.

Allen M. Young

Date of Issue (Vol. 39, No. 2): 7 January 1986

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Cover illustration: Micropylar end view (×130) of the egg of *Sericosema* sp. (probably *juturnaria*) (Geometridae). The scanning electronmicrograph was taken by Thomas D. Eichlin, Sacramento, of eggs furnished by Ron Robertson, Santa Rosa, California.

JOURNAL OF
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A NEW SPECIES OF *TILDENIA* FROM ILLINOIS (GELECHIIDAE)

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ABSTRACT. *Tildenia georgei* Hodges, new species, is described from Illinois. The larvae are leaf miners on *Physalis heterophylla* var. *ambigua*. An illustrated identification key to adults of the four nearctic species of *Tildenia* is presented.

A new species of *Tildenia* was discovered in southern Illinois by Paul Gross while he was conducting research on insects associated with *Physalis heterophylla* var. *ambigua* (Gray) Rydberg (Solanaceae). Reared adults were sent to me for identification. The moths proved to be an undescribed species that is closely related to *Tildenia glochinella* (Zeller) and *Tildenia inconspicuella* (Murtfeldt) and indistinguishable from them in maculation and other external features. *Tildenia georgei* Hodges is described to permit discussion of it and related species.

Tildenia georgei, new species

Description. A small, dark, gray-brown moth. Upper surface as in Fig. 1. **Head:** Haustellum with pale yellow scales basally; maxillary palpus pale yellow; labial palpus upturned, extending to vertex, scales of lateral surface dark gray, individual scales terminally margined with very pale gray, mesal surface pale yellowish gray, scales darker on third segment; third segment slightly shorter than second segment, apex acute; frons and vertex pale yellowish gray, scales with yellow and purple reflections, scales anterad of eyes dark gray before pale gray apexes, scales on occiput pale yellowish gray basally and apically, dark gray before apex; antennal shaft with alternate scale rows pale yellow and dark gray, apex pale yellow. **Forewing:** Length, 3.3–4.7 mm; upper surface mottled pale gray, dark gray, pale yellow, and pale yellowish orange, a row of yellowish-orange scales on fold from near base to ⅗ length of fold, fringe shades of gray; undersurface nearly uniformly dark gray on membrane, fringe pale yellowish gray at membrane, mottled gray elsewhere. **Hindwing:** Membrane evenly gray, fringe yellowish gray basally becoming darker beyond base; male without row of long scales from costal margin of dorsal surface. **Foreleg:** Scales on anterolateral surface nearly uniformly dark gray, tipped with very pale gray, apex of each tarsomere mainly pale gray. **Midleg:** Much as for foreleg, coxa paler, yellowish gray. **Hindleg:** Coxa mainly pale yellow with shining

FIG. 1. *Tildenia georgei*, new species, paratype male.

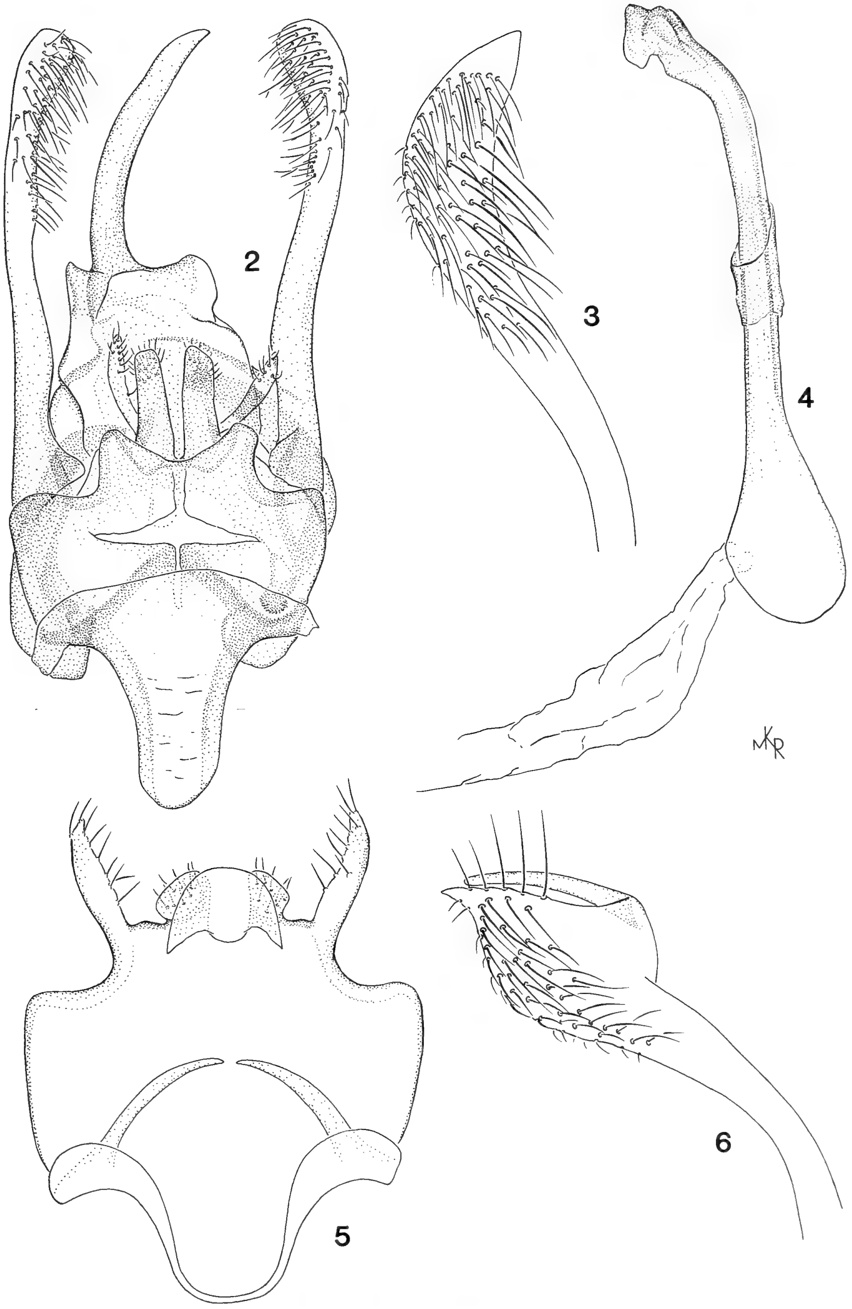
reflections; femur pale yellow dorsally, becoming darker ventrally, all scales tipped with pale gray; tibia pale yellow basally and dorsally, mottled gray and pale yellow elsewhere, lateral spurs dark gray, scales narrowly margined with pale gray; tarsus mainly gray, apex of each tarsomere pale yellowish gray. **Abdomen:** Shining dark gray dorsally, distal row of scales on each segment paler than preceding scales; ventral surface pale yellowish gray medially, some mainly gray scales laterally. **Male genitalia:** As in Figs. 2, 4. **Female genitalia:** As in Fig. 7. **Larva:** Leaf miner on *Physalis heterophylla* var. *ambigua* (Gray) Rydberg.

Types. Holotype: Male. Illinois, Mason County, Sand Ridge State Forest; collected 16 August 1982, emerged 7 September 1982; leg. Paul Gross. **Paratypes:** 6 males, 6 females. Same data as for holotype (1 male, 1 female). Same locality and data as for holotype except collected on 3 September 1979 (5 males, 5 females). All specimens are in the collection of the U.S. National Museum of Natural History.

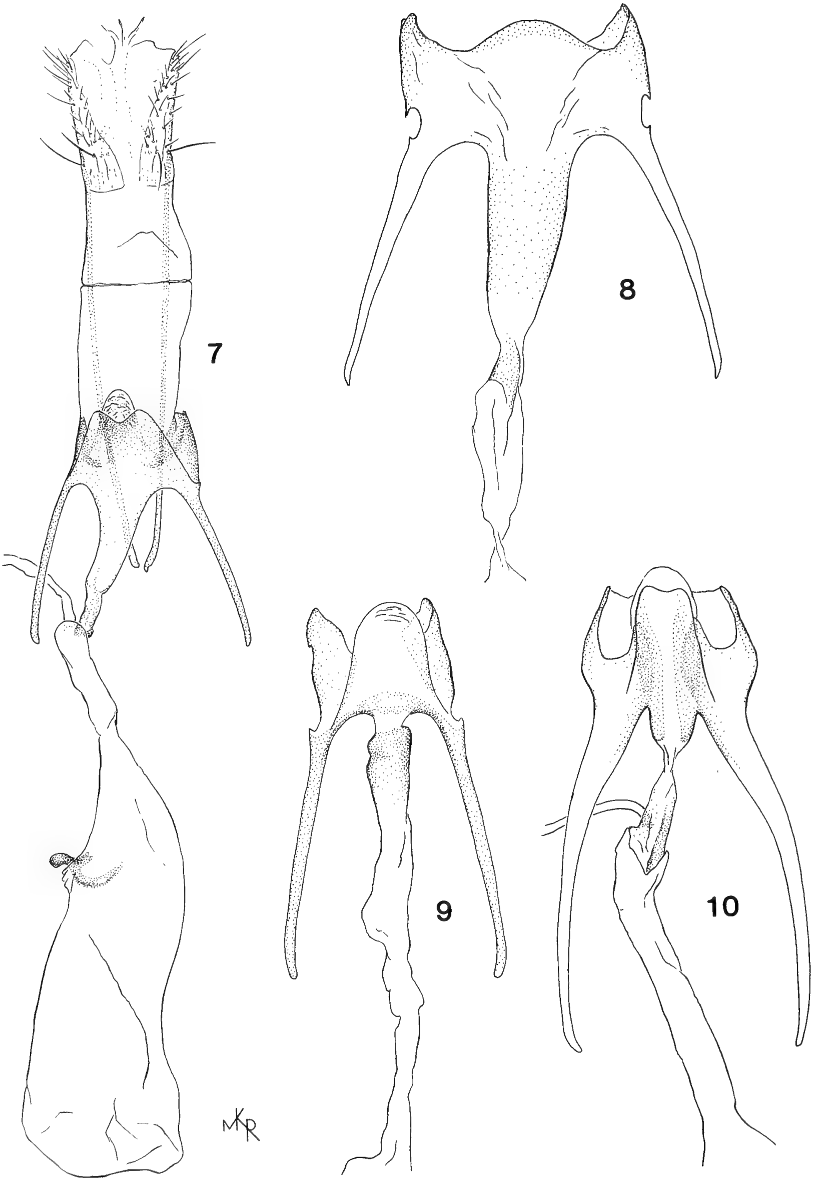
Remarks. *Tildenia georgei* is very similar in appearance to *inconspicuella, glochinella,* and *Keiferia lycopersicella* (Walsingham). Males can be distinguished by their lack of a row of long scales on the costal margin of the dorsal surface of the hindwing. Distinguishing characters are in the genitalia of both sexes and are indicated in the key. The genitalia must be examined for specific and generic determination.

Key to Adults of Nearctic *Tildenia* Species

1. Males **2**
– Females **5**
2. Apex of valva with long, slender, medially directed lobe (Fig. 6) .... *altisolani* (Keifer)
– Apex of valva without such a lobe **3**
3. Saccus shorter than lateral width of vinculum, broadly rounded (Fig. 5) .... *glochinella*
– Saccus longer than lateral width of vinculum, lateral margins nearly parallel before narrowly rounded apex (Fig. 2) **4**
4. Valva with apex slender, extending to narrowly acute tip (Fig. 3); pair of annelar lobes posterolaterad of aedeagus small, lightly sclerotized .... *inconspicuella*
– Valva with apex broadly acute (Fig. 2); pair of annelar lobes posterolaterad of aedeagus well developed, prominent .... *georgei*



FIGS. 2–6. *Tildenia* spp., male genitalia: **2, 4,** *T. georgei*; **3,** *T. inconspicuella*, apex of left valva; **5,** *T. glochinella*, saccus and ventral view of vinculum; **6,** *T. altisolani*, apex of right valva.



FIGS. 7–10. *Tildenia* spp., female genitalia: **7,** *T. georgei*; **8,** *T. inconspicuella,* apophyses anteriores and base of bursa copulatrix; **9,** *T. glochinella,* apophyses anteriores and base of bursa copulatrix; **10,** *T. altisolani,* apophyses anteriores and base of bursa copulatrix.

5. Ductus bursae heavily sclerotized basally, projecting anteriorly as a cone or cylinder beyond the margin of apophyses anteriores (Fig. 8) 6
– Ductus bursae membranous basally (Fig. 9) .... *glochinella*
6. Ductus bursae heavily sclerotized basolaterally, sclerotized part projecting anteriorly less than ⅛ length of apophyses anteriores (Fig. 10) .... *altisolani*
– Ductus bursae heavily sclerotized basally, sclerotized part projecting anteriorly more than ½ length of apophyses anteriores (Fig. 7) 7
7. Heavily sclerotized base of ductus bursae nearly cylindrical (Fig. 8) .... *inconspicuella*
– Heavily sclerotized base of ductus bursae conical, curved to the left anteriorly (Fig. 7) .... *georgei*

Other species of *Tildenia* are known in North America. They too are superficially similar and to date can be distinguished by characters of the male and female genitalia only. Most of them are from Arizona, but this may reflect entomologists' collecting, not the moths' distribution. I anticipate treating them in a subsequent fascicle of *The Moths of America North of Mexico.*

This species is named for George Gross, father of Paul Gross.

ACKNOWLEDGMENTS

I thank Molly K. Ryan for the line drawings that illustrate this paper, Douglas C. Ferguson for the photograph of the adult and review of the manuscript, and J. F. Gates Clarke and W. W. Wirth for review of the manuscript.

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OBSERVATIONS ON THE BIOLOGY OF *PARNASSIUS CLODIUS* (PAPILIONIDAE) IN THE PACIFIC NORTHWEST

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ABSTRACT. This paper examines the biology and life history of *Parnassius clodius* Menetries in the Pacific Northwest. Habitats used by the species include subalpine meadows high in the mountains and lowland rain-forests west of the Cascade Range. The primary larval foodplants belong to the genera *Dicentra* and *Corydalis* of the family Fumariaceae. Larvae in alpine habitats often display a gray-brown camouflage pattern that blends with the rocks of the habitat. However, larvae in lowland rain-forests display a conspicuous black and yellow-spotted pattern that appears to mimic the warning colors of polydesmid millipedes. Larval development in lowland habitats is completed within a single year, and pupation takes place inside a strong, well-formed silken cocoon. Male butterflies display a "rape" type of mating, with no evidence of courtship behavior or sexual pheromones. Tough, tear-resistant wings and a large female sphragis may be related to this sexual behavior.

Parnassius clodius Menetries belongs to a genus that is considered to be relatively primitive within the Papilionidae (Tyler, 1975). These are the only butterflies that have a moth-like pupa enclosed within a silken cocoon. Because of the putatively "primitive" nature of these butterflies, their life history and ecology is of considerable interest. Of the three species of *Parnassius* found in North America, only *P. clodius* is uniquely endemic to this continent and is widely distributed in the western mountains from southern Alaska to central California, western Wyoming, and northern Utah (Ferris, 1976). Some details of the life history and ecology of this species are outlined by Edwards (1885), Tyler (1975), and Dornfeld (1980). During the past twenty years, the present authors have studied various aspects of *P. clodius* biology in Oregon, Washington, and western Wyoming, resulting in much additional information.

Ecology and Life History

In terms of ecology, *P. clodius* occupies two distinctly different types of habitat. One consists of open subalpine meadows and rocky slopes above timberline at high elevations in the mountains. We have observed the species in subalpine meadows throughout western Oregon and Washington, and in Yellowstone National Park of Wyoming. We also observed the species on alpine talus slopes above timberline at Harts Pass, Okanogan County, Washington.

However, the most frequent habitat of *P. clodius* in the Pacific Northwest is the lowland rain-forests extending from the western slope of the Cascade Range west to the Pacific Ocean. Although typically found in moist riparian habitats along forest streams and mountain valleys, the species was formerly found in the Portland and Seattle metropolitan areas and is still quite abundant in the low foothills surrounding the Willamette Valley in Oregon and the Puget Sound trough in Washington. This forest habitat extends from the 4000 ft. (1200 m) elevation down to sea level near the ocean.

The primary larval foodplant in these coastal rain-forests is the wild bleeding heart *Dicentra formosa* Andr., which is very abundant in moist forest habitats along the West Coast. A second probable foodplant is *Corydalis scouleri* Hook., a relatively uncommon species. We have not yet observed *P. clodius* larvae on this plant in the field, but they accept it readily in the laboratory. At high elevations in the alpine habitat and east of the Cascades, *Dicentra uniflora* Kell. is a likely foodplant. This species is a known foodplant of *P. clodius* in northern California (John F. Emmel, pers. comm.). All of these plants belong to the family Fumariaceae, and it is probable that related species such as *Dicentra cucullaria* L. and *Corydalis aurea* Willd. would also provide acceptable foodplants.

The female butterflies oviposit on and near the *Dicentra* plants. However, we have also observed females ovipositing on shrubs up to four feet above the *Dicentra* beds. Evidently a specific chemical emanating from the foodplant is sufficient to induce oviposition anywhere in the general vicinity of the foodplant. The larvae develop within the egg shell but do not emerge from the egg until the following spring. Eggs deposited on shrubs usually reach the *Dicentra* beds when the shrubs drop their leaves in the fall. Foodplant records such as *Viola* and *Rubus* mentioned by Ackery (1975) are almost certainly in error and may be due to this indiscriminate oviposition by the females.

Early instar larvae have small tubercles, but later instars are mostly smooth with fine hairs. The larvae stay hidden in debris at the base of the foodplant most of the time. Feeding takes place very rapidly, so the larvae are exposed from cover only briefly. Nevertheless, *P. clodius* is frequently parasitized by tachinid flies in many localities. Osmeteria are poorly developed in *Parnassius* larvae and are not as important for defense against predators compared to *Papilio* larvae.

Parnassius clodius larvae display two very distinct color morphs. One form is black with a lateral row of bright yellow spots on each side of the body (Fig. 1). The form of these spots is highly variable,

FIGS. 1–3. **Left (1),** larva of *P. clodius,* black form, Benton Co., Ore. **Middle (2),** larva of *P. phoebus,* Yakima Co., Wash. **Right (3),** larva of *P. clodius,* gray-brown form, Castle Lake, Siskiyou Co., Calif.

FIGS. 4–6. **Left (4),** *Harpaphe haydeniana,* Polk Co., Ore. **Middle (5),** open net cocoon and pupa of *P. phoebus* (behind thick *Sedum* stems in lower center). **Right (6),** well-formed cocoon of *P. clodius* cut open to reveal pupa ready to eclose.

ranging from large round spots to long slender bars, or may be divided into several smaller spots. This color pattern is very similar to that of *P. phoebus* Fabr. (Fig. 2) and the Eurasian *P. apollo* L. (illustrated by Stanek, 1969). However, *P. phoebus* differs in having a second, more dorsal row of yellow spots on each side of the body. The second color form in *P. clodius* is gray-brown or pinkish gray with creamy yellow lateral spots and dorsal rows of narrow chevron markings equivalent to the dorsal row of spots seen in *P. phoebus* (Fig. 3). In our experience,

TABLE 1. Sequence of experiment testing the mimicry-model system of *Parnassius clodius* larvae and the millipede *Harpaphe haydeniana* as protection against the grasshopper mouse *Onychomys leucogaster*.

1. *Clodius* larvae given to mouse—larvae eaten.
2. Millipedes given to mouse—millipedes bitten, producing defense odor detectable to observer, mouse then rejected millipedes.
3. Meal worms given to mouse—worms eaten.
4. *Clodius* larvae given to mouse—larvae sniffed and rejected.
5. Adult meal worm beetles given to mouse—beetles eaten.
6. *Clodius* larvae given to mouse—larvae sniffed, handled, finally eaten after long delay.
7. Millipedes given to mouse—millipedes sniffed and rejected.
8. Meal worms given to mouse—worms eaten.

the gray-brown form is dominant in alpine populations of *P. clodius,* for example at Harts Pass in Okanogan County, Washington and at Donner Pass in Nevada County, California. This morph appears to be a camouflage pattern that blends with the rocks in the alpine habitat. By sharp contrast, the black and yellow-spotted form is very conspicuous, is dominant in the lowland rain-forest populations of *P. clodius,* and appears to mimic the warning colors of polydesmid millipedes such as *Harpaphe haydeniana* Wood (Fig. 4). These millipedes are very abundant in the moist, riparian habitats used by *P. clodius* larvae.

Some populations of *P. clodius* are polymorphic for both larval color forms. For example, larvae sent to us by John F. Emmel from Castle Lake in Siskiyou County, California displayed both color forms. Likewise, an adult female butterfly collected at Chinook Pass near Mt. Rainier National Park, Washington produced ten larvae, five of the black form and five of the pinkish gray form. In these, the black larvae retained the narrow yellowish dorsal chevrons of the gray larvae, a trait absent in most lowland black larvae. This ratio between the black and gray forms is suggestive of a simple Mendelian inheritance for these color morphs. However, the chevron markings are apparently controlled by a separate set of gene loci.

In 1973, one of the present authors (McCorkle) conducted an experiment to test the predator protection of the mimicry-model system that apparently exists between lowland *P. clodius* larvae and the millipede *Harpaphe haydeniana*. Grasshopper mice (*Onychomys leucogaster* Max.) from eastern Oregon were used as predators in this experiment, since these insectivorous rodents do not occur within the ranges of the butterfly or millipede and would have no prior experience with these arthropods. The sequence of this experiment is shown in Table 1.

This experiment appears to demonstrate that the mimicry color pattern of lowland *P. clodius* larvae can give them a degree of protection against predators, although predators may with sufficient experience learn to distinguish the larvae from millipedes. In nature, however, the millipedes are commonly exposed in the open, while *P. clodius* larvae are usually hidden and only briefly exposed during feeding. Thus, the mimicry may work quite well in nature, since predators would be expected to have abundant experience with the millipedes and little experience with the larvae.

In lowland populations of *P. clodius,* development is completed in a single year. The larvae emerge from the egg shells during March and start to feed on the young *Dicentra* plants. Full larval development is reached usually by late April or May, followed by pupal development of several weeks, and adult butterfly emergence in June and July depending upon elevation. The pupa is short and rounded, dark brown in color, and quite similar to a saturniid moth pupa. It is enclosed within a strong, well-formed silken cocoon (Fig. 6). By contrast, the cocoon of *P. phoebus* is very loose and poorly formed (Fig. 5). Wilson in Ehrlich and Ehrlich (1961) has suggested that this terrestrial cocoon may be an adaptation to the harsh, alpine climate, rather than a primitive trait. However, the above observations do not support this idea, since the lowland *P. clodius* has the best formed cocoon, and the more alpine *P. phoebus* has a poorly formed cocoon.

Sexual Behavior

The mating system of *P. clodius* adults is quite interesting, since these butterflies display virtually no evidence of courtship behavior. Indeed, the males display a "rape" type of mating in which the males engage the females and copulate by brute force. In dramatic contrast, most higher butterflies display elaborate courtship rituals in mating, often involving specialized sexual pheromones in both the male and female. For example, Brower, Brower and Cranston (1965) have outlined in detail the courtship patterns of *Danaus gilippus* Cramer. Likewise, *Speyeria* butterflies display a very elaborate courtship ritual in which the males flutter around the females, stimulating the females with a sweet, musky smelling pheromone that is easily detected by the human observer. In turn, the females release a second pheromone that stimulates the male to twist his abdomen towards the female for actual copulation. There is evidence that the female pheromone of *Speyeria* is often species specific and frequently serves as a reproductive isolating mechanism that prevents interspecific hybridizations (see Grey, Moeck & Evans, 1963).

However, *P. clodius* males, upon sighting a female, chase rapidly after her and literally attack her from behind. Upon grasping the female in mid-air, the male and female drop abruptly to the ground.

The female then lies limply on the ground, often with wings crumpled in the vegetation, while the male sits on top of her in copulation. *Parnassius* have extremely tough, tear-resistant wings, which may be an adaptation to this rough mating behavior. Otherwise, few females would survive mating with intact wings. Both of the present authors have independently observed this mating behavior in the field on several different occasions. Two additional anecdotal observations of mating behavior may also be mentioned here. On one occasion in the field, McCorkle captured a virgin female in the first swing of the net, followed shortly by capture of a male in a second swing. Before the two butterflies could be removed from the net, they were already in copulation. On a second occasion, a reared male was placed near a virgin female in a laboratory window. Upon seeing the female, the male immediately attacked and engaged her in copulation. We would suggest that the "rape" mating behavior observed in these butterflies may be a primitive trait, compared to the elaborate "courtship" mating behavior observed in most other groups of butterflies.

Moreover, females of many so-called "primitive" butterflies carry an external sphragis or internal genital plug following mating in order to prevent subsequent matings by additional males. Mated females of *P. clodius* carry one of the largest and best developed sphragis structures seen in butterflies. By contrast, the sphragis of *P. phoebus* is much smaller (see illustrations in Tyler, 1975 and Dornfeld, 1980). Presence of a sphragis may be typical of butterflies with a "rape" type of mating behavior, since older, mated females are often resistant or non-responsive to males in species with a "courtship" mating type.

Scott (1973) has made similar observations of the mating behavior in *P. phoebus*. He has suggested that virgin females of *Parnassius* may release a sexual pheromone attractive to the males, and that the females cease to produce this pheromone after mating and attachment of the sphragis. As a consequence, the males do not waste time and energy pursuing mated females. This possible pheromone system may well exist in *P. clodius*, but further studies are presently needed for confirmation. Such a pheromone system could be species specific and serve to prevent interspecific hybridization between *P. clodius* and *P. phoebus* when sympatric. However, females of *P. clodius* also differ from those of *P. phoebus* in having the dorsum of the abdomen completely naked, which may also be important for species recognition during mating.

In terms of relationships, it is quite possible that *P. clodius* represents a relatively generalized, primitive condition within the genus, considering the lowland habitat, well-formed cocoon, and large female sphragis. *Parnassius clodius* is closely related to a group of Eurasian *Coryda-*

lis-Dicentra feeders which include *P. eversmanni* Menetries, *P. mnemosyne* L., *P. stubbendorfii* Menetries, and *P. glacialis* Butler. It is interesting to note that these last two species are also reported to feed upon *Aristolochia* (Ackery, 1975), the same foodplant used by such related genera as *Archon* and *Parnalius* (=*Zerynthia*). In contrast, the *Sedum-Saxifraga* feeders such as *P. phoebus, P. apollo, P. bremeri* Bremer, and *P. nomion* Waldheim appear to be more specialized in habitat, foodplant, cocoon development, and female sphragis.

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THE BIOLOGY AND IMMATURE STAGES OF *AUTOMERIS RANDA* AND *AUTOMERIS IRIS HESSELORUM* (SATURNIIDAE)

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ABSTRACT. The biology and immature stages of *Automeris randa* and *Automeris iris hesselorum* are described for the first time. Mature larvae and adults of both species are illustrated and a key to the *Automeris* larvae of the United States is presented. *Automeris randa* occurs in the Pelincillo Mts. of Arizona and New Mexico. The larval food plants of *A. randa* include *Quercus* and *Celtis*. *Automeris iris hesselorum* has been collected near Pena Blanca Lake, Santa Cruz Co., Arizona. The larval food plants of *A. iris hesselorum* include *Quercus* and *Eysenhardtia polystachya*. Both species are single brooded in Arizona.

Although *Automeris* is a large neotropical genus, few members occur north of Mexico. To date, only six species of *Automeris* are known to occur in the United States and only one species, *Automeris io* (F.) is widely distributed. *Automeris io* occurs from southern Canada to Mexico and inhabits most of the contiguous states with the exception of those in the far west. *Automeris louisiana* Ferguson & Brou and *A. zephyria* Grote are endemic species, while *A. cecrops pamina* (Neumogen), *A. randa* Druce, and *A. iris hesselorum* Ferguson are primarily Mexican species that reach their northern limit of distribution in Arizona or New Mexico. Ferguson (1972) noted that the biology and immature stages of *A. iris hesselorum* were undescribed, and the occurrence of *A. randa* in the United States was not known until 1976, thus, this species was not illustrated or discussed by Ferguson. The purpose of this paper is to describe the biology and immature stages of *A. randa* and *A. iris hesselorum*.

Automeris randa

Automeris randa is widely distributed in Sonora and Chihuahua, Mexico, but in the United States is known only from the area near the Arizona–New Mexico–Mexico border. The first United States record was that of a male captured by Peter Jump in 1976 at Guadalupe Canyon, Cochise Co., in the Peloncillo Mts. of Arizona. Between 1976 and 1981 numerous trips were made to the area, but only a few additional males were captured. But, during this time, *randa* was also collected at Cottonwood Canyon, 1440 to 1600 m, Cochise Co., Arizona and Clanton Draw, 1660 m, Hidalgo Co., New Mexico by Jump. Both of these locations are also in the Peloncillo Mts. Then in 1982 and 1983 both males and females were captured by numerous collectors at Guadalupe Canyon, and a specimen was taken in the same mountain range at Skeleton Canyon.

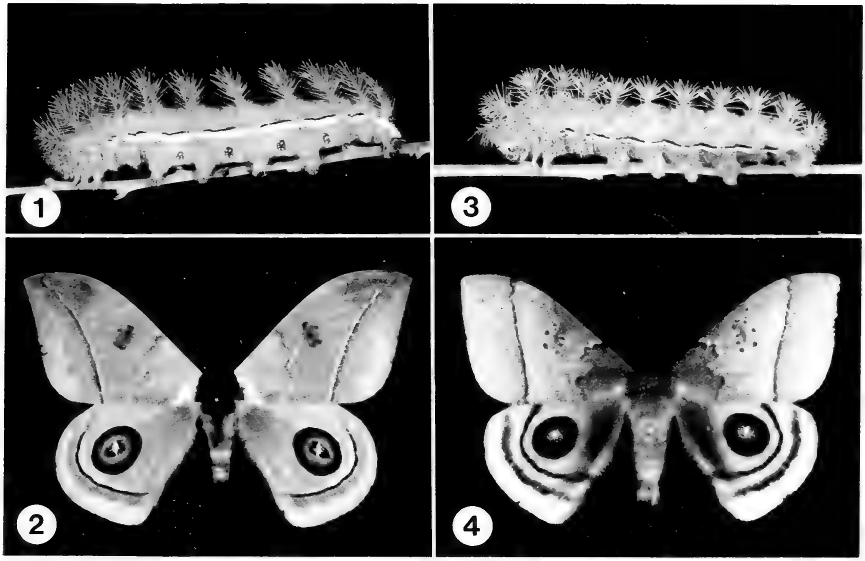
The adults (Fig. 2) have apricot colored forewings, while the marginal area is light brown. Some females have a slight purplish tint on the forewing. Two thin lines, yellow and brown, extend from near the apex of the forewing to the inner margin. The thin antemedial line is yellow and the base of the wing is dusted with white scales. On the hindwing, the margin is light brown and there is a reddish brown to orange submarginal band that is distal to a thin black and thin yellow line. The basal and medial hindwing area is orange, and surrounds a large multi-colored eyespot. The thorax is dark brown, and the abdomen is orange. Forewing length of the males ranges from 42 to 48 mm; females from 44 to 55 mm. According to LeMaire (pers. comm.), *randa* may represent a subspecies of *A. rubescens* Walker, but a change is not contemplated unless additional work is done on this complex.

Capture records from Arizona and New Mexico indicate that adults have been taken at lights between 30 June and 7 August. Based on these records, the peak flight appears to be from late July through early August. In captivity, adults emerged between 0900 and 1500 h. After wing expansion they remain quiescent throughout the day. Mating generally occurs after 2200 h and the pair remain together for about 45 min. The female begins the ovipositional flight the next night. The white eggs are deposited in clusters of 20 to 45 on the underside of the leaf.

The larvae feed gregariously until the 4th or 5th instar and then singly or occasionally in pairs. Early instar larvae are yellow but become green or blue-green at the onset of the 4th or 5th instar and develop a prominent yellow subspiracular line that is usually bordered on either side by a thin black and red line. The dorsal and dorsolateral scoli are relatively long and slant forward during the 5th–7th instars, giving the larva a distinct appearance (Fig. 1). Although little phenotypic variation was observed, it was found that the number of larval instars varied from 6 to 7. The larvae having the additional instar had larger head capsules and greater overall size and, thus, may have been females. First through last instar larvae collected in Guadalupe Canyon have been found on various oaks and hackberry, *Celtis pallida* Torr.

Prior to pupation, larval coloration may change from green to yellow or yellowish brown. In captivity all larvae pupated on the host plant by attaching leaves together and spinning a thin but tightly woven cocoon. Neither the cocoon nor the leaves are attached to the branch with silk and would have fallen into the leaf litter when the tree shed its leaves.

In addition to *A. randa*, other species of saturniids collected during



FIGS. 1–4. **1,** mature larva of *A. randa* (0.65×); **2,** male *A. randa* (0.65×); **3,** mature larva of *A. iris hesselorum* (0.85×); **4,** male *A. hesselorum* (1.0×).

late July at Guadalupe Canyon included: *Hyalophora gloveri, Eupackardi calleta, Antheraea polyphemus oculea, Agapema galbina anona, Citheronia splendens, Anisota oslari, Sphingicampa hubbardi,* and *Automeris cecrops pamina.*

The larval description is based on 26 larvae reared from ova deposited by a female collected at Guadalupe in 1983 and on four second instar field collected larvae provided by Steve McElfresh in 1982 and reared to maturity by the author. Length and width measurements give the size range of larvae at the end of each instar.

Larval Description

First instar. Head: Diameter 1.0 mm. Color yellow. **Body:** Ground color yellow. Length 5.6 mm, width 1.0 mm. Dorsal scoli branched, shaft and spines yellow with black tips. Dorsolateral, lateral and sublateral scoli yellow. Dorsal, lateral and ventral surfaces yellow. Thin mid-dorsal brown line extends from mesothorax to caudal segment. True legs and prolegs yellow.

Second instar. Head: Diameter 1.7 mm. Color yellow. **Body:** Ground color yellow. Length 10 mm, width 1.6 mm. Dorsal scoli yellow, spines with black tips. Dorsolateral, lateral and sublateral scoli yellow. Two thin black lines extend length of larva. Mid-dorsal line extends from metathoracic segment (T3) to last abdominal segment (A9). Lateral line mid-way between dorsolateral and lateral scoli extending from T3 to A9; interrupted by yellowish brown intersegmental area. Dorsal, lateral and ventral surfaces yellow. True legs and prolegs yellow.

Third instar. Head: Diameter 2.4 mm. Color yellow. **Body:** Ground color yellow. Length 13–15 mm, width 2.1 mm. Dorsal and dorsolateral scoli branched, shaft and spines yellow, some with black tips. Lateral and sublateral scoli branched and yellow. Three thin black lines extend length of larva. Mid-dorsal and dorsolateral lines as in second instar. Black spiracular line extends from T1 to A9. Dorsal, lateral and ventral surfaces yellow. Spiracles black. True legs and prolegs yellow.

Fourth instar. Head: Diameter 3.0 mm. Color yellowish green. Clypeus light brown. **Body:** Ground color yellowish green. Length 19–21 mm, width 4.5 mm. Dorsal and dorsolateral scoli yellow, tip of shaft and spines black. Lateral and sublateral scoli branched, shafts and spines yellowish green. Dorsal and lateral surfaces with numerous thin lines extending length of larva. Line I, mid-dorsal black line bordered on either side by thin yellow line. Line II, greenish gray line passes just below base of each dorsolateral scoli. Line III–IV, two lines, yellow above black, pass between dorsolateral and lateral scoli. Dorsal projection from black line disrupts yellow line as it pass each scoli. Line V, gray-green line connects base of each lateral scoli. Line VI, yellow line passes just ventral to line V and lateral scoli. Ventral surface gray-green. Spiracles black. Prolegs light yellow with light brown shields. True legs gray-green.

Fifth instar. Head: Diameter 4.1–4.7 mm. Color green to blue-green with short white setae. Clypeus cream. **Body:** Ground color green to blue-green. Length 27–34 mm, width 8–9 mm. All scoli shafts and spines match ground color. Dorsal and dorsolateral thoracic scoli shafts with upper ¼ black. Dorsal abdominal scoli with black tips on some spines. Lateral and sublateral scoli reduced in size. Lighth bluish gray mid-dorsal line extending length of larva and edged by thin light yellow on either side. Thin short black line extends from base of dorsolateral scoli to dorsal scoli and then between dorsal scoli. Black spiracular line thin and disrupted by base of spiracle, subspiracular yellow and black spiracular lines extend from T3 to A9. Small red patch with short white setae extending from cream colored pinaculum in intersegmental area of sublateral surface just anterior of each proleg and on A7. Anal and proleg shields light brown to light orange with numerous short white setae extending from cream colored pinaculum. Prolegs and ventral surface green. Spiracles light brown. True legs light orange.

Sixth instar (Fig. 1). **Head:** Diameter 5.5–5.9 mm. Color green to blue-green with short white setae. Clypeus cream. **Body:** Ground color green or blue-gray. Length 52–56 mm, width 12 mm. Dorsal and dorsolateral scoli enlarged (7 mm) with thin shafts and numerous long thin spines (4 mm). Lateral and sublateral scoli reduced (2–2.5 mm) in size. All scoli match ground color; no black tipped spines present as in previous instar. Short black vertical bar occurs between the dorsal and dorsolateral scoli. Broad yellow subspiracular line below thin black spiracular line which is disrupted by lower edge of spiracle. Ventral edge of subspiracular line often thinly edged with black and red. Both lines extend from anterior edge of T3 to A9. Red patch with short white setae extending from cream colored pinaculum in intersegmental area of sublateral surface just anterior to each proleg and A7. Anal and proleg shields reddish brown with white setae extending from cream colored pinaculum. Spiracles light orange. True legs brownish orange.

Seventh instar. Head: 7.9–8.1 mm. Color and comments same as previous instar. **Body:** Length 72–78 mm, width 17–19 mm. Ground color green or blue-gray. Dorsal and dorsolateral scoli; shafts 9–11 mm, spines to 6 mm. There is no noticeable difference between sixth and seventh instar larvae, other than overall size.

Automeris iris hesselorum

Like the previous species, *Automeris iris hesselorum* has an extremely limited distribution in the United States. Ferguson (1972) illustrated the adults in color and indicated that all of the Arizona records were from Pena Blanca Lake, Santa Cruz Co. This species was taken with some frequency until 1969, but available records suggest that none have been captured at Pena Blanca Lake since 1972. In addition to Pena Blanca Lake, a single specimen has been taken at San Rafael Valley, Cochise Co., Arizona. The dates of capture range from mid July to early August. Similarly, a large series taken in Temoris, Sonora, Mexico were collected between 19 July and 8 August. The flight period probably extends for a week or two on either end of the known season.

The adults are easy to separate from the other two species of *Automeris* occurring in Arizona. *Automeris iris hesselorum* has a wing shape similar to that of *Automeris io*. The forewings are brownish pink, and the dark brown postmedial line extends from the costa to the inner margin in a straight line and remains the same distance from the wing margin (Fig. 4). The wing span of the male varies from 57 to 65 mm; female from 68 to 74 mm. The forewings of *A. randa* and *pamina* are falcate or pointed and the yellowish medial line extends diagonally from near the apex to about midpoint on the inner margin of the wing.

It would appear that the larvae of *hesselorum* utilize a wide variety of food plants. Ron Wielgus (pers. comm.) collected a late instar *hesselorum* larvae on an unidentified species of oak at Pena Blance Lake in 1968. During this same period, larvae were reared in captivity on various *Quercus* species, and desert willow, *Chilopsis linearis* (Cav.) which is in the family Bignoniaceae and not related to willow as the common name suggests. Larvae of *hesselorum* were collected in Mexico on Kidneywood, *Eysenhardtia polystachya* (Ort.) but when transferred to oak failed to survive (Steve Prchal, pers. comm.).

First through 4th instar larvae are a uniform golden yellow and their bodies are slightly tapered at each end. Early instar larvae feed gregariously on the underside of the leaves. Fifth and 6th instar larvae are green and appear somewhat similar to larvae of *Automeris io*. Mature larvae have a prominent white subspiracular line below thin black and red lines that extend from the first abdominal segment to the caudal segment (Fig. 3). The larval description is based on three larvae reared to maturity by the author on oak. The three fertile ova were received from Steve Prchal, who had collected a female *iris hesselorum* in Sonora, Mexico.

Larval Description

First instar. Head: Diameter 0.9 mm. Color golden yellow. **Body:** Ground color golden yellow. Length 4.9 mm, width 1.2 mm. Scoli coloration matches ground color.

Second instar. Head: Diameter 1.7 mm. Color golden yellow. **Body:** Ground color golden yellow. Length 11 mm, width 2.1 mm. Scoli coloration matches ground color.

Third instar. Head: Diameter 2.5 mm, color golden yellow. **Body:** Ground color golden yellow. Length 21–24 mm, width 4.5 mm. All scoli with golden yellow spines and shafts. Dorsal and dorsolateral scoli with some spines tipped with black. Light blue-gray mid-dorsal line extends from metathorax (T3) to caudal abdominal segment (A9). True legs, prolegs and spiracles golden yellow.

Fourth instar. Head: Diameter 3.8–4.0 mm. Color golden yellow. **Body:** Ground color yellowish green. Length 26–29 mm, width 6 mm. All scoli golden yellow, dorsal and dorsolateral scoli with black tips on some spines. Light bluish gray mid-dorsal line extends from T3 to A8. Yellow subspiracular undulating fold extends from A1 to A8. Small red patch with golden pinaculum in intersegmental area of sublateral surface just anterior of each proleg. Spiracles gold. True and prolegs yellowish green.

Fifth instar. Head: Diameter 4.9 to 5.2 mm. Color green, adfrontal suture traced in brown. **Body:** Ground color green. Length 34 mm, width 9 mm. All scoli green, ⅓ or fewer of spines tipped with black. Thin red and black partially broken subspiracular line dorsal to broad white lateral line which may be edged in red on lower edge. Broad white and thin red lateral lines interrupted by lateral scoli. All three lateral lines (black, white and red) extend from posterior edge of T3 to A8. Small red patch with green pinaculum occur in intersegmental area of sublateral surface just anterior to each proleg and on A7. Dorsal surface green to bluish green, lateral and ventral surfaces green. Proleg shields reddish. Spiracles light brown. True legs green.

Sixth instar. Head: Diameter 6.4–6.8 mm. Color and comments same as in previous instar. Body: Length 61 mm, width 12 mm. Ground color green. There is no noticeable difference between the fifth and sixth instar larvae other than overall size and a slight difference in the lateral lines. The black subspiracular line of the previous instar becomes red in the intersegmental areas and black only on the segment. A thin red line borders the ventral edge of the yellow lateral line.

Key to the Last Instar *Automeris* Larvae of the United States

1\. Prolegs green; shields red or green. Prominent, continuous straight lateral yellow, white or red spiracular or subspiracular line extends from metathorax or abdominal segment 1 (A1) to A8 or beyond. Ventral surface primarily green **2**

– Prolegs black, shields red or brown. White spiracular or subspiracular line broken or absent. Ventral surface black or red **5**

2\. Spiracular or subspiracular lines white and red. Dorsal and dorsolateral abdominal scoli rosette type, shaft less than 5 mm long **3**

– Subspiracular line yellow, bordered dorsally by thin black line. Spiracular line absent. Dorsal and dorsolateral abdominal scoli shafts slant anteriorly, shaft length 9–11 mm. (Arizona & New Mexico) .... *A. randa* Druce

3\. True legs pink or red. Prolegs green; shields pink or red. Spiracular line red **4**

– True legs green. Prolegs and shields green. Spiracular line absent. Subspiracular line white, bordered by thin red or red and black line. (Arizona) .... *A. iris hesselorum* Ferguson

4\. Abdominal spiracles contained within red spiracular line. (Louisiana & Mississippi) .... *A. louisiana* Ferguson & Brou

– Abdominal spiracles protrude from upper edge of red spiracular line. (various subspecies, widespread) .... *A. io* (F.)

5\. Dorsal abdominal area yellow with numerous black and light yellow lines extending length of larva. Two lateral white lines are interrupted by vertical yellow lines connecting lateral and dorsolateral scoli. Scoli yellow and black. (New Mexico & western Texas) .... *A. zephyria* Grote

– Dorsal abdominal area with numerous black, blue-gray or white lines extending length of larva. Diagonal white lines on lateral surface extend from base of dorsolateral scoli to lateral scoli on succeeding segment. Scoli blue-gray and black. (Arizona & New Mexico) .... *A. cecrops pamina* (Neumogen)

Discussion

To a greater extent than in any other state, the saturniid fauna of Arizona is significantly influenced by that of Mexico. Southern Arizona represents the most northern range of many Mexican plants, reptiles, birds, and insects (Lowe, 1964). The typically Mexican saturniid species such as *Citheronia splendens sinaloensis* Hoffmann, *Eacles oslari* Rothschild, *Sphingicampa montana* (Packard), *Sphingicampa albolineata* (Grote & Robinson), *Adeloneivaia isara, Rothschildia cinctus* Tepper, *Automeris randa,* and *Automeris iris hesselorum* usually occur from 20 to no further than 80 km north of Sonora, Mexico. Other quasi-Mexican species [*Anisota oslari* Rothschild, *Sphingicampa hubbardi* (Dyar), *Hemileuca tricolor* (Packard), *Automeris cecrops pamina* (Neumoegen), *Eupackardi calleta* (Westwood), and *Agapema galbina anona* (Ottolengui)] tend to be relatively abundant and with the exception of *H. tricolor,* occur from Arizona to Texas.

The Mexican species that occur in Arizona can be placed into three categories: dependable resident, undependable resident, and temporary resident. *Citheronia splendens* and *Eacles oslari* are examples of dependable residents. They are not necessarily common but represent species that are found each year. Undependable residents include *Rothschildia cinctus, Sphingicampa albolineata,* and *Sphingicampa montana.* These are permanent residents which are infrequently captured, because they occur in isolated areas, generally have low population levels, and lack biological and habitat data. For example, seven blacklight stations were set up in the southern branch of Pena Blanca Canyon and operated for two consecutive nights. Each station had two to three 15 watt blacklights and was separated from the next station by 75 to 100 m. One *R. cinctus* and two *S. montana* were captured; both *montana* were taken at the same light. On the third and fourth nights a mercury vapor light was operated, and nearly a dozen *montana* were captured. If each station had been operated by a different collector, most might have been assumed that neither *S. montana* nor *R. cinctus* were present. Collecting techniques, location, experience, persistence, and chance interact to influence the collector's perception of species abundance and distribution.

Automeris randa is probably best described as an unpredictable resident. The fact that *randa* occurs over a wide area within the Peloncillo Mountains of Arizona and New Mexico suggests it is well established. This species probably remained uncollected due to the isolation and inaccessibility of its habitat. During a trip to Guadalupe Canyon we traveled for over 20 miles on unmarked dirt roads and after arriving, found that only vehicles with high road clearance could actually enter the canyon.

Automeris iris hesselorum and *Adeloneivaia isara* are the most recent, but perhaps not the only, examples of temporary Arizona residents. Specimens of *Citherona mexicana* (Grote & Robinson) and *Sphingicampa albolineata* were labeled "Cochise Co., Arizona" and *Hylesia coinopus* Dyar as "So. Arizona/Poling" and are treated as mislabeled or with suspicion. The ephemeral nature of these species may be influenced by seasonal variation in the weather of northern Sonora and southern Arizona. Perhaps a succession of favorable winters and summers allows the temporary/ephemeral species to become established in Arizona, but periodically, climatic conditions exceed their tolerances, causing local extinction. Based on the observation that *S. albolineata* is now known to be a resident species in Cochise Co., the ephemeral nature of *A. iris hesselorum* and *A. isara*, and the recent discovery of *A. randa*, the past occurrence of *Citheronia mexicana* and *Hylesia* seem more likely.

ACKNOWLEDGMENTS

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COURTSHIP AND OVIPOSITION PATTERNS OF TWO *AGATHYMUS* (MEGATHYMIDAE)

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ABSTRACT. Males of *Agathymus estelleae* take courtship sentry positions near teneral virgin females long before the females are ready to mate. Males of *Agathymus mariae* are territorial and pursue virgin females that approach their territories. Oviposition patterns of the two species are very similar. Females alight on or near the plants to oviposit and do not drop ova in flight.

Few detailed observations of the courtship and oviposition of the skipper butterflies in natural environments have been published. For the family Megathymidae Freeman (1951), Roever (1965) (and see Toliver, 1968) described mating and oviposition of some Southwestern U.S. *Agathymus,* and over a hundred years ago (1876) Riley published an excellent paper on the life history of *Megathymus yuccae* (Boisduval & LeConte) which included data on oviposition of the female; otherwise, only the scantiest comments have been made. C. L. Remington (pers. comm.) and others tell us that there is a significant possibility that the Hesperioidea are less closely related to the true butterflies (Papilionoidea) than to certain other Lepidoptera and even that the Megathymidae may not be phylogenetically linked to the Hesperiidae. For several years we have been making on-the-scene studies of these two aspects of megathymid behavior, both for their interest in understanding the whole ecology of these insects and for their possible reflection on higher relationships. In this first paper we are presenting our findings for two close relatives in the genus *Agathymus.*

In 1976 the four of us took advantage of an opportunity to watch a number of courtship sequences of *Agathymus estelleae* (Stallings & Turner) and their pattern of ovipositing. Most of these observations were made on 7, 8, 12, and 14 September, 16.5 km north of Saltillo, Coahuila, Mexico on Highway 57 at an elevation of approximately 1380 m. The females emerged from 0800 to 0930 h (CDT) and in the wild, crawled up on a leaf of their food plant as their wings expanded and hardened. Shortly after the females commenced to emerge, males appeared and flew by the female, often as close as 30 cm. The first male to locate a female would then perch on a leaf of the food plant, *Agave lecheguilla* Torr., or on a stone or small shrub about 8 m or less downwind from the female; other males would fly by the female and would be pursued by the first male, who would chase them out of his "territory." The sentry site of the first male appeared to be rather small, as subsequent males would take up positions downwind from the female as close as 5 m from the first male. There tended to be three males in attendance by the time of the maiden flight. Butterflies would fly through the area and would not be pursued by the males except for dark skippers with white fringes, which the males evidently mistook for other *estelleae*. After the female's wings had expanded fully, she would rest on the leaf with her wings folded so that the apex of the forewings touched. The males, on the other hand, rested with their forewings apart, and their hindwings dropped down almost perpendicular with their body. We called this the male launching position, as they were able to take off in full flight immediately.

Two to three hours after a female emerged she would make her maiden flight, which seemed a long period to us. She would rise from her resting position in a circular flight and fly downwind very rapidly in an undulating manner some 2 to 5 m above the ground. In nearly every instance she flew directly over the male who had been first to establish a sentry position. The first male would rise above and just behind to meet her as she flew over his position dipping down towards her so that he appeared to touch her. She would quickly drop down to or near a food plant, followed closely by the male. All of this happened within a few seconds, in which the female had not traveled over 40 m from her original resting site. If there were other males watching the female, they joined in the pursuit of her. Usually as the female and first male came to rest, they were in copulation within 3 or 4 sec. If there were other males they would alight by the female and try to mate with her. If none of the males had succeeded in mating with her in about 7 sec, she would fly off in a straight line pursued by all of the males. We were never successful in observing what happened when she came to rest a second time. On three occasions, if the first male was successful in mating, the other males flew away but returned within 5 to 10 sec and alighted within 15 to 20 cm of the copulating pair. Within a few seconds the unsuccessful males again flew away and then returned within 5 to 10 sec but would alight 60 to 100 cm from the copulating pair. Again, the unsuccessful males would fly away and return shortly, this time alighting about 2 m away from the pair. After a final brief inspection, the unsuccessful males would fly away and not return. The mating pair would remain in copulation from 66 min to five hours. We had no difficulty in moving them into a wire cage, so that we could recover the ova to be laid later. On two occasions we happened to flush virgin females before they were ready to mate. Their flight was in a straight line to another plant or bush, and although there were males around, none of them pursued these females.

On 7 September a pair was found in copulo at about 1430 h, clinging to the underside of a *lecheguilla* leaf; when they flew away, the female appeared to be flying and the male dangling. This copulation had presumably started much earlier, because four observed couplings took place at 1050, 1118, 1120, and 1155 h.

While vision is undoubtedly a major part of the courtship process, we assume that the female emits a pheromone shortly before or as she makes her pre-mating flight. On one morning the wind shifted after a male had established his sentry position. We noted with interest that he maintained his position even though he was then upwind from the female. When the female took off on her mating flight she flew downwind, with the result that the first male was an unsuccessful suitor, because a downwind male reached her before he did.

One observation day was very hot, and from noon until 1600 h we saw no flight activity among the *estelleae,* although there were other butterflies flying in the area. Shortly after 1600 h some scattered clouds appeared along with some female *estelleae*. Each of the females proceeded to oviposit by alighting on a leaf of the food plant with wings completely closed and then dropped an ovum that fell to the base of the plant where it might lodge among the leaves or bounce out on the ground. This took from four to seven seconds. We were wondering why the first females did not drop more than one ovum at a time, when we were accommodated by a female which proceeded to drop five to seven ova at one location, without flying. A few days later we again watched females lay as many as five ova in one sitting. We noted that after a female dropped five to 10 single or multiple ova she would alight on a rock or bush and rest before proceeding with her ovipositing. Since in many years of field work we had seldom found larvae in juvenile plants or plants located in the shade of a bush or rock, we had always supposed that the females were very selective as to where they placed their ova. However, we were in error, as the females were indiscriminate as to the size or location of the plants where they dropped their ova. We suspect that there are more predators in the juvenile plants or plants under bushes and that the ova or the small larvae had a lesser chance to survive there.

At about 1630 h the cloud cover usually became heavier, and the temperature dropped slightly. Various butterflies in the vicinity sought shelter, but the *estelleae* females continued their activities. Once a slight breeze came up, and we could smell moisture. Evidently, the *estelleae* recognized the oncoming shower, for they immediately sought shelter in plants and bushes and on the downwind side of small rocks.

A minute or two later it began to rain, and it was evident that several of the females had not picked a good site for shelter as they commenced flying about seeking a more sheltered area.

One of the females that we kept for ova count produced 95 ova the first day, 23 the second day, 10 the third day, 23 the fourth day, 4 the fifth day, 14 on the sixth day, and 8 on the seventh day; when she died she had 3 ova left in her body for a total of 180 ova. Ova of this species vary in color from green through a sand color; all of those laid on the last two days by this female were green.

Two of the authors (DBS and VNTS) conducted a series of observations 5 and 6 October 1983 in the Guadalupe Mountains near Carlsbad, New Mexico for the purposes of determining the courtship and ovipositing patterns of *Agathymus mariae* (Barnes & Benjamin), a species rather closely related to *A. estelleae*.

Females emerged from their pupae from 0900 to 1030 h (MST). The males emerged some 30 min earlier than the females. A newly emerged female would crawl up a leaf of the plant on its inner side, approximately one-third of the distance from the tip of the leaf. It took about 2 to 3 hours for the wings to expand and harden.

Males that had emerged the prior day or earlier patrol the area around the food plants (*Agave lecheguilla*). Males that emerged earlier in the day eventually join in the patrol. The patrolling on the part of the males consists of flying back and forth over the food plants. It is interrupted by the males alighting on small rocks or directly on the ground in an open area where they can see and be seen; they would remain there from 1 to 10 min and then resume their patrol. The patrol flight was usually within 1 m of the ground. As they repeated their patrol and alighting procedure, they would sometimes alight on the ground, where they had been, and at other times would alight in a new area. The selection by a male of a new area within which to alight may be dictated by the failure of a female to fly over the previously selected site. In defending territory a male would pursue another male who entered his territory. They would often fly 6 to 10 m up into the air.

Males would often fly by a teneral female within 30 to 40 cm without any indication that they recognized her presence.

It appears that *mariae* males alight in an open area and depend on a female finding them by flying over them. This is in contrast to *estelleae* where the male establishes a sentry position in relation to a specific female which he will pursue when she makes her first flight. Thus, while *estelleae* and *mariae* have different courtship patterns, the males of each establish a position during the courtship period of each day and defend it against other males.

We noted a number of day-flying saturniid moths (*Pseudohazis*) flying about, which we sometimes mistook for an *Agathymus,* but the male *mariae* evidently had no such difficulty.

Around noon a female would take off on her first flight. She would circle in a fluttering manner around the area where she had been resting. Her flight was usually not over 70 cm above the ground, and the radius of the circle was about 8 or 9 m. This circle nearly always covered an area that would have at least one male temporarily on the ground. When the male sighted the female, he would take off in pursuit of her. As the male approached the female, she would drop to the ground, alighting on a rock or a leaf of the food plant where he would join her; within 5 sec they would be in copulation. The duration of copulation varied from 48 min to several hours.

After copulation the fertilized female would remain at rest until 1600 or 1700 h, at which time she would commence ovipositing. We think the period of day when females oviposit is determined by temperature, because captive females in protected areas where the temperature was less than in more exposed areas would commence ovipositing shortly after mating. A female would fly in a fluttering manner to a food plant where she would alight on one of the outer leaves and drop an ovum. Some females dropped a single ovum while others dropped two ova. We suspect that some females drop more than two ova at a single stop, although we did not observe any doing this.

Since the females that we observed alighted on the outer leaves of the food plant, all of the ova fell on the ground. We were able to recover ova that we saw laid. The female would usually take a short rest after depositing 3 to 5 ova.

The three couplings that we observed occurred at noontime, specifically at 1155, 1210 and 1242 h.

Our observations of *Agathymus carlsbadensis* (Stallings & Turner) in this same general area of the Guadalupe Mountains was inconclusive. We think the courtship pattern is very similar to that of *A. mariae.* The ovipositing pattern appears to be entirely different. We never did observe a female alighting on a plant to oviposit. At least five different times we observed females hovering over or near their food plant. We suspect that they were ovipositing from this hovering position, but we were unable to recover any ova.

In the 1940's we corresponded with W. P. Medlar, a collector in California who advised us that he had observed *Agathymus stephensi* (Skinner) ovipositing. According to him the female hovered over or near the food plant and flipped the ova towards the plant. Freeman reported the same thing in 1951 for *Agathymus aryxna* (Dyar) and *Agathymus evansi* (Freeman). In 1951 when Freeman's paper was published the name *neumoegeni* was being mistakenly applied to *aryxna*. He followed this mistake. Correspondence that we received from Freeman at the time of his observations mention only *evansi* as ovipositing from a hovering position; no mention was made of *aryxna*. Roever (1965) reported that he had not observed females flipping their ova into the plant while hovering over or near a plant; however, he noted that both of the species alight on or near the plant when ovipositing. He reported that he had observed ovipositing by the female while on or near a food plant. He made the same observations for *Agathymus neumoegeni* (Edwards), *A. polingi* (Skinner), *A. baueri* (Stallings & Turner), *A. freemani* (Stallings & Turner). It is evident that more observations are needed in order to reconcile these divergent reports.

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BIOLOGY OF THE HALF-WING GEOMETER, *PHIGALIA TITEA* CRAMER (GEOMETRIDAE), AS A MEMBER OF A LOOPER COMPLEX IN WEST VIRGINIA[1]

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ABSTRACT. Field and laboratory studies were conducted during 1983 in two counties of eastern West Virginia where forest defoliation by a looper complex (Geometridae) had been heavy the previous two years. *Phigalia titea* Cramer, dominated, making up 77–94% of feeding larvae; *Erannis tiliaria* (Harris), *P. strigateria* (Minot) and *Alsophila pometaria* (Harris) were also present. Adult *P. titea* were found in the field from 17 March to 26 April, eggs from 17 March to 3 May and larvae from 3 May to 15 June. Descriptions of oviposition sites and eggs are given; females were found to contain a maximum of 1447 eggs. At constant 24°C *P. titea* larvae required a mean total of 28 days to mature through five instars when fed on sugar maple leaves, but larval growth rates were found to vary with host plant species. Descriptions of the five larval instars are given.

As defoliators of hardwood forests numerous species of native geometrids produce either consistent but little noticed damage or sporadic but significant damage during outbreaks in eastern hardwood forests. Outbreaks may consist primarily of a single species or represent a complex of geometrid defoliators.

During the spring of 1981 and 1982, approximately one million acres of hardwoods in eastern West Virginia were defoliated each year to varying degrees ranging from 20–100%. The West Virginia Department of Agriculture assessed the looper infestation as causing more damage to hardwoods in one year than all other defoliators in the state have in the past 20 years. Loopers have been the most obviously destructive forest insects in West Virginia in recent times, with numerous reports of tree mortality following heavy defoliation (Anon., 1983). While various species were suggested as comprising the defoliator complex, no detailed observations had been made (Anon., 1981, 1982).

The extensive defoliated acreage and resulting mortality of hardwoods, especially oaks and hickories, justified a more detailed study on the looper complex in West Virginia. Sampling of larval populations showed four looper species to be present at all study sites: *Phigalia titea* Cramer, *P. strigateria* (Minot), *Erannis tiliaria* (Harris) and *Alsophila pometaria* (Harris). In all samples *P. titea* made up the majority of the looper population, ranging from 77% to 94%, depending on the site. While some information on *P. titea* is available (Baker,

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1972; Talerico, 1968), it is often of a superficial nature or contains information contrary to observations made during this study. The outstanding exception is the fine study of adults by Rindge (1975).

METHODS AND MATERIALS

Study Area

Three sampling sites were selected in West Virginia. Two were in Cacapon State Park in Morgan County of West Virginia's Eastern Panhandle within the most heavily defoliated region; the third site was near Elkhorn Mountain at the border of Grant and Hardy counties on the southern edge of the affected region. The vegetation at all sites is often referred to as oak-hickory-pine, although originally chestnut was a dominant species. Both study areas are dry upland sites consisting in part of steep shale slopes.

The two Cacapon State Park sites were on Cacapon Mountain. The site designated Batt Picnic Area (Batt PA) was east facing at an elevation of 381 m and had complete looper defoliation in 1982. The second site, designated Cacapon Overlook (Cac. OL) was along both sides of a north/south ridge at an elevation of 701 m and suffered about 25% looper defoliation in 1982. The Elkhorn (Elk.) study area was on Getz Mountain, 1–2 km south of Elkhorn Mountain, at an elevation of about 732 m. During 1982 the Elkhorn area also received about 25% looper damage.

Field Collection and Description of Looper Life Stages

Sampling for all looper species was initiated with adult observations on 17 March 1983 at Cacapon State Park and 24 March at Elkhorn Mountain. Samples were taken at 6- to 8-day intervals through 15 June, at which time most larvae had moved into the soil for pupation.

During the weeks of adult *Phigalia* activity, collections were made and relative numbers and locations of males and females were noted during timed walks through each study site. Males were determined to species through genitalia dissection; females were collected for determination of species and fecundity. Fecundity was studied by two methods: (1) dissection of field collected females and (2) caging of females on dead twigs for oviposition, counting deposited eggs and then dissecting the post-ovipositional females to count residual eggs.

Phigalia eggs were observed in the field and developmental color changes noted on a weekly basis. Eggs on dead twigs or other vegetation were collected from 17 March through 26 April, were held 1 to 4 weeks at 4°C, then placed at room temperature to hatch; viability was determined.

TABLE 1. Potential egg counts from dissected female *Phigalia titea* collected at various dates and study sites in 1983. Sample size given in parentheses.

Site	Date	No. eggs/female	Range
Batt PA	III.17 (40)	309	21–884
	III.24 (5)	215	11–454
	IV.7 (7)	48	9–114
	IV.14 (7)	23	8–51
	IV.20 (5)	29	7–54
Cacapon OL	III.24 (1)	1364	
	III.31 (6)	542	395–836
	IV.14 (6)	859	288–1409
Elkhorn	III.24 (2)	910	643–1177
	III.31 (6)	775	177–1447

At each sampling date between larval hatch and pupation, foliage samples were collected with pole pruners and placed in plastic bags for transport to the laboratory. Samples of 100 to 200 larvae were taken from the pruned vegetation and preserved for determination of species, and in the case of *P. titea*, to determine instar composition and to prepare larval descriptions.

Larval Development

To determine intervals between larval molts, newly hatched larvae from the egg viability study were placed in groups of 10 on leaf clusters of host plants in petri dishes and held at 24°C. In one experiment, 200 first instar larvae were reared on sugar maple; one group of 100 set up 27 April, a group of 20 set up 6 May and a group of 80 set up 11 May. In a second experiment begun 4 May, growth rates of larvae were compared when fed on red oak and red maple; 50 larvae were reared on each food plant.

RESULTS AND DISCUSSION

Fecundity

Most of the *P. titea* females collected from Batt PA for dissection were already ovipositing, and the resultant potential egg count may have been lower than the number of eggs which they were capable of producing. The expected trend of lower potential egg numbers per female with increasing time into the season is shown in Table 1. Females collected at Batt PA from 7 to 20 April were depleted.

Egg counts of dissected females from Cac. OL and Elk. were considerably higher than oviposition rates previously reported for *P. titea*; Talerico (1968) reported that several caged females produced from

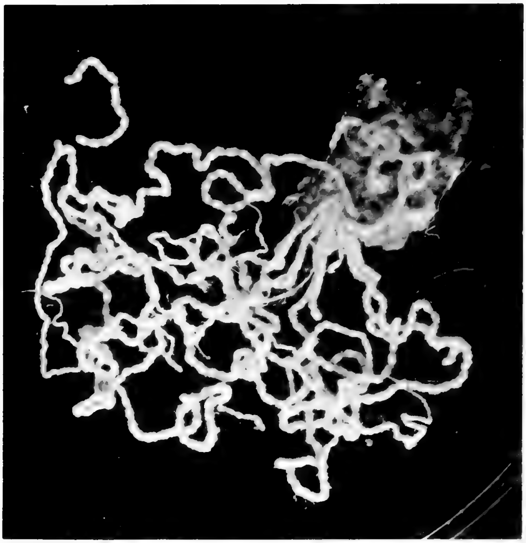

FIG. 1. Dissected ovaries of a *Phigalia titea* containing 1364 eggs.

127 to 139 eggs each. Data show that dissection of preovipositional females gives an accurate indication of reproductive potential since 90% of eggs were laid in the laboratory cages (Table 2). The highest egg count from a dissected female was 1447. Figure 1 shows dissected ovaries of a *P. titea* female with 1364 eggs. The four ovarioles per ovary contained the following egg numbers: 166, 164, 193, 157, 184, 185, 153, 162.

Oviposition Sites and Egg Descriptions

Eggs were generally laid on dead twigs, singly or in clusters, with the cluster configuration and size depending upon structural features of the oviposition site. Common oviposition locations were under loose, flaking bark of dead twigs of maples (*Acer* spp.), oaks (*Quercus* spp.), black gum (*Nyssa sylvatica* Marsh.), common witch hazel (*Hamamelis virginiana* L.), flowering dogwood (*Cornus florida* L.), grape (*Vitis* spp.) and around bark cracks of hickory (*Carya* spp.) twigs. Many clusters were under loose bark at crotches of dead twigs. Other locations included deep splits in dead twigs, bostrichid burrows, frass of shallow buprestid or cerambycid burrows, exposed face of girdled twigs, empty chorions of Saturniidae, small Lepidoptera pupae or cocoons, spider egg sacs, and dead crumpled leaves of composites from the previous year. One of the most interesting locations was inside empty chorions of previous year's eastern tent caterpillar, *Malacosoma ameri-*

TABLE 2. Egg counts for female *Phigalia titea* allowed to oviposit in the laboratory and subsequently dissected. Sample size given in parentheses.

		# eggs laid		# eggs/dissected female			
Site	Date	Mean	Range	Mean	Range	Mean total/female	Range
Cacapon OL	IV.7 (8)	724	496–1035	65	3–243	789	551–1266
	IV.14 (3)	686	242–1022	26	11–49	712	260–1133
	IV.20 (5)	664	280–1128	40	3–123	704	299–1251
Elkhorn	IV.7 (5)	394	72–545	36	7–83	430	155–597
	IV.14 (9)	601	41–1140	49	2–278	650	60–1198
	IV.26 (5)	337	110–432	53	5–147	390	115–516

canum (Fab.), egg clusters (J. E. Weaver, pers. observ.). Diameters of 65 randomly collected egg-bearing twigs of various host species averaged 7.2 mm (range 2–15 mm) at the oviposition sites.

Eggs were slightly roughened by reticulate sculpturing, as previously described by Forbes (1948). The shape was oval with one end of the egg more flattened or broadly rounded and the opposite end more conical; heaviest sculpturing was at the broad end. Measurement of 80 eggs collected at both sites at Cacapon State Park on various dates averaged 0.905 (0.858–0.990) mm long and 0.521 (0.495–0.561) mm wide: These sizes were only about half that reported for *P. titea* eggs in Virginia (Talerico, 1968).

When first deposited, eggs were greenish yellow to yellow in contrast to an earlier description by Talerico (1968). Further color changes reflected embryonic development, the rate of which is temperature dependent. Within 2 to 3 days at 24°C, eggs began developing a salmon pink color which first appeared at the blunt end of the egg. The eggs gradually became darker pink over a period of several days, and when approaching maturation, dark red to black spots appeared at the blunt end. At about 24 h prior to hatch, the eggs appeared dark purple as a result of the dark head capsule and body of the larva being visible through the lavender chorion. At this stage, microscopically, the larva was seen curled inside with head and posterior end meeting at the blunt end of the egg. The pale spiracular stripe of the larva was easily seen. At constant 24°C, development time from oviposition to hatch required 7 to 8 days.

Larvae eclosed by chewing an irregular hole through the blunt end of the egg. Empty chorions were an iridescent lavender and were easily observed in the field. Eggs parasitized by *Telenomus alsophilae* Viereck (Hymenoptera: Scelionidae) appeared chocolate brown at the time adjacent unparasitized eggs were hatching. In the laboratory, parasite adults did not eclose until about 13 to 15 days after *P. titea*

TABLE 3. Comparison of developmental time for *Phigalia titea* larvae reared on sugar maple,[a] red oak[b] and red maple.[b]

	Time in instar (days)					
	Mean			Range		
Instar	Sugar maple	Red oak	Red maple	Sugar maple	Red oak	Red maple
1	4.30	4.24	4.50	3–5	3–5	3–5
2	3.02	3.18	3.18	2–5	2–4	2–4
3	3.50	2.74	3.70	2–5	2–4	2–5
4	3.43	3.36	4.30	2–6	2–4	3–6
5	7.66	6.92	7.24	6–11	6–8	6–9
Prepupa	6.90	5.88	7.06	4–10	5–7	6–9
Total	28.41	26.32	29.98	21–40	20–31	24–36

[a] Based on 200 larvae.
[b] Based on 50 larvae.

larval hatch. Chorions of parasitized eggs retained a brown color, thus allowing easy evaluation of percent parasitism in a field situation.

Percent hatch of 12,855 eggs randomly collected at the three study sites averaged 94.4. Some eggs which failed to hatch had obviously suffered mechanical injury at collection; many eggs remained dark yellow as if no embryonic development had occurred, while others were dark pink. Dead larvae were observed in some eggs. Parasitism was low in all egg collections and, at most sites, did not appear to contribute significantly to mortality.

Larval Growth Rates

As reported by Talerico (1968) and confirmed in this study, *P. titea* has five larval instars. Growth data for 200 larvae reared from eggs which hatched on three different dates are combined and given in Table 3. It was obvious from this evaluation that time spent per instar was related to developmental stage of host plant foliage. Larvae which hatched on 27 April were reared on the flowers and very young leaves of sugar maple, larvae from 6 May on young to moderately aged leaves and larvae from 11 May primarily on mature leaves. Greater length of time was required between 1st instar and prepupation with increasingly older foliage, e.g. larvae set up on 27 April matured on the average 6 days faster than larvae set up on 11 May. This difference is not apparent in Table 3, however, since all data are combined.

As expected, larvae reared on different host plants develop at different rates. The period from hatch to pupation was about 26 days for red oak and about 30 days for red maple. Field observations during the 1983 season substantiated this finding. At any point during the larval season, later instar larvae were always on oak, hickory and birch and earlier instars on dogwood, maple, blackgum, witch hazel, and most other hosts.

Larval Description

Talerico (1968) made only brief reference to larval color patterns. Descriptions of color patterns of each instar from the populations within the West Virginia study areas are given below. Head capsule widths are the average of 50 specimens per instar.

Instar 1. Head capsule (0.329 mm) medium to dark reddish brown with paler frons. Ground color of body of newly hatched larvae slate grayish black. Dorsal pinnaculae dark, dull yellow; pair of small pale yellow middorsal pyramidal streaks at posterior margin of each segment from mesothorax through abdominal segment 6. Spiracular stripe from creamy white to pale yellow, extending almost continuously from prothorax through abdominal segment 6. Subspiracular area brownish to yellowish brown. Caudal shield and anal prolegs medium brown to dull yellow-brown. Late 1st instar larvae appear much more pale, with medium olive ground color, after intersegmental areas are exposed with larval growth. Particularly prominent just prior to molt is dull yellow-brown cervical area which is protuberant and dwarfs head capsule. In mature 1st instars, caudal, cervical, and proleg sclerites medium brown and very evident against paler body.

Instar 2. Head capsule (0.621 mm) dark reddish brown to black with pale maculations. Basic body ground color greenish brown to slate black. Paired cervical shields small but prominent. Pair of fine, indistinct white dosal stripes down length of body but discontinuous between segments. Pinnaculae dark. Spiracular stripe diffuse and faint, but present; fades out on abdominal segment 7. Secondary setae present but sparse on body, located primarily above spiracular line.

Instar 3. This is the first instar that begins to develop a striping pattern approaching that of mature larvae. These larvae, however, are very dark; mature individuals appear shiny black, with striping being evident only under magnification.

Head capsule (1.05 mm) black with prominent grayish white mottled areas. Fine irregular grayish white striations down length of body. Paired dorsal stripes filled with small orange spots on posterior margin of each segment. Pinnaculae black. Diffuse orange coloration along spiracular area most prominent on protuberances of abdominal segments 1 and 5; lateral orange areas of thoracic segments and abdominal segment 6 reduced. Caudal and cervical areas black with white mottling; venter black. Secondary setae more numerous than in previous instar including some below spiracular line.

Instar 4. Head capsule (1.87 mm) black and white mottled with a higher proportion of white than in previous instar. Frons mottled, clypeus white. Two pairs of black irregular dorsal stripes, orange-filled. Supraspiracular stripe a pair of black irregular lines, white-filled and flanked with orange. Spiracular area with pair of black irregular lines, white-filled, running just above and below spiracle. Area in immediate vicinity of spiracle on each segment prominently suffused with orange. Setae SD1, L1 and L2 within this orange area and each on separate black chalaza. Spiracular chalazae of second abdominal segment most prominent; abdominal segment 8 with pair of prominent chalazae forming dorsal hump. Subspiracular stripe of double irregular black lines, grayish-white-filled. Shields mottled black and white. Legs black; abdominal sternites 7 to 8 white.

Instar 5. Head capsule (2.83 mm) white with distinct black maculations. Body ground color pale lavender-gray with pairs of fine irregular black lines, orange-filled dorsally, pale gray-filled subdorsally. Orange patterns, chalazae, shields and venter as in instar 4. Peritremes black; spiracular valve off-white. Basic appearance of this larva paler with striping more prominent than in previous instars.

P. titea Pupae

The pupa of *P. titea* is illustrated by Talerico (1968). During the current study, measurements were made of 80 pupae; mean length was 13.45 mm and range was 11–15.5 mm. Length was not related to sex, but female pupae were characteristically stouter.

Life History

Adult *P. titea* emerged from the soil where they overwintered as pupae and climbed vertical surfaces. Males eclosed several days to a week before females and were most commonly seen resting on tree trunks. Females climbed tree trunks of a wide range of sizes and remained there for a period of hours to a day or two. Females (and thus eggs) were rarely found on small dead trees. Mating most commonly occurred on tree trunks, after which females climbed upward to locate suitable oviposition sites.

Male *P. titea* were first observed flying at Berkeley Springs, WV, near Cacapon State Park on 8 March. At Batt PA on 17 March, males were numerous and resting on tree trunks. The total numbers of females appeared relatively less than males, because of their virtual winglessness and related cryptic appearance and, because their behavior rendered them more difficult to observe; 40 females were found in a 2 h walk. Most of the Batt PA females were on dead twigs, but some were still emerging from the soil and beginning to climb tree trunks. Of the few eggs present on the twigs, about 99% were yellow. The number of adults seen on 24 March was similar to that of the previous week; numbers of observed females and males began to decline by 31 March and continued to decline markedly each week. The last male was observed at Batt PA on 14 April and the last female on 26 April.

A few males were seen at Cac. OL on 17 March and at Elk. on 24 March. Females were observed for the first time on the latter date at both sites. Numbers of adults continued to increase at Cac. OL and Elk. through 7 April, then sightings began to decline on 14 April. No males and low numbers of females were seen on 26 April. Adult populations of *P. titea* were markedly lower at Cac. OL and Elk. than at Batt PA. At peak female activity, an average of 8 to 10 were observed in a 2 h walk.

A few eggs were seen at Batt PA on 17 March with more than 99% of these being yellow. The first ovipositing females were observed at Elk. on 24 March and at Cac. OL on 7 April. By the later date, about 10% of eggs at Batt PA were pink and females at Elk. and Cac. OL were reaching peak oviposition activity. On 14 April, about 90% of the eggs at Batt PA were pink, while at other sites only about 20% had developed pink coloration. By 26 April, 95% of the eggs at Cac. OL and Elk. were pink.

Egg hatch began in early May and by 3 May was about 85% complete at Batt PA; remaining eggs were in the purple stage, indicating hatch would occur within about 24 h. At Batt PA, 1st instar larvae were very evident, as they hung on silk lines below the dead twigs on

TABLE 4. Instar composition (% of population) of *Phigalia titea* taken at study sites between 3 May and 8 June.

Date	Instar	Study site		
		Batt PA	Cacapon OL	Elkhorn
V.3	1	87	90	100
	2	13	10	
V.10	1	6	73	94
	2	87	26	6
	3	7	1	
V.17	1	0	40	0
	2	4	52	82
	3	59	7	17
	4	37	1	1
V.24	2	0	13	3
	3	2	67	71
	4	28	19	26
	5	70	1	0
V.31	3	0	4	3
	4	2	78	52
	5	98	18	45
VI.8	4		8	7
	5		92	93

which eggs had been laid. Ballooning actively occurred, with the larvae riding air currents into trees which were just beginning to leaf. It appeared that larvae arrived at potential host trees randomly by means of wind activity, but they showed preference for hosts by either settling quickly and beginning to feed or continuing to balloon if the initial host was not suitable. Considerable larval mortality probably occurred at this time.

On 3 May at Batt PA, some larvae were beginning to feed with damage being initially in the form of pinholes and skeletonizing. On this date at Cac. OL, egg hatch was about 20% complete but was just beginning at Elk. No feeding was evident at these sites.

Despite the fact that eggs were laid over a period of several weeks at each site, egg hatch at any one site occurred relatively in synchrony due to effect of low temperatures on earlier laid eggs. Progression of *P. titea* larval development for each of the study sites is given in Table 4. Differences in altitude and temperature at the study sites produced developmental events, resulting in adult emergence to pupation being one to two weeks earlier at Batt PA than at the other two sites. Differences in developmental time also occurs depending on orientation of slope.

ACKNOWLEDGMENTS

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THE RELATIONSHIP BETWEEN *PEDALIODES PERPERNA* AND *PETRONIUS* (SATYRIDAE), WITH THE DESCRIPTION OF A NEW SUBSPECIES

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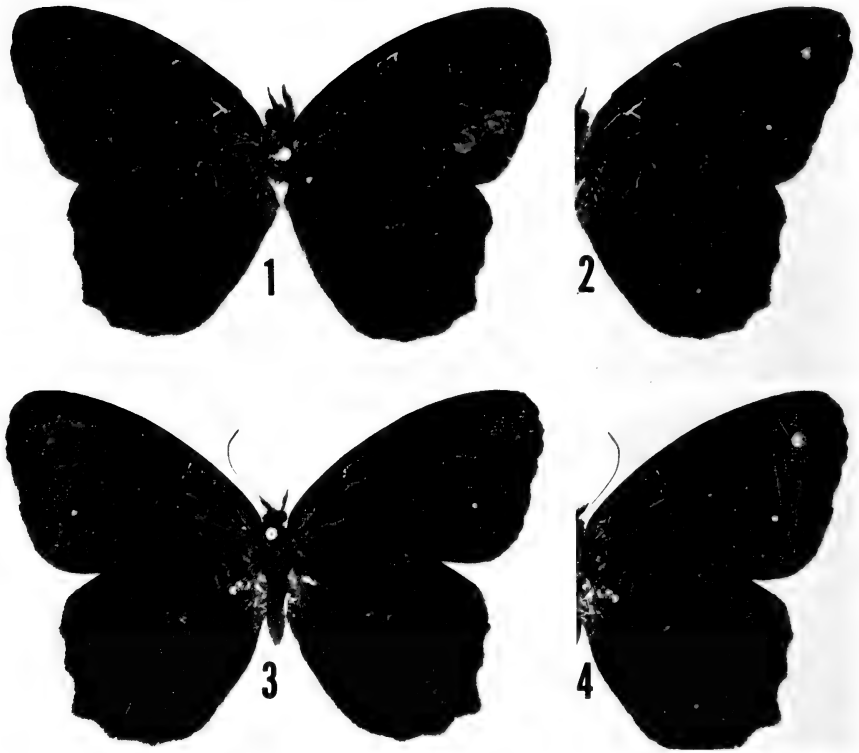
ABSTRACT. The species *Pedaliodes perperna* and *P. petronius* are compared and confirmed as separate species, rather than as forms of one species. *Pedaliodes petronius kerrianna* (La Mesa, near El Valle, Cocle, Panama) is described as new. The habits and habitat of the new subspecies are discussed and a possible foodplant association proposed. Adults and male and female genitalia of both species are illustrated and discussed.

The interrelationship between *Pedaliodes perperna* (Hewitson) and *P. petronius* Grose-Smith has puzzled workers for years. Both species look rather similar, but there are significant differences in their sizes (*petronius*: forewing length about 35 mm, vs. less than 30 mm for *perperna*), wing shapes, maculation and the genitalia. Weymer (1912: 253) classified *petronius* as a ♀ form of *perperna*, the fact that the type of the former was actually a ♂ notwithstanding. *P. petronius* is one of the largest *Pedaliodes* and certainly is the largest member of the genus occurring in Central America. The differences that are apparent when the two taxa are examined are of a nature that it seems incredible that they were ever considered to be conspecific.

Superficial characteristics clearly separate *petronius* from *perperna*, but genitalic characters are even more dramatic. The penis of *petronius* (Fig. 14) is narrow, straight and not contorted in contradistinction to the contorted, stout penis of *perperna* (Fig. 13) and most other *Pedaliodes*. The ♂ genitalia of *P. petronius* are somewhat reminiscent of those of *Praepronophila* Forster (see Forster, 1964:183, fig. 263), a very different butterfly in all other respects. The ♀ genitalia are at least as dramatic, especially as regards the setose, ornate lamella antevaginalis of *petronius* (Fig. 16), as opposed to the simple structure of *perperna* (Fig. 15) and other, less spectacular differences. Perhaps *petronius* should be placed in another genus, but I have not yet examined enough "*Pedaliodes*" to determine whether this separation would be justified; therefore, *petronius* provisionally remains in *Pedaliodes* but as a species separate from *perperna*.

Ecological separations also support the separation of the two species. *P. petronius* usually flies below 1000 m elevation wherever it has been recorded with adequate altitudinal data, whereas all of the specimens of *perperna* that I have seen have come from 1500–2000 m elevation. The ecological niche of *petronius* apparently is somewhat different, as is detailed in the description of the northern population of *petronius*.



FIGS. 1–4. *Pedaliodes perperna* (Hewitson). **1 & 2,** syntype ♂, upper (1) and under (2) surfaces, no data (Allyn Museum photo no. 040979-4/5; **3 & 4,** syntype ♀, upper (3) and under (4) surfaces, no data (Allyn Museum photo no. 040979-6/7). Both specimens are in British Museum (Natural History) collection.

The differences here cited are certainly enough to ascertain that *Pedaliodes perperna* and *P. petronius* are separate species that replace one another altitudinally and are not even closely related within the genus *Pedaliodes*.

Pedaliodes perperna (Hewitson)
(Figs. 1–4, 13, 15a–b)

Pronophila perperna Hewitson (1862:16–17). Type-locality not specified, but stated to be Venezuela by W. F. Kirby (1871:104). ♂ and ♀ syntypes in BM (see below) [examined].

Pronophila satyroides C. and R. Felder (1867:469–470). Type-locality: Caracas, Venezuela. Syntypes should be in BM, but not located.

This species was described well by Hewitson (1862), and the ♂ genitalia were figured by Forster (1964:166; fig. 224), though the orientation is different than that shown here. I can add little to the superficial description of either the ♂ or of the ♀, except to state that some Costa Rican ♀ specimens have the extradiscal area of the upper forewing strongly laved with rufous, thereby setting off the ocellus in Cu_1–Cu_2 more than is shown in the figure of a Venezuelan specimen.

The ♂ genitalia (Fig. 13) are of the *Pedaliodes* type as illustrated by Forster (1964: figs. 198–260) with the contorted and complex penis. This organ is relatively shorter than is that of *petronius*, which in turn is relatively very straight and simple. The valva has a bilobate tip and no dorsal tooth like that which characterizes *petronius*.

Female genitalia (Fig. 15) with simple, lightly sclerotized lamella ante- and postvaginalis, the latter with few setae. Width of lamella antevaginalis constant and attachment to ductus bursae simple. Antrum simple, ductus bursae only moderately sclerotized with paired dorsal supportive bars; ductus seminalis attached at juncture of ductus bursae and corpus bursae. Signa well developed with external spines.

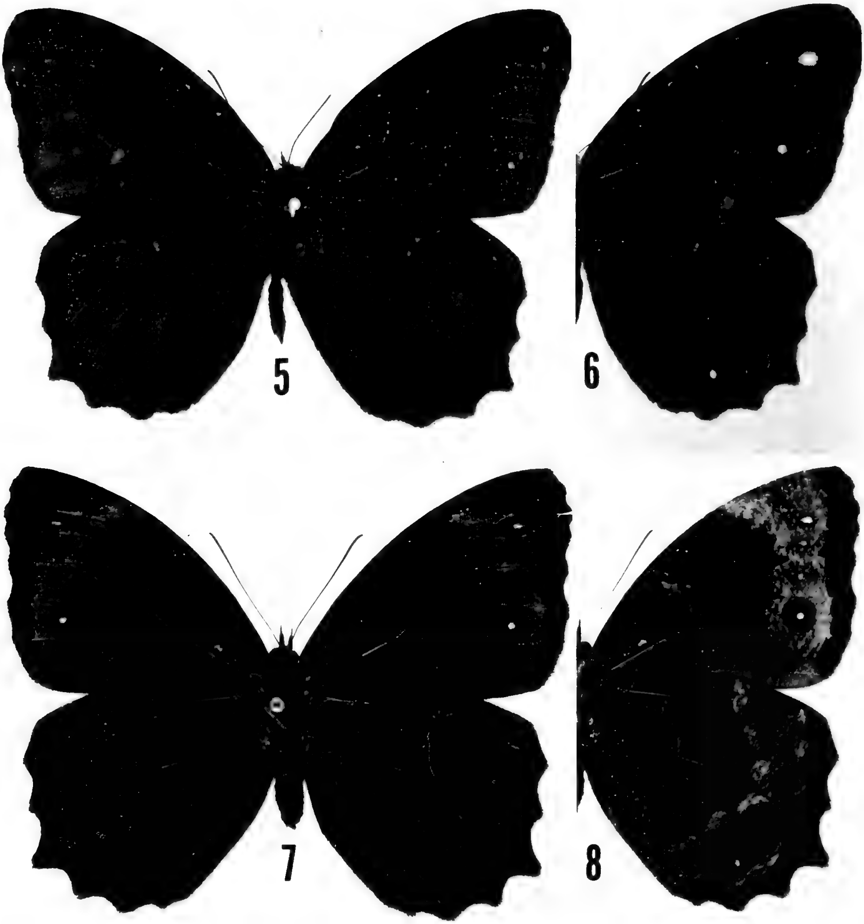
This species is apparently seldom common throughout its rather broad (for a *Pedaliodes*) range. I have seen specimens from Costa Rica, Panama, Colombia and Venezuela, but from no locality have I enough material to pass judgment on possible geographic differentiation. All of the specimens have come from between 1500 and 2200 m elevation. By contrast, the following species is from a lower elevation, and two distinct geographic segregates have evolved.

I had initially intended to designate the ♂ specimen as the Lectotype for *P. perperna*, but several circumstances make this untenable. First, this specimen has no abdomen, hence its genitalia cannot be checked if the popular conception of *perperna* proves to encompass more than one species. Second, it is possible only by secondary sources to determine from which population of the species the syntypes were taken. I suspect that Kirby (1871) was correct, and the specimens came from Venezuela, and further, it is likely that either the hills around Caracas or the vicinity of Colonia Tovar was the more precise type locality. This decision, however, should be left to some worker doing a comprehensive revision of this group of *Pedaliodes*.

Pedaliodes petronius petronius Grose-Smith
(Figs. 5–8)

Pedaliodes petronius Grose-Smith (1900:19). Type-locality: Valdivia, Colombia. HT in BM [examined].

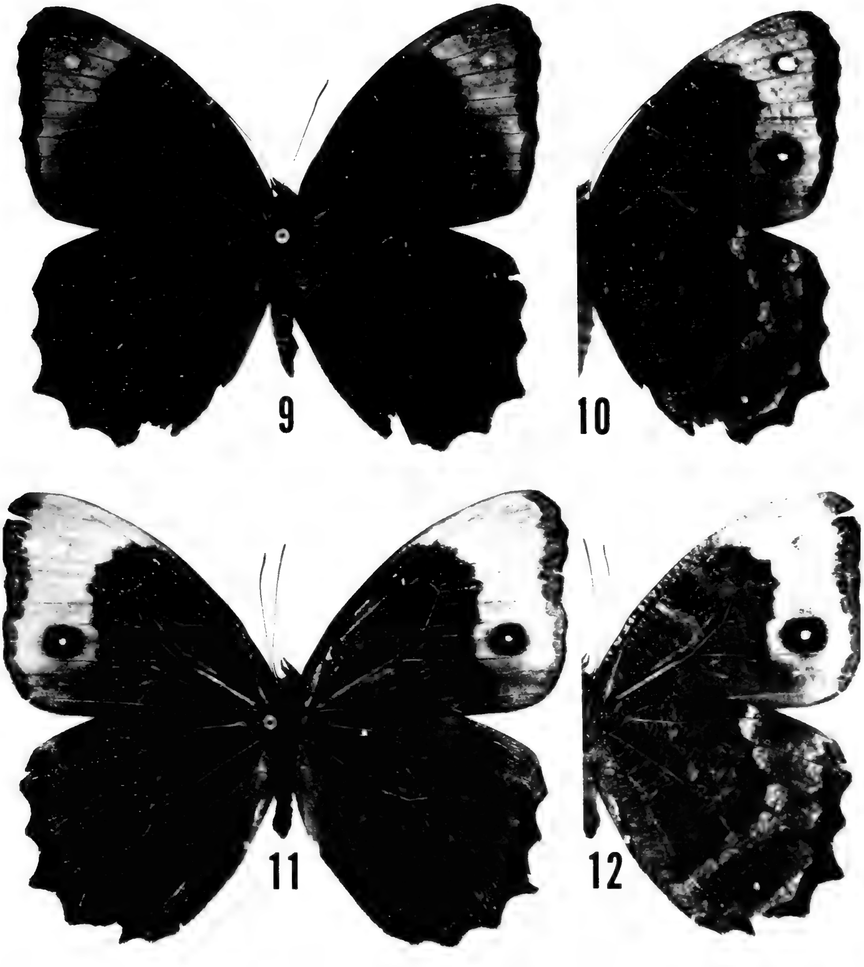
Although this subspecies was described originally from Colombia, by far the majority of specimens have been from Panama, probably because of the recent emphasis on collecting in that country. Most of the specimens seen have come from the lower flanks of Panamanian



FIGS. 5–8. *Pedaliodes petronius petronius* Grose-Smith. **5 & 6,** holotype ♂, upper (5) and under (6) surfaces, COLOMBIA: ANTIOQUIA: "Valdevia" (=Valdivia) (Allyn Museum photo 040979-10/11), British Museum (Natural History) collection; 7 & 8, ♀, upper (7) and under (8) surfaces, PANAMA: PANAMA; Cerro Jefe, 900 m, 9.iv.1977 (Allyn Museum photo 090178-9/10), G. B. Small, Jr. collection.

mountains (Cerro Jefe, Panama prov.), apparently in low montane forests (see below for details of the habitat of this species).

The ♂ is totally fuscous above, and the ♀ is only slightly irrorated with lighter scales toward the apex of the forewing. The under side is fuscous boldly marked postdiscally with tan on both wings and with a chestnut discal band; the ocelli stand out clearly against the ground color of both wings.



FIGS. 9–12. *Pedaliodes petronius kerrianna,* new subspecies. **9 & 10,** holotype ♂, upper (9) and under (10) surfaces, PANAMA: COCLE: La Mesa, nr. El Valle, 820 m, 5.i.1978; **11 & 12,** paratype ♀, upper (11) and under (12) surfaces, PANAMA: COCLE: La Mesa, nr. El Valle, 820 m, 5.i.1978. Both specimens are in Allyn Museum collection.

♂ and ♀ genitalia substantially the same as those of *P. p. kerrianna* (q.v., Figs. 14 and 16).

It does not seem to be a common insect; I have seen only a few examples, but it may not always be rare where it is found if encountered at the right time. Superficially, it seems to resemble members of the *poesia* group, but the genitalia are totally unlike any members of that complex.

Pedaliodes petronius kerrianna, new subspecies (Figs. 9–12, 14, 16a–c)

Male (Figs. 9–10). Head, thorax and abdomen dorsally covered with fuscous hairs; head and thorax with gray-brown ventral hairs, abdomen with buff ones ventrad. Palpi covered with fuscous dorsal and ventral and white lateral hairs. Legs with light gray-brown hairs.

Upper surfaces of both wings deep fuscous with subapical buff patch from just outside forewing cell to 1A and usually small, barely noticeable black ocellus placed on inner part of buff patch in Cu_1–Cu_2. Wings with narrow dark marginal line following contours of wings.

Under forewing basically fuscous with markings as in *p. petronius,* but differs as follows: between cell and margin is large buff patch speckled with fuscous scales, positioned about as on upper side; black ocellus with white pupil in Cu_1–Cu_2 larger than in *p. petronius*; subapical white ocellus in M_2–M_3 much larger than that of *petronius*; and with supernumerary white subapical point in M_1–M_2. Under hindwing about as in *p. petronius,* except brighter and more contrasting and submarginal ocellus in Cu_1–Cu_2 larger and more prominent.

Male genitalia as illustrated (Fig. 14), similar to nominate subspecies, but dorsal tooth on valva somewhat less pointed and prominent. The long, straight penis and the toothed valva immediately distinguish this species from *P. perperna.*

Length of forewing of holotype ♂ 34.1 mm; those of the 22 ♂ paratypes at hand range from 33.3 to 34.6 mm, averaging 34.14 mm.

Female (Figs. 11–12). Head, thorax, abdomen and appendages about as in ♂. Upper surface similar to nominate subspecies except for buff subapical forewing patch with its more prominent black, white pupilled ocellus in M_1–M_2 of the same wing and at least hint of hindwing submarginal ocellus in Cu_1–Cu_2.

Under surface much like that of *p. petronius,* but characterized by brighter buff forewing subapical patch, larger forewing and hindwing submarginal black ocelli with white pupils in Cu_1–Cu_2 and generally more contrasting appearance.

Female genitalia (Fig. 16) very ornate with numerous, presumably sensory scales and setae on VIII tergite and lamella postvaginalis. The normally membranous area anteriad of the papillae anales moderately sclerotized in this species; inner margin of lamella postvaginalis spinose and bearing two separate types of scales: a multidentate, short scale and a bidentate longer one. Lamella antevaginalis lightly to moderately sclerotized and cup-shaped; antrum heavily sclerotized and ornate. Ductus bursae similar to that of *perperna,* but tapered toward antrum. Signae longer than those of *perperna.* Attachment of ductus bursae to lamella antevaginalis (sterigma) much more heavily sclerotized than in *perperna.*

Lengths of forewings of the four ♀ paratypes at hand range from 36.0 to 37.4 mm, averaging 36.75 mm.

Described from 59 specimens, 48 males and 11 females, from Cocle province, Panama.

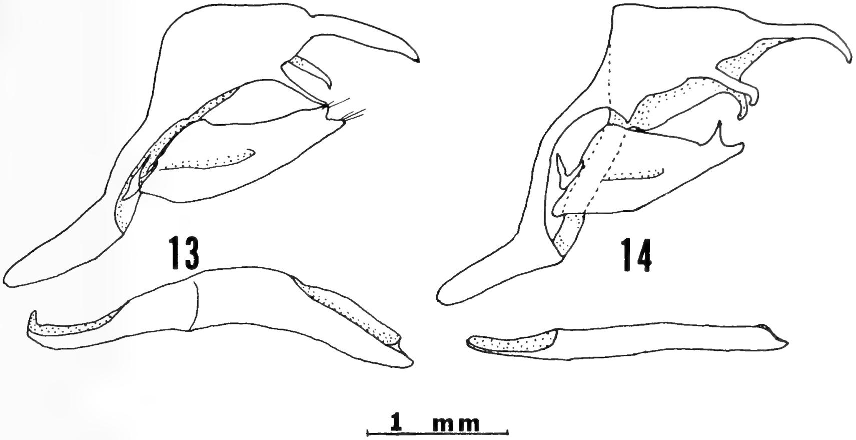
Holotype ♂: PANAMA: COCLE: La Mesa, near El Valle, 820 m; 5.i.1978 (G. B. Small).

Paratypes: 47 ♂, 11 ♀, same locality and collector as holotype, variously from November, December, January, June and July, 1978–1983.

Disposition of type-series: holotype ♂, 22 ♂ and four ♀ paratypes in Allyn Museum of Entomology; 25 ♂ and seven ♀ paratypes returned to Mr. Small for his collection and for distribution to other museums.

This subspecies is named at Mr. Small's request for Kerry Ann (Mrs. Robert) Dressler who discovered the original Panamanian colony. She, along with Mr. Small, has materially increased our understanding of Central American lepidopterology, especially of the fauna of Panama and Costa Rica.

Mr. Small (pers. comm.) has written me extensively on the habits

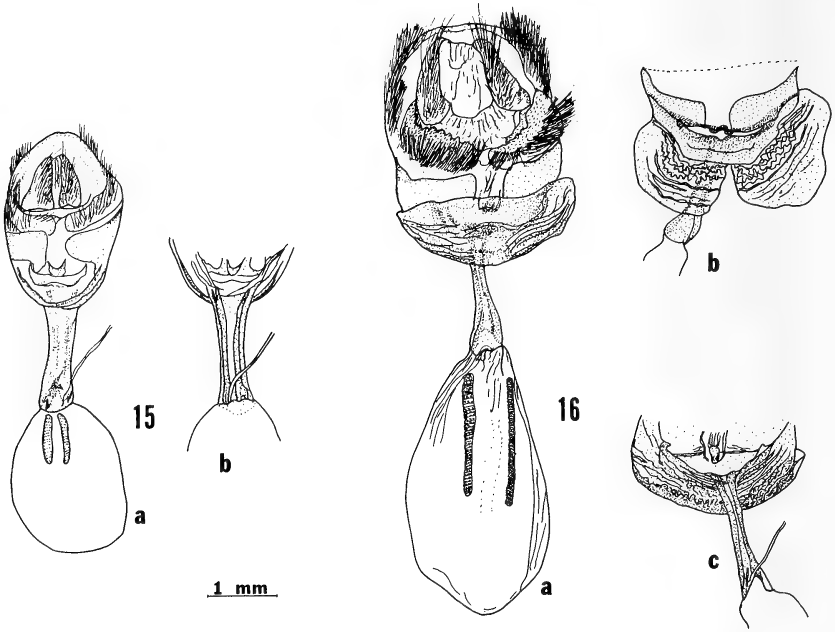


FIGS. 13 & 14. ♂ genitalia of *Pedaliodes*. **13,** *P. perperna* (Hewitson); genitalia preparation M-6653-v (Lee D. Miller); VENEZUELA: DIST. FED.: El Junquito. **14,** *P. petronius kerrianna* new subspecies, paratype; genitalia preparation M-6599-v (Lee D. Miller); PANAMA: COCLE: La Mesa, nr. El Valle. Both specimens are in Allyn Museum collection.

and habitat of this insect, as follows: "The locality is La Mesa, ca. 850 m, above the town of El Valle de Anton, Cocle Province. The butterfly flies in a very wet thickety area with scattered thin trees festooned with moss and bromeliads (it does not fly in the surrounding thick forest). The average canopy height is about 15 ft., and paths through the area quickly become quagmires. Whether it is a natural formation or secondary succession following clearing of thick forest is problematical. A thick-leaved *Clusia* (HYPERICACEAE) is abundant as are a number of MELASTOMACEAE, including *Miconia oinochrophylla* Donn.-Sm. and *Tococca guianensis* Aubl. Bromeliads on the ground are common, especially *Guzmania musaica* (Linden and Andre) Mez. in Dc. A broad-leaved cane type grass, *Olyra standleyi* Hitchc., is very abundant, and I strongly suspect that this is the larval food-plant. It is noteworthy that this grass is abundant near the top of Cerro Jefe, Panama Province, where typical *petronius* flies, and that this grass is not found in the thick forest, apparently needing a well lighted area in order to thrive."

Small states further, "In cloudy weather (which is most of the time) the butterfly makes rather short flights and alights low in the cane or other vegetation. However, when the sun shines brightly, it flies strongly and over the tops of the thickets and is very difficult to net. It generally flies from around 9:30 to 11:30 A.M.

"I have visited the locality in November, December, January, June



FIGS. 15 & 16. ♀ genitalia of *Pedaliodes* species. **15,** *P. perperna* (Hewitson); VENEZUELA: DIST. FED.: El Junquito; genitalia preparation M-6554 (Jacqueline Y. Miller); a: ventral view; b: dorsal view of sterigma and ductus bursae. **16,** *P. petronius kerrianna*, new subspecies; PANAMA. COCLE: La Mesa, nr. El Valle; genitalia preparation M-6662 (Jacqueline Y. Miller); a: ventral view; b: ventral view of sterigma and ductus bursae with lamella antevaginalis partially removed; c: dorsal view of sterigma and ductus bursae.

and July and have observed or captured it on each occasion. It appears to be particularly numerous in November, although not abundant. At other times, it was in rather small numbers. It probably flies in every month, as I have records of typical *petronius* from Cerro Jefe in March and April."

An additional ♀ specimen apparently of *kerrianna* was collected by Mr. Small at Moravia, Cartago, Costa Rica, at 910 m (3000 ft.) elevation on 27 July 1965. I have seen 13 other specimens collected by R. Hesterberg at the same locality, though sometimes higher on the mountain. He states that *petronius* is found at elevations to nearly 1500 m, but that the ecological preference cited by Mr. Small is true of the Costa Rican specimens as well. These specimens and others have been excluded from the type-series because the available material differs very slightly from the La Mesa specimens. P. J. deVries (pers. comm.) has reported other Costa Rican captures, and comments further on the ecological preferences of *kerrianna*. He says that it flies between 800 and 1000 m on the eastern slope of the Sierra de Talamanca, more specifically in the Valle de Reventazon along the Rio Pacadre in the Rio Chirripo region. He evidently has not found it at as high elevation as has Mr. Hesterberg.

ACKNOWLEDGMENTS

Many people provided information and inspiration for this article. Plant identifications were provided by Drs. Henry Stockwell and Annette Aiello of the Smithsonian Tropical Research Institute, Barro Colorado Island, Panama, and points of nomenclature (especially the authors of the plants) were confirmed by Dr. David Hall of the Florida State Museum, Gainesville, Florida. The authorities at the British Museum (Natural History), London, England, especially Messrs. R. I. Vane-Wright and P. R. Ackery, allowed me access to the type specimens of both *Pedaliodes petronius* and *perperna* and greatly assisted me in other ways during my visit to London in 1979. Mr. Philip J. DeVries, Department of Zoology, University of Texas, Austin, Texas, and Richard L. Hesterberg, formerly of San Jose, Costa Rica, and now of Clearwater, Florida, provided habitat and range information on Costa Rican populations of *kerrianna*. Mrs. Robert (Kerry Ann) Dressler originally found the El Valle population of the butterfly named after her. The photographs were made by the late Dr. A. C. Allyn and my wife and colleague, Jacqueline, of this institution, and they also read and critically reviewed the manuscript. J. Miller also provided the female genitalic dissections and analyses. Mr. Michael J. Adams, Blandford, Dorset, England, answered innumerable questions about the taxonomy of Pronophilini. Clearly, Mr. Gordon B. Small, Jr., Balboa, Canal Zone, Panama, deserves special thanks, since it was he who first provided me with material of both *petronius* and *kerrianna* and gave the detailed habitat notes quoted herein. I must express my heartfelt gratitude to all of these people for their enthusiastic cooperation.

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ECOLOGICAL NOTES ON *SYNANTHEDON DOMINICKI* DUCKWORTH AND EICHLIN (SESIIDAE) IN FLORIDA AND FIRST DESCRIPTION OF THE FEMALE

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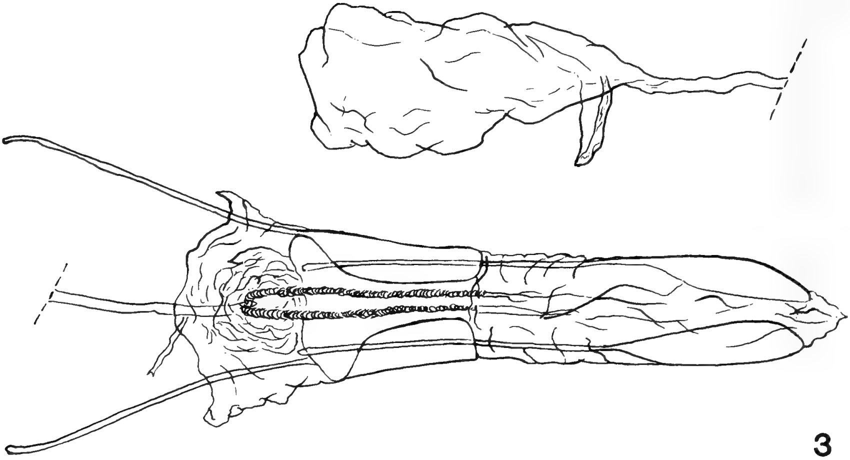
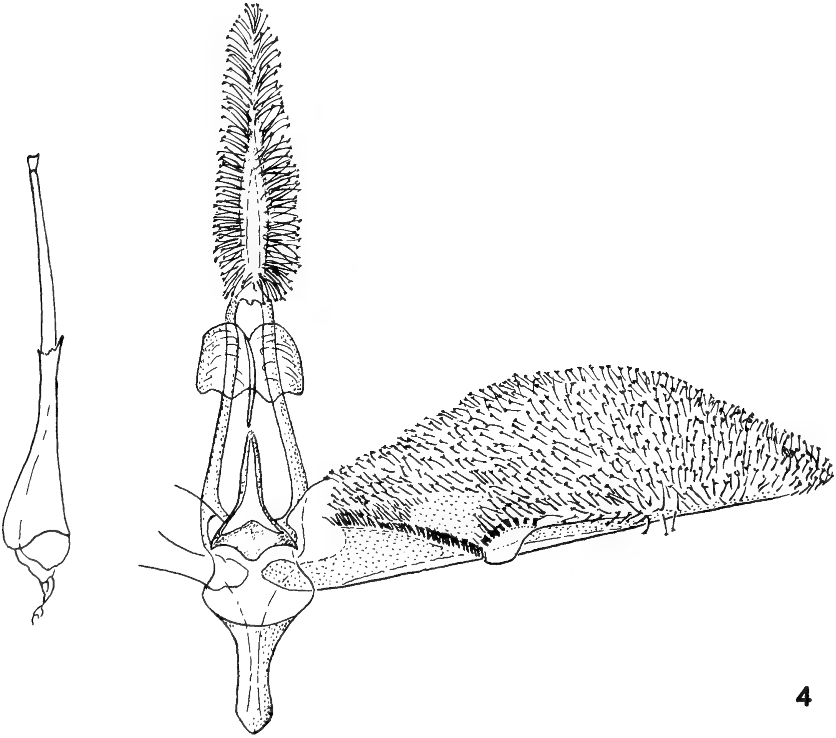
ABSTRACT. *Synanthedon dominicki* Duckworth and Eichlin, a clearwing moth previously known from only one specimen, was captured in sizeable numbers (40 specimens) in west-central Florida throughout most of the month of March 1985. The species responded only to the pheromone isomer (E,Z) 2,13-octadecadienyl acetate and occurred only in cypress swamp habitat and the adjacent hydric hardwood forest ecotone. It was totally absent from nearby mesic and xeric plant communities. The first females of *Synanthedon dominicki* ever collected are also described. The species appears to be widely distributed in Florida but in a narrow ecological zone seldom collected for sesiids.

The rare clearwing moth, *Synanthedon dominicki* Duckworth and Eichlin, is known from only one specimen taken on the Wedge Plantation, South Santee River, Charleston County, South Carolina on 27 March 1967 (Duckworth & Eichlin, 1973). The holotype is a male collected at a black light, and the female until now was unknown.

Throughout the early months of 1985, several sesiid pheromones, or, more correctly sex attractants, were employed to survey clearwing species at numerous locations in west-central Florida. The initial chemical isomer of the attractants was identified by Tumlinson et al. (1974), and the isomer effective for attracting *S. dominicki* was first identified by Schwarz et al. (1983). Several permanent sampling stations using sticky traps were placed in natural plant communities located on the 500 acre Ecological Research Area of the University of South Florida in Hillsborough County. Beginning on 4 March 1985, male *S. dominicki* began appearing in traps at two of the sampling stations. One group of traps was located in the center of a bald cypress (*Taxodium distichum*) swamp, and the other group was situated in a stand of water oaks (*Quercus nigra*) adjacent to the cypress swamp. A total of 40 male *S. dominicki* were taken in several traps baited with the attractant (E,Z) 2,13-octadecadienyl acetate between 4 March and 31 March. Most of these males (25) were trapped during a ten day period

FIGS. 1 & 2. Adults of *Synanthedon dominicki*: **1**, male; **2**, female.





FIGS. 3 & 4. *Synanthedon dominicki*: **3,** female genitalia (ventral view); **4,** male genitalia (ventral view, left valve removed).

in mid-March. *S. dominicki* failed to respond to any of five other isomers used, and none was trapped in either February or April in the Tampa Bay area, even though all traps were baited continuously during those months also. Thus, the emergence window for adults was rather short and confined to early spring. This species appears to be quite habitat specific, because no males were taken in numerous traps placed in plant communities located just outside the swamp ecotone, such as pine flatwoods, pine-turkey oak, oak-palmetto scrub, live oak hammock, wax myrtle-brush, or old-field communities.

Traps were checked at hourly intervals for several days in mid-March to determine the duration of the daily flight period for male *S. dominicki*. They entered traps only between 1300–1600 h, with the greatest flight activity occurring at mid-afternoon.

Two additional male *S. dominicki* were taken in sticky traps set 5–14 April 1985 in a swampy hardwood forest near Crystal River, Citrus County, Florida. This location is approximately 90 mi. north of the permanent sampling stations in the Tampa Bay area. Since this record is at least a week later than the end of the flight observed this year near Tampa, it suggests that the emergence period for the moth may be sightly later in north-central Florida or last somewhat longer.

While checking traps at the border of the cypress swamp on 10 March 1985, a single female *S. dominicki* was hand-netted as she hovered in the vicinity of a small waterlocust (*Gleditsia aquatica*). She was captured about 1600 h, while observed to be intermittently landing on and hovering above the vegetation of this tree. The host plant of *S. dominicki* is unknown, but it could not be determined if she was laying eggs on the waterlocust. This specimen constitutes the first record of the female of this rare clearwing moth, and the description follows below.

Surprisingly, a second female was collected in an insect flight trap on 15 April 1985 in a swampy area near White Springs in Columbia County, Florida. This is a northern Florida location about 200 mi. north of the Tampa Bay area and fits the postulated later emergence window as one proceeds northward.

Description of *Synanthedon dominicki*

Female (Fig. 2): **Head.** Front blue-black, some white adjacent to eyes; vertex blue-black, orange mixed posteriorly; occipital fringe orange; labial palp smoothly scaled, orange with black apically; antenna blue-black, lacking ventral cilia and lacking preapical white spot.

Thorax. Blue-black, narrow subdorsal stripe, orange beneath wings; legs blue-black, white on spurs and at joints of tarsal segments.

Wings. Forewing length: 9–10 mm. Forewing opaque, blue-black, ventrally with yellow at wing bases; hindwing hyaline with brown-black on small, narrowly triangular discal spot and with some diffuse dark scaling apically.

Abdomen. Entirely blue-black except for orange-red on posterior end, including anal tuft and tip of abdomen.

Female genitalia. Structures as shown (Fig. 3), with well-differentiated ostial region, and membranous narrow pouch-like protrusion on corpus bursae.

Male (Fig. 1) (see female description above and original description of species, Duckworth & Eichlin, 1973): Specimens differ slightly from male holotype in that the antennae lack pre-apical white spots, and the vertex of the head has orange mixed at the posterior margin. The major difference from the female is the forewing opaqueness, males with basal one-half hyaline, females entirely opaque.

Forewing length of males. 7–9 mm.

Male genitalia. As illustrated (Fig. 4).

Host plant. Unknown.

Distribution. Using sex attractants, the range has now been extended from South Carolina (type locality) to Georgia, Alabama and Florida.

Discussion. The data for the first recorded female specimen is as follows: Ecological Research Area, University of South Florida, Tampa, Hillsborough County, Florida, 10 March 1985, collected by L. N. Brown. This specimen will be deposited in the collection at the U.S. National Museum of Natural History, Washington, D.C.

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HOW TO DO GENETICS WITHOUT MAKING THE BUTTERFLIES CROSS

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ABSTRACT. It is possible to find out whether an inherited variety of a butterfly is sex-linked and, if it is not sex-linked, whether the variety is dominant or recessive to normal (in short, to find out its basic genetics) without carrying out pedigreed breeding experiments. These require much space, time and record-keeping, and are in any case not possible in some species.

Instead, one can raise offspring from the two types of female captured in the wild or followed while ovipositing. The mates of the females need not be observed. A fairly simple calculation based on the numbers of the two types of offspring produced by the two types of female will then reveal the inheritance of the variety.

The method is illustrated with data on the green and yellow forms of the African *Papilio phorcas*.

Working out how the different forms of a butterfly are inherited can be tedious; a pedigree record must be kept over a number of generations, the offspring of different females must be kept separate, and one needs to be fairly skilled in mendelism to set the crosses up in the way that will give the necessary information. If the variant one is studying is confined to the female, as are the white forms of some *Colias* or the black form of *Papilio glaucus,* the exercise becomes even harder, for as one cannot tell what color the male "ought" to be, one must do the crosses "blind." In addition, some butterflies cannot easily be mated in captivity.

It is, however, possible to do butterfly genetics without any of this hassle. Provided wild caught females can be persuaded to lay eggs or can be found ovipositing in the field, it is possible to determine the genetics of naturally occurring forms simply by raising the offspring of wild females. Neither the possibility that the female may be producing a mixed brood after mating with two males, nor even combining the offspring of different females in one breeding cage, will spoil the method. The only requirements are that one must be certain which color of female was the mother of the eggs, and that one of the forms should be rarer than the other. (When the forms are exactly equal in frequency the method fails completely and it requires very large numbers of offspring indeed when the rare form is over around 35% of the population.) With some tropical species one must be very cautious about information obtained from whole egg rafts, as these are sometimes laid cooperatively by several females; unless all the females have been seen from the laying of the first egg, and all are of the same color, the result can be completely unreliable (Turner, 1971, 1981; Mallett & Jackson, 1980).

I will describe the method for a butterfly having just two forms, and use data on the green and yellow forms of the African *Papilio phorcas* for illustration. North temperate zone workers may find it easier to think in terms of *Colias*: to do this, simply substitute mentally "white" for "green." With three or more forms the method becomes, needless to say, more complicated.

The method depends on a principle readily derived from the tenets of population genetics, that if the females of a rare form, having mated randomly with the males in their population, give rise to offspring which are mostly of the common form, then the rare form is recessive. On the other hand, if the rare form is dominant, it will give this fact away by producing among its offspring roughly equal numbers of the two forms. The common form, whether dominant or recessive, always tends to produce a majority of offspring like itself.

Some mathematical precision can be given to this idea (I give the proof elsewhere—Clarke et al., 1985). If the frequencies of the dominant and the recessive *genes* (not forms) in the population are p and q, then the recessive females, overall, produce offspring in just these proportions. If the green form of *Papilio phorcas* was recessive and the gene frequencies for yellow and green were 75% and 25%, then in aggregate a sample of eggs from a number of green females would produce 75% yellow and 25% green offspring. So, calling D the proportion of dominants in the offspring and R the proportion of recessives, we have the formula for the offspring of *recessive* females:

$$D = p, \qquad R = q \tag{1}$$

where p is the frequency of the dominant gene and q the frequency of the recessive.

Dominant females on the other hand produce the two forms according to the formula

$$\frac{D}{R} = \frac{p}{q} + \frac{1}{q^2} \tag{2}$$

where p and q are as before the frequencies of the dominant and recessive genes.

If the gene frequencies were as before, but the *green* form was dominant, then in the offspring of green females we would have

$$D/R = 0.25/0.75 + 1/0.75^2 = 2.11$$

and

TABLE 1. Offspring of wild females of *Papilio phorcas* from Nairobi and Ngong (Kenya). From Clarke et al. (1985).

Offspring	Mother Green	 Yellow
Green	78 (84%)	37 (51%)
Yellow	15 (16%)	35 (49%)

$$D = 2.11/(1 + 2.11) = 0.68, \qquad R = 1/(1 + 2.11) = 0.32$$

so that 68% of the offspring of green females would be green and 32% yellow.

To determine whether a rare form is dominant or recessive, we therefore compare the frequencies of the two forms among its offspring with those we would expect according to formula (1) and formula (2). Provided the butterflies are mating at random, one of these formulae will give an answer fitting the data, and the other will not. Obviously, to do this we need to know the values of p and q which, as we will see, can be obtained *either* from a population sample or from further breeding work.

What is needed, therefore, is a set of offspring derived from females of the *rare* form. There is no need for the mate of the mother to be known, nor to have any minimum number of offspring from any one female (they could well be eggs found by following ovipositing females around in the field), nor any need to keep the offspring of different females separate. All that is needed is the certainty that they are the offspring of the rare type of female.

In addition, it is necessary to have an estimate of the frequency with which the rare form occurs in the population, obtained by catching as many individuals as possible without making a special effort to capture either kind, or provided the population is large and the butterflies not too sedentary, simply by keeping a tally of the numbers of the two forms seen. If this is not obtainable, a satisfactory substitute is a large set of offspring derived from the *commoner* kind of female. Again, so long as they certainly are from this type of female, no further information is needed.

In sum, we need (1) a set of offspring from the *rarer* type of female, *plus* (2) *either* a field estimate of the proportions of the two forms *or* a set of offspring from the *commoner* type of female. Data of this kind for *P. phorcas* are shown in Table 1, where I have combined all the offspring of a large number of wild green mothers and of yellow wild mothers from the Nairobi area (including the town of Ngong). In addition, the yellow form has been reported as rare in this region, probably being a little less than 20% of the population. Suppose first that yellow is recessive. The frequency of the gene is then given by

$$q = \sqrt{0.2} = 0.447$$

(a surprisingly large frequency—nearly 45%—as recessive genes are always much more common than the form which they control). As the yellow form is recessive, yellow females should produce yellow and green offspring, from formula (1), in the proportions

$$\text{yellow} = q = 0.447$$
$$\text{green} = p = 1 - q = 0.553$$

These proportions are close to the observed numbers of the two kinds of offspring and we strongly suspect that the yellow form is recessive.

Does the hypothesis that the yellow form is dominant fare worse? In that case the frequency of the green gene (which must be recessive) is

$$q = \sqrt{(1 - 0.2)} = 0.894$$

As the yellow form is dominant, it will give rise to yellow and green forms, according to formula (2), in the ratio

$$\text{yellow/green} = p/q + 1/q^2$$

or in this case 1.368 : 1. This means that among the offspring we expect

$$1.368/(1 + 1.368) = 0.578 \text{ yellow and}$$
$$1/(1 + 1.368) = 0.422 \text{ green}$$

which is not such a good fit to what is actually observed (Table 1). The yellow form therefore appears to be recessive.

However, suppose that we do not have a good estimate of the frequencies of the two forms in the population (and the estimate of 20% yellow is in fact not particularly accurate). A perfectly good substitute for this estimate is the number of the two forms appearing among the offspring of the *common* female form. Our data for the numbers of yellow and green females arising from green mothers are given also in Table 1.

Start by supposing that yellow is dominant. In that case the yellow and green proportions from the *green* mothers are direct estimates of the gene frequencies p and q, giving in this case $p = 0.161$ (yellow) and 0.839 (green). We can test this against the offspring of yellow females, again by using the formula

$$\text{yellow/green} = p/q + 1/q^2$$

and in this case yellow : green is 1.614:1; yellow individuals should be 1.614/(1 + 1.614) = 0.617 and green individuals 1/(1 + 1.614) = 0.383 of the offspring. Again, the fit is not very good.

Checking whether yellow being recessive gives a good fit is harder this time. If yellow is recessive the ratio of green/yellow from green mothers, which from Table 1 can be calculated as 78/15 = 5.2, will give q if we solve the equation

$$(1 - q)/q + 1/q^2 = 5.2$$

This is a quadratic in q, and according to standard algebra, the general solution is that if x is the ratio of green to yellow from green mothers, then

$$q = \frac{1 \pm \sqrt{4x + 5}}{2x + 2} \tag{3}$$

Substituting 5.2 for x in (3) gives us $q = 0.490$ and therefore $p = 0.510$. These should be the proportions of yellow and green among the offspring of yellow mothers, which is clearly an excellent fit (Table 1). The yellow form is obviously recessive.

The results, particularly if numbers are small, might not be so obvious as this, and then a statistical test would have to be applied, comparing the observed and expected *numbers* (*not* the percentages).

We can summarize the value of the method with Table 2. The first column shows the frequency of the *form* which is actually recessive, and the next the frequency of the recessive gene. If we obtained offspring from recessive females (which are the rare form *above* the line and the commoner form *below* it) we would obtain the offspring proportions shown in the third column; the fourth column shows the offspring which would be obtained from the dominant females (which are the rare form in the lower half of the table). The last column shows the proportions which we would calculate for the offspring of rare females (recessive above the line, dominant below) when we took the *wrong* hypothesis about the dominance. By comparing this with the numbers in bold type, we can see how easy, or not, it is to tell that we are in fact wrong. It can be seen that provided one or other form is below about 30%, the method will distinguish very well which of the forms is dominant but that it will not work when the forms are nearly equally common in the population.

It is, however, still worth making the observations even when the forms are equally abundant, for this allows us to distinguish a sex-linked gene. For if the gene were carried on the X chromosome, then *both* kinds of female would produce offspring in the same proportions:

TABLE 2. Proportions of two types of offspring from both types of mother at different population frequencies of the rare form.

Actual frequency of recessive form (yellow)	Actual frequency of recessive gene (yellow)	Recessive (yellow) females give dominant : recessive (green : yellow)	Dominant (green) females give dominant : recessive (green : yellow)	Wrong assumption about dominance of rare form predicts that it will give green : yellow
0.001	0.032	**0.968:0.032**	0.999:0.001	**0.499:0.501**
0.005	0.071	**0.929:0.071**	0.995:0.005	**0.496:0.504**
0.01	0.100	**0.900:0.100**	0.991:0.009	**0.493:0.507**
0.05	0.224	**0.776:0.224**	0.959:0.041	**0.470:0.530**
0.1	0.316	**0.684:0.316**	0.924:0.076	**0.444:0.556**
0.2	0.447	**0.553:0.447**	0.862:0.138	**0.399:0.600**
0.3	0.548	**0.452:0.548**	0.806:0.194	**0.360:0.640**
0.4	0.633	**0.367:0.633**	0.755:0.245	**0.325:0.675**
0.5	0.707	**0.293:0.707**	0.707:0.293	**0.293:0.707**
0.6	0.775	0.225:0.775	**0.662:0.338**	**0.633:0.367**
0.7	0.837	0.163:0.837	**0.619:0.381**	**0.548:0.452**
0.8	0.894	0.106:0.894	**0.578:0.422**	**0.447:0.553**
0.9	0.949	0.051:0.949	**0.538:0.462**	**0.316:0.684**
0.95	0.975	0.025:0.975	**0.519:0.481**	**0.224:0.776**
0.99	0.995	0.005:0.995	**0.504:0.496**	**0.100:0.900**
0.995	0.998	0.002:0.998	**0.502:0.408**	**0.071:0.929**
0.999	0.9995	0.0005:0.9995	**0.5004:0.4996**	**0.032:0.968**

The ease with which one can tell which form is in fact recessive can be seen by comparing, in any particular row, the figures printed in bold type. Within the dotted lines, the figures are well-matched and the dominance is hard to determine; above and below these lines there is clear discrimination, and this is particularly marked when the recessive form is very rare or very common, as at the top and bottom of the Table.

say 60:40 green and yellow from both green and yellow mothers. Whereas, if the gene is not on the sex chromosome, the proportions, as can be seen from the center line of Table 2, are mirror images; the yellow form produces yellow : green in the ratio 0.71:0.29, whereas green produces them in the ratio 0.29:0.71.

It should be noted that this method becomes *completely* unreliable if the offspring of pedigreed captive matings are included in the data; the only permissible use of captive bred butterflies is to take virgin females and mate them to wild-caught males, or to collect larvae at random in the wild and then test their offspring, for the first generation only, by mating them in captivity. Indeed, when I first tried to apply the method to *Papilio phorcas*, there were few matings and I included the offspring of some pedigree broods to swell the numbers; the method then gave the totally incorrect answer that yellow was dominant, which shows how unreliable it is in those circumstances.

I believe that useful information could be obtained on the genetics of some of the more "difficult" species of butterflies and moths, by using this technique. The recipe provided above will be found quite easy to follow if it is applied step by step. As an example, readers might like to try to determine the inheritance of an imaginary white *Colias,* occupying 3% of its population, and giving 51 white to 49 orange from white mothers.

As a matter of history, it is worth recording that the first use of a primitive version of this method appears to have been by E. B. Poulton (1914), who determined in this way that one of the rare forms of *Papilio dardanus* was produced by a dominant gene.

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NOTES ON *PSEUDOSPHINX TETRIO* (L.) (SPHINGIDAE) IN PUERTO RICO

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ABSTRACT. An egg cluster of *Pseudosphinx tetrio* (L.) (Lepidoptera:Sphingidae) was reared to determine the duration of each developmental stage. The adult emerges after 53 days following oviposition: eggs eclose in three or more days (n = 90, sd = 0); the mean time span of the five larval instars is 24 days (n = 22, sd = 0.8), or if six stages, 29–30 days (n = 2); prepupa, close to four days (n = 22, $\bar{x}$ = 3.8, sd = 0.5); pupa, about 22 days (n = 22, $\bar{x}$ = 22.2, sd = 0.5). Larvae feed on Apocynaceae such as: *Plumeria* spp., *Allamanda cathartica,* and *A. violacea.* All stages, including the egg, are illustrated and briefly described. The morphometric variation of most stages is reported, as well as notes on the coloration of the newly molted larvae and pupae, and other data on the biology of the species.

One of the most popular ornamental trees in Puerto Rico is *Plumeria rubra* L. (Magnoliophyta: Apocynaceae), known locally as ramo or pucha de novia, frangipani or alelí. Especially during July to September, *P. rubra* trees are attacked by larvae of the sphingid moth *Pseudosphinx tetrio* (L.) (Fig. 2), which can defoliate and deflower a tree in a few days. *Pseudosphinx tetrio* has been reported as feeding in other *Plumeria* species in Puerto Rico such as *P. alba* and *P. obtusa* (Martorell, 1976) but has not been recorded feeding on species in other genera. The association of *P. tetrio* with *Plumeria* spp. was suggested by Fabricius (1775), when he described the moth under the name *Sphinx plumeriae* (Cadiou, pers. comm.). Haber (1984) described the floral biology of *P. rubra* in Costa Rica.

This moth is widespread throughout the American tropics and has been reported from the southern United States (McDonnough, 1938; Hodges, 1971) to Paraguay and southern Brazil (Moss, 1920; Forbes, 1930). In Central America it has been suggested as a possible coral snake mimic (Janzen, 1980). This species is also known from the Caribbean, having been reported from Cuba under the name of *Sphinx asdrubal* (Poey, 1832), Jamaica (Gundlach, 1891), the Dominican Republic (Druce, 1881–1900), and the Puerto Rico Region (Dewitz, 1877; Gundlach, 1891; Forbes, 1930; Martorell, 1945, 1976; Wolcott, 1948; and Medina-Gaud & Martorell, 1974).

There is only one nearly complete account of the duration of development of this species (Dinther, 1956), although partial observations have been reported earlier (Merian, 1726; Sepp, 1852, both cited by Dinther; and Janzen, 1983).

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The purpose of this paper is to report the duration of the developmental stages in the life history of *P. tetrio*. I will also add other biological information that was gathered during the study.

MATERIALS AND METHODS

An egg cluster was collected during the afternoon of 14 August 1982 in a xerophytic forest near road 333, 8 km from Guanica, a small town in southwest Puerto Rico. The cluster was placed in a polyurethane box, subsequently transferred to a plastic jar, and then placed in an incubator at 24–26°C, 24 h darkness. Humidity was provided by placing wet pieces of towels in the jars. After eclosion 30 larvae were placed individually in 30 ml cups and fed with *P. rubra* (red variety). After the third instar each larva was transferred to a 1000 ml jar. The containers and the larvae were cleaned with tap water at least every two or three days. When the pupal stage was reached, all food was removed from the jars. Prior to the emergence of adults, a piece of the central vein of a *P. rubra* leaf was placed in the jar in order to facilitate climbing and wing expansion. After emergence, several adults of each sex were kept in a 0.1 m^3 plastic box and fed with sugar water.

A previous partial rearing, from which data was taken on prepupal and pupal weight loss and some of the stage duration, had been done under similar conditions except for the dark-light period which had been about 12–12 h.

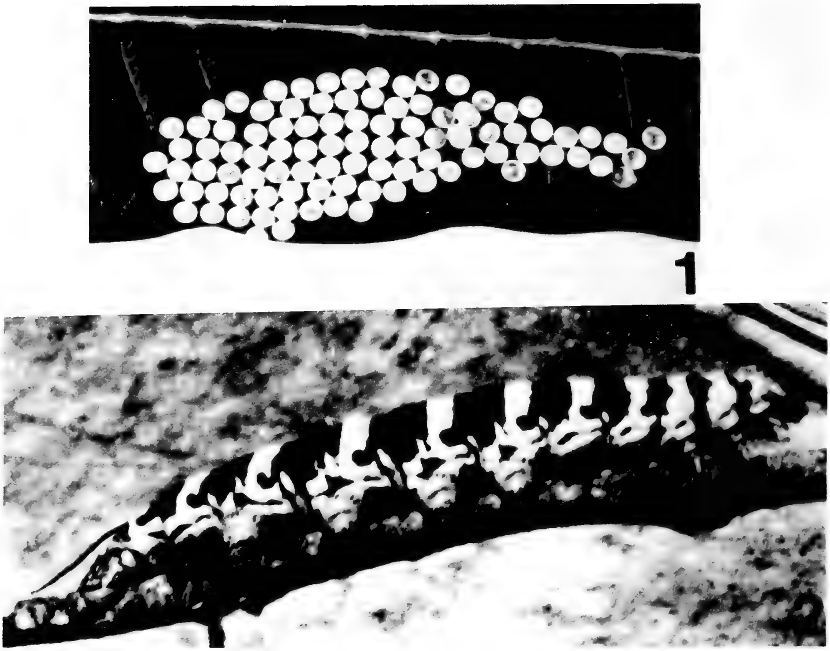
Eggs were measured with an ocular micrometer. All other measurements were made, usually during the first day of the appearance of the instar, using a metric ruler except for the cephalic width which was measured with a caliper. To measure the length of the larvae, the insect was allowed to remain inactive, and then it was firmly held by the extremities and measured.

Sixty other larvae, kept in groups of less than 12 specimens, were regularly fed with leaves of the apocynaceans *Allamanda cathartica* L., *A. violacea* G. Gardn. & Fielding, *Nerium oleander* L., and occasionally, *P. rubra*.

RESULTS AND DISCUSSION

Egg

The egg cluster consisted of 96 eggs (Dinther, 1956, reported a maximum of 69) and was found on the upper surface (Dinther, 1956, reported clusters only on the lower surface) of a *Plumeria obtusa* leaf. All but two eggs were laid in a single layer and generally, very close to or touching each other (Fig. 1). The cluster lacked a cover like that secreted by other moths. The eggs showed no sculpturing except for minute punctures on the surface. They were pale green, ellipsoidal,



FIGS. 1 & 2. *Pseudosphinx tetrio* stages: **1**, egg cluster; **2**, fifth larval instar.

and measured 2.2 × 2.5 mm (n = 11, sd < 0.1). Ninety of the 96 eggs hatched, two larvae were found with part of their intestine protruding from a lateral injury, which I presumed was caused either by the edges of the shell or by cannibalism of other larvae. Two of the six eggs that failed to hatch had a small hole in one of the extremes (parasitism?). Eclosion takes place synchronously, at least three days (n = 90, sd = 0) after oviposition.

Larva

The color of the newly molted, eruciform larva of each instar is light yellow and dark gray in alternating transverse rings. Several hours later, the larvae acquired the typical yellow and black coloration (Fig. 2).

Larval length and head capsule width increase in successive instars but tail length decreases after the third instar, probably due to reabsorption or to breakage followed by the production of a new but shorter tail. Table 1 summarizes the morphometric variation among these structures throughout the five, or six, larval instars. The results are in general agreement with those reported by Dinther (1956).

TABLE 1. Morphometric variation of total larval length, cephalic capsule width, and tail length in *Pseudosphinx tetrio* (L.). All measurements in mm. Usually there are five larval instars, a sixth was reached by a few specimens, two of which did not pupate.

Character n x̄ sd	Instar					
	1	2	3	4	5	(6)
Total larval length	30	29	29	28	28	4
	17.0	13.0	20.7	34.3	63.0	69.3
	0.4	1.9	2.8	4.0	9.4	5.7
Cephalic capsule width	30	29	28[a]	28	28	4
	1.0	2.0	3.0	4.8	7.1	8.8
	0	0.2	0	0.4	0.7	0.5
Tail length	30	29	27[b]	28	27	3[a]
	3.9	7.3	12.4	11.8	11.1	9.7
	0.3	1.1	1.1	3.1	4.6	5.0

[a] One measure not taken.
[b] Two broken tails, not measured.

Larvae fed with *P. rubra* passed through five larval instars, less frequently six. Fifth instar larvae can consume three to four leaves per day. The mean duration of each instar is: 1st = 3.2 days (n = 29, sd = 0.5); 2nd = 4.2 days (n = 29, sd = 0.5); 3rd = 4.6 days (n = 28, sd = 0.9); 4th = 5.5 days (n = 28, sd = 0.8); 5th = 6.5 days (n = 24, sd = 1.0); a mean total of 24.0 days (n = 22, sd = 0.8). If a sixth instar is present, eight more days are needed for a total of 29–30 days. Larvae that reach a sixth instar have a shorter fourth and fifth instars (4.5 and 5 days, respectively).

Other larvae were fed leaves of *Allamanda cathartica* and *Nerium oleander*, after being fed during the first two days with *P. rubra* leaves. Offered alone, *A. cathartica* leaves were eaten slowly, but those of *N. oleander* remained almost untouched. Other larvae were fed with *A. violacea* leaves.

Based on the available information, I presume that *P. tetrio* larvae rarely feed on *Allamanda* spp. in nature. An examination of the collection and of the accession cards at the Entomology Museum, Agricultural Experiment Station, Río Piedras, Puerto Rico, revealed only one record of *P. tetrio* larvae feeding naturally on *A. cathartica*. *Allamanda cathartica* constitute a new plant host record for *P. tetrio* in Puerto Rico. Other larvae were offered leaves of *Pterocarpus indicus* (Fabaceae), *Carica papaya* (Caricaceae), *Bambusa vulgaris* (Poaceae), *Lagerstroemia speciosa* (Lythraceae), *Calotropis procera* (Asclepiadaceae), and *Wedelia trilobata* (Asteraceae), but all the leaves remained untouched and many larvae died of starvation.

FIGS. 3–5. *P. tetrio* stages: **3,** pupa; **4,** male; **5,** female.

Prepupa

This stage is characterized by the shortening and darkening of the body, reduction of the prolegs, and bending of the tail. By the end of the prepupal stage, the larva has spun a silken case using also part of the uneaten foliar material. This period lasts almost four days (n = 22; $\bar{x}$ = 3.8, sd = 0.4; n = 30; $\bar{x}$ = 4.0; sd = 0.2 in the previous partial rearing). During the prepupal stage the organism loses 38.9% of its weight at the beginning of this stage (initial mean weight = 12.15 g; sd = 2.64; final mean weight = 8.74 g; sd = 1.68; n = 24).

Pupa

The newly formed pupa is yellow. After the second to the third hours, brown spots appear on its surface, and by the sixth hour the color has darkened to yellowish brown with lateral dark stripes on the thorax and rings on the abdomen. Later the pupa acquires the typical uniformly dark brown coloration (Fig. 3). During this stage there is a mean weight loss of 18.2% (initial mean weight = 8.74 g, sd = 1.68; final mean weight = 7.15 g, sd = 1.45; n = 24). Female pupae are slightly longer (L) and wider (W) than males (♀, n = 10, $\bar{x}_L$ = 72.1 mm, sd = 3.1; $\bar{x}_W$ = 17.2, sd_W = 1.1; ratio L/W = 4.2; ♂, n = 12, $\bar{x}_L$ = 69.6, sd_L = 2.0; $\bar{x}_W$ = 16.0, sd_W = 0.4; ratio L/W = 4.4). The pupal stage lasts about 22 days (n = 22, $\bar{x}$ = 22.2, sd = 0.5; n = 30, $\bar{x}$ = 21.4, sd = 0.6 for a previous partial rearing).

Adult
(Figs. 4, 5)

Adult females measure slightly more in length (L), width (W), and wingspan than males (♀, n = 7, $\bar{x}_L$ = 59.7 mm, sd = 2.3; $\bar{x}_W$ = 15.3, sd_W = 1.2; n = 3, wingspan range 134–150; ♂, n = 9, $\bar{x}_L$ = 56.7, sd_L = 4.4; $\bar{x}_W$ = 13.9, sd_W = 0.6; n = 4, wingspan range 107–129). Wingspan values are similar to those reported by Dinther (1956). Adults kept in captivity lived up to 10 days but no eggs were laid.

It is interesting to speculate about why this cycle remained little known for such a long time. Apparently, this is partly due to the susceptibility of some stages to infections (Moss, 1920; Janzen, 1983; and Abreu, pers. comm.). In addition, earlier reports lack information about rearing conditions, which may have been inappropriate and might have caused unsuccessful rearing attempts.

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GENERAL NOTES

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NATURAL HISTORY NOTES ON *ASTRAPTES* AND *URBANUS* (HESPERIIDAE) IN COSTA RICA

The close evolutionary affinity between *Astraptes* and *Urbanus* skippers (Hesperiidae) as members of the "*Urbanus* group" within the Pyrginae (Evans, 1952, Catalogue of the American Hesperiidae. Part II, British Museum of Natural History, London, 178 pp.) suggests similarities in the comparative biology of immature stages among representative species in both genera. For example, published larval food plant records for both genera include Leguminosae, and *Astraptes* has only been found feeding on members of this family (e.g., Howe, 1975, The butterflies of North America, Doubleday & Co., New York, 591 pp.; Kendall, 1976, Bull. Allyn Mus. No. 39, 9 pp.). While the majority of *Urbanus* species are legume-feeders as caterpillars, a handful of species are grass-feeders (Howe, op. cit.). Further field studies on the natural history of selected species in both genera may either confirm existing patterns of larval food plant patterns or augment them with records involving yet other families of dicotyledonous plants. It is evident that, within the Hesperiidae, tropical genera and species have undergone considerable evolutionary divergence in terms of larval food plants, with ten or more distinct food plant families known for some regions of the Neotropics (e.g., Kendall, op. cit.). In this note I summarize life cycle and larval food plant notes for *A. fulgerator* (Walch) in Costa Rica and make some brief comparisons with similar data on *U. proteus* (Linnaeus) from the same or similar localities within the country. Information on egg laying behavior is also presented. Two new larval food plant families for *A. fulgerator* are presented. The comparison of larval biology between these two genera was prompted by the striking differences in larval appearance between them, even when both are found on legume food plants and suggesting very different strategies of larval defense against visually hunting predators.

Life cycle and related natural history notes on *A. fulgerator* and *U. proteus* were accumulated intermittently over more than ten years at the following Costa Rican localities: "Bajo La Hondura" near Coronado (10°03′N, 84°00′W; 900 m elev.), San Jose Province (1972–1973); "Cuesta Angel" near Cariblanco (10°16′N, 84°10′W; 1000 m elev.), Heredia Province (1973); "Finca La Tigra" near La Virgen (10°23′N, 84°07′W; 220 m elev.), Sarapiqui District in Heredia Province (1982); "Finca La Lola" near Siquirres (10°06′N, 83°30′W; 80 m elev.), Limon Province (1983); "San Rafael de Ojo de Agua" near Ojo de Agua (8°41′N, 83°28′W; 600 m elev.), Alajuela Province (1984); "Barranca Forest" near Puntarenas (9°30′N, 84°35′W; 50 m elev.), Puntarenas Province (1984). These localities encompass a broad range of vegetational formations, from lowland to montane tropical wet forest, and including highly seasonal regions (Ojo de Agua and Barranca). All observations on egg laying behavior and collections of early stages were made in highly disturbed secondary habitats, including the borders of forest (La Tigra), forest remnants (Ojo de Agua and Barranca), and in a cacao plantation (La Lola). Immature stages were often reared through adulthood by confining eggs or caterpillars in tightly closed clear plastic bags containing fresh cuttings of the food plant. Food plant voucher specimens were collected for identification in all instances. Notes are also included for an undetermined species of *Astraptes*.

Urbanus proteus Natural History

Various authors have discussed the life cycle of this common skipper, and in this note I highlight only certain aspects of natural history relevant to a discussion of larval food plant exploitation and comparative behavior of immature stages between this species and *A. fulgerator*. Eggs (each about 1.8 mm dia., white to pale yellow with vertical grooves; spherical with flattened top) are deposited singly on ventral surface of mature

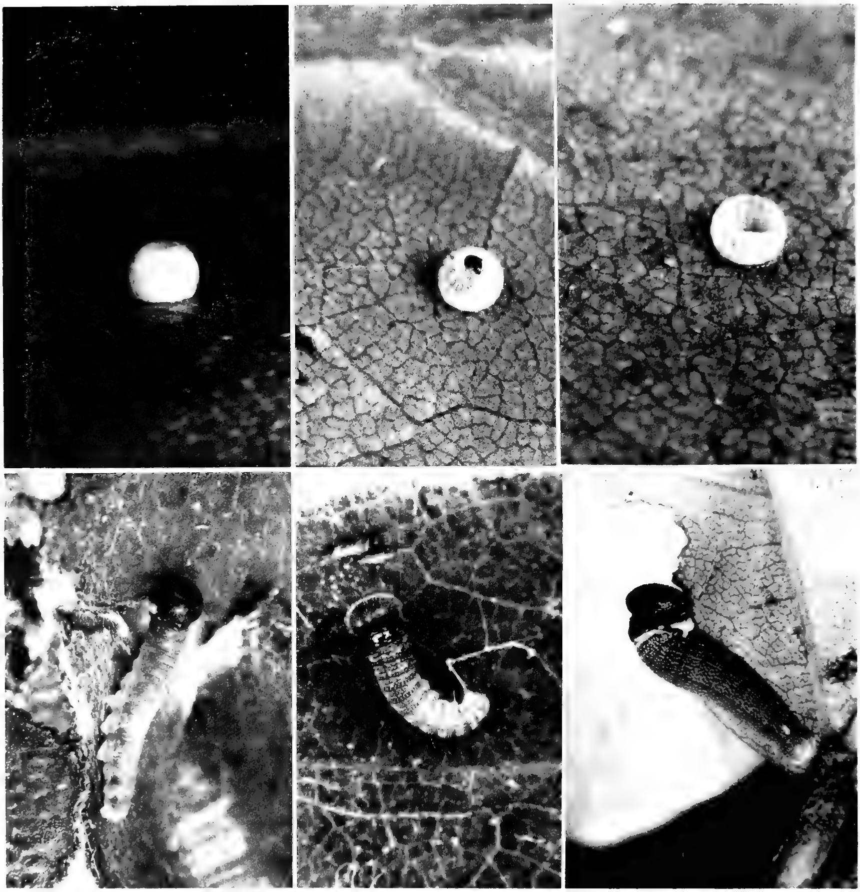

FIG. 1. Egg, first-instar, and second-instar caterpillars of *Urbanus proteus* in Costa Rica. Upper panel, from left to right: recently deposited egg, lateral view; egg in the process of hatching; egg shell after hatching. Bottom panel, left to right: first-instar about 10 minutes after hatching; first-instar constructing shelter (note silk threads); second-instar feeding at the edge of a mature leaf of *Mucuna* sp. (Leguminosae).

leaves of *Mucuna* spp. (Leguminosae), and only the top of the egg shell is eaten during the hatching process (Fig. 1). The first and second instar caterpillars construct a shelter in which to be concealed by folding over an irregularly shaped fragment of leaf along the leaf edge (Fig. 1). The caterpillar lines both surfaces of this structure with a loose network of silk and generally perches on the underside of the "roof" portion of the shelter (Fig. 2). Although initially a pale reddish brown, the caterpillar generally retains the same basic body color pattern throughout all instars: head capsule markedly bi-lobed vertically and shiny dark brown; neck "collar" red-brown above and red below (lateral-ventral flanges); body light green with "speckled" appearance and sparse pubescence of short, soft hairs (white); body sometimes appearing orange-green and with one pair of longitudinal orange lines running the length of the body; next-to-last abdominal segment with one pair of large orange blotches dorso-laterally; anal plate dark greenish brown

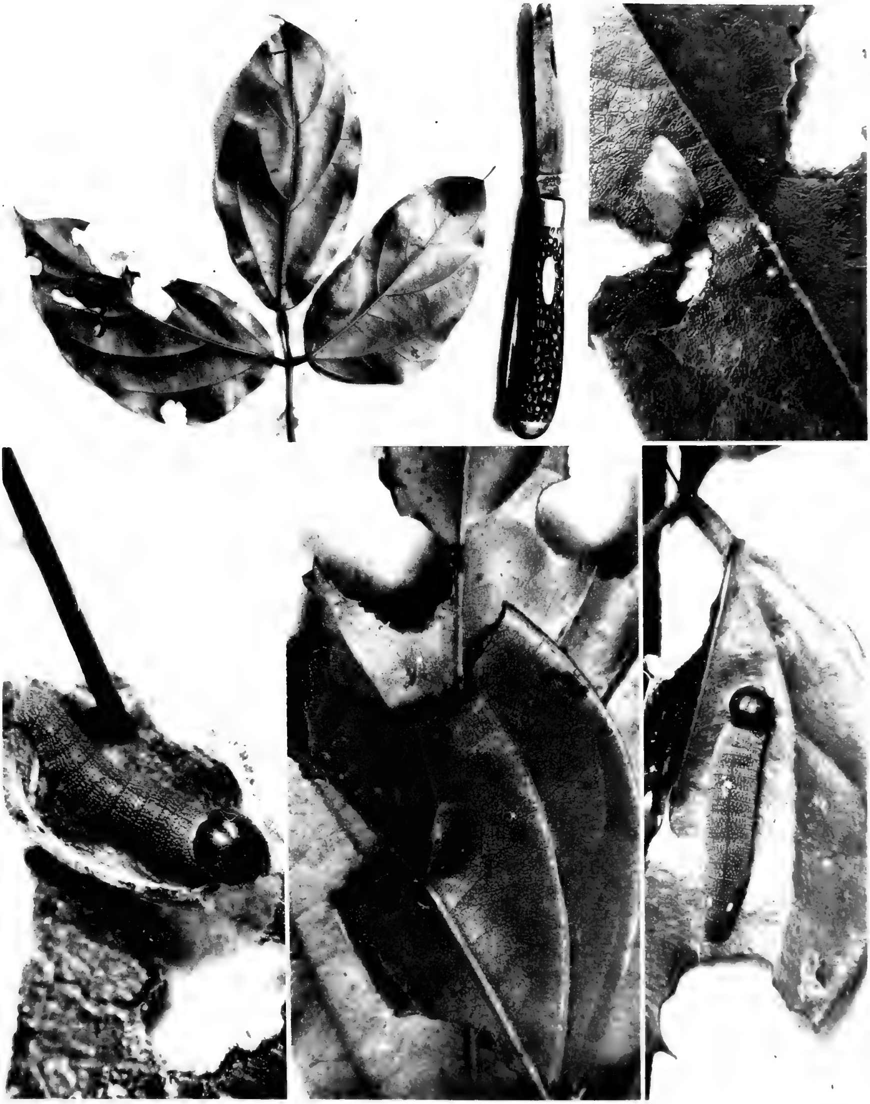

FIG. 2. *Urbanus proteus* natural history. Upper panel, left to right: *Mucuna* leaves showing characteristic feeding pattern of young caterpillar; dorsal view of tent shelter of second-instar caterpillar on the dorsal surface of the leaf. Bottom panel, left to right: third-instar caterpillar perching on silk mat on the "roof" portion of tent shelter; fourth-instar tent shelter from dorsal aspect and with caterpillar hidden from view; fourth-instar caterpillar perched on "roof" portion of tent shelter shown in the previous photograph (match up areas of leaf damaged by larval feeding).

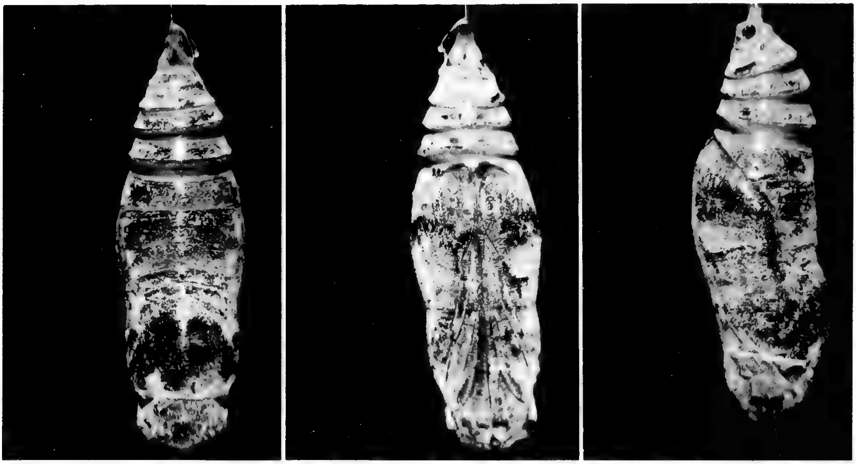

FIG. 3. Dorsal, ventral, and lateral views of pupa of *Urbanus proteus*, respectively.

but with thin border of orange. Later instars fashion tent shelters by tying together two lobes of the tri-lobed *Mucuna* leaf (Fig. 2); always solitary. Entire larval period lasts about 45 days, with transition from third to last (fifth) instar in about 20 days with an increase of 16 mm in body length (from 19 to 35 mm). The 21 mm long × 6 mm wide chestnut brown pupa is generously dusted with a bluish white pubescence (Fig. 3) and is formed with the tent shelter used by the final instar caterpillar. Eclosion takes place in about 16 days. In Costa Rica, caterpillars of *U. proteus* appear to be dusk or nocturnal feeders. It is very likely that this species occurs on a broad range of legumes in Costa Rica as noted elsewhere (e.g., Comstock & Vazquez, 1961, Ann. Inst. Biol. 31:349–448; Howe, op. cit.).

Astraptes fulgerator Natural History

Egg very similar to that of *U. proteus* except 2.0 mm diameter and placed on both meristem and mature food plant leaves. In a large patch of *Erythrina* sp. (Leguminosae) seedlings all less than 0.5 m tall in the cacao grove at La Lola, a fresh appearing female placed one egg each on a total of five seedlings within a two minute period one morning. In each case, the butterfly alighted on the underside of a large meristem leaf and quickly affixed an egg to it (12 March 1983). At La Tigra, one female distributed a total of eight eggs within a 7.0 m tall *Erythrina* tree over several minutes during a morning of intermittent drizzle and sunshine. All eggs were affixed singly to the undersides of mature leaves, one egg per leaf and widely scattered throughout the lower portion of the leafy canopy. During a drizzle spell, the butterfly flew off, only to return about ten minutes later to resume oviposition in this tree. Egg hatching involves devouring only the top portion of the shell, and the caterpillar (about 3 mm long with reddish brown body and large black head capsule) immediately crawls to the edge of the same leaf and constructs a tent shelter in a manner identical to that described earlier for *U. proteus*. The first and second instar larva rests on the underside of the "roof" leaf flap of the shelter; later instars build larger tents as also noted for *U. proteus*. Fifth instar larvae of *A. fulgerator* were found at Ojo de Agua (26 February 1984) feeding on mature leaves of *Calea urticifolia* (Willd.) (Compositae) and a single fifth instar of this species was found on *Trigonia rugosa* Benth. (Trigoniaceae) at Barranca a week later (2 March 1984). In both cases, larvae were concealed inside tent shelters similar to those found on *Mucuna* for an unidentified species of the same genus (see below) and for *U. proteus*. Both food plant shrubs possessed predominantly mature, well-worn, and heavily insect damaged leaves, with little or no meristem leaves evident during this dry season period (January–April) at both localities. Mature caterpillars of A. *fulgerator* were present on both food plants at a time when meristem leaves were either entirely absent (*T. rugosa*) or very scarce (*C. urticifolia*). For *C. urticifolia* there was a mean length ($\bar{x}$ ± S.D.) of 1.02 ± 0.43 cm for meristem leaves (defined here as soft unfurling leaves within the length range of 0.2–4.0 cm) for a total of 18 leaves measured on three branches on 26 February 1984. On 15 March 1984, $\bar{x}$ ± S.D. was 2.54 ± 1.05 cm for a total of 36 meristem leaves within the same size range on the same three branches. In captivity A. *fulgerator* fifth instars successfully completed development on the mature, worn leaves of their food plants. When the caterpillar and its woody vine-like food plant shrub were discovered along a foot path within the Barranca forest habitat (Fig. 4), a freshly eclosed adult A. *fulgerator* was netted about 10 m from the spot one hour later.

The fifth instar caterpillar of A. *fulgerator* attains a body length of 48 mm, a maximal body width of 8 mm, and a head capsule width of 6 mm. The reddish brown, markedly bi-lobed head capsule is densely covered with short-to-long white hairs (Fig. 5). The neck "collar" is yellowish orange and the ground color of all body segments is a deep wine-red; each body segment with a thick transverse white band, and the entire body is blanketed with fine white hairs of varying lengths (Fig. 5). The anal plate is dull red as are all legs. During the daytime, the caterpillar remains well concealed in a shelter formed by folding over a portion of leaf and anchoring it with a few silk threads (Fig. 5). The pupa is housed in a tent shelter formed by pulling together two or more adjacent leaves (Fig. 5). The pupa itself is very similar to that of *U. proteus*, but measuring 25 mm long by 9 mm wide; the cuticle is generously covered with a dusting of bluish white pubescence (Fig. 5). Eclosion takes place in about 19 days.

Unidentified *Astraptes* Natural History

The fifth instar caterpillar stage of an unidentified *Astraptes* was found concealed in a tent shelter on a *Mucuna* vine at Bajo La Hondura (26 December 1972) (Fig. 6). The caterpillar was 35 mm long when discovered and grew to 50 mm in length by 18 January 1973, at which time a massive number of larvae of an endoparasite emerged from it and formed a mass of cocoons on the cuticle (Fig. 6). The caterpillar is dark brown with conspicuous lateral blotches of pale green; the anal plate is dull red and the head capsule a glossy dark brown. The head capsule is covered with short reddish hairs. A second caterpillar found at this site was reared to the pupa stage. About two days prior to pupation, it became an active, orange colored prepupa, eventually pupating within its tent shelter. The 25 mm long by 8 mm thick pupa similar to those previously described. The parasitized caterpillar yielded a total of 100 *Apanteles* sp. wasps (Hymenoptera: Braconidae: Microgasterinae), a group known only to be endoparasites of Lepidoptera caterpillars (P. M. Marsh, pers. comm.).

Astraptes fulgerator has been reported as feeding on various Leguminosae (e.g., Comstock & Vazquez, op. cit.; Howe, op. cit.) and other species of the genus also on legumes (Kendall, op. cit.). The discovery in Costa Rica of this skipper exploiting both Compositae and Trigoniaceae as larval food plants is new to science. Kendall (op. cit.) lists some 11 plant families as being reliable larval food plant records for Hesperiidae in Mexico, but that list does not include Compositae or Trigoniaceae. One plant family that does turn up in hesperiid larval food plant records in the American tropics and subtropics is Malpighiaceae, a group found along with Trigoniaceae in the order Polygalales of the subclass Rosidae (Cronquist, 1981, An integrated system of classification of flowering plants, Columbia, New York, 1262 pp.). Furthermore, the Leguminosae, a common hesperiid larval food plant family and utilized by both *Urbanus* and *Astraptes*, is also within the Rosidae, but in a different order, the Fabales (Cronquist, op. cit.). Howe (op. cit.) summarizes the wide geographical distribution of A. *fulgerator* and the wide variability in the color pattern of the caterpillar stage. It would not be surprising to discover a polyphagous habit in such a species, and this note confirms this pattern for A. *fulgerator* in Costa Rica. While both *Urbanus* and *Astraptes* exploit legumes such as *Mucuna* vines in Costa Rica, the relatively aposematic appearance of *Astraptes* caterpillars compared with the subdued or cryptic-like colors of *Urbanus* caterpillars suggests a divergence in larval

FIG. 4. Habitat and larval food plant of *Astraptes fulgerator* at Barranca. Top: disturbed primary-secondary forest where the larval food plant, *Trigonia rugosa* (Trigoniaceae) was found. Bottom, left and right: habitat area where freshly-eclosed adult *A. fulgerator* netted; *T. rugosa* showing insect-damaged mature leaves (machete for scale).

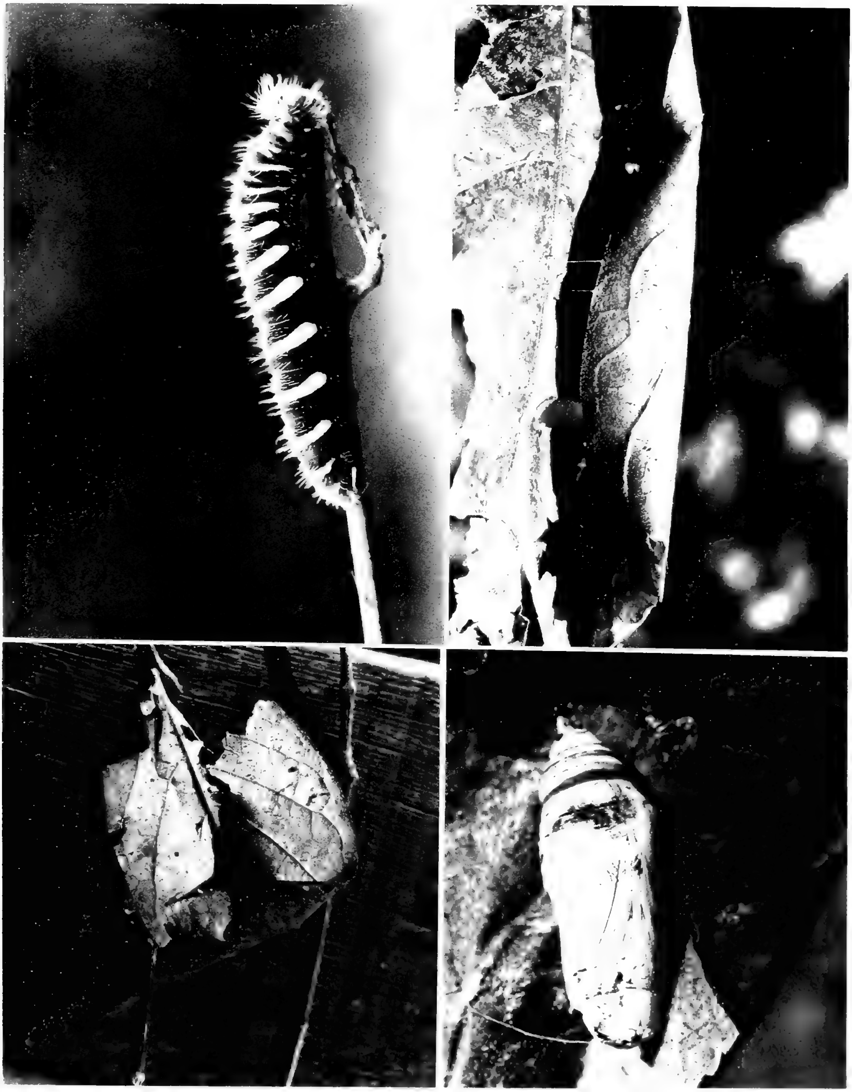

FIG. 5. *Astraptes fulgerator* natural history. Above panel, left to right: fifth-instar caterpillar, lateral view; tent shelter of fifth-instar caterpillar on *Trigonia rugosa* food plant. Bottom, left to right: tent shelter containing pupa; ventral aspect of pupa showing dusting of pubescence.

defense against predators that possess color perception abilities. While the seeds of some *Mucuna* species possess toxic secondary compounds demonstrated to thwart predation by vertebrates (e.g., Janzen, 1969, Evolution 23:1–27), far less is known about the existence of poisonous compounds within the leaves of these vines. Other herbivores routinely associated with some *Mucuna* species in Costa Rica, such as *Morpho peleides* Kollar

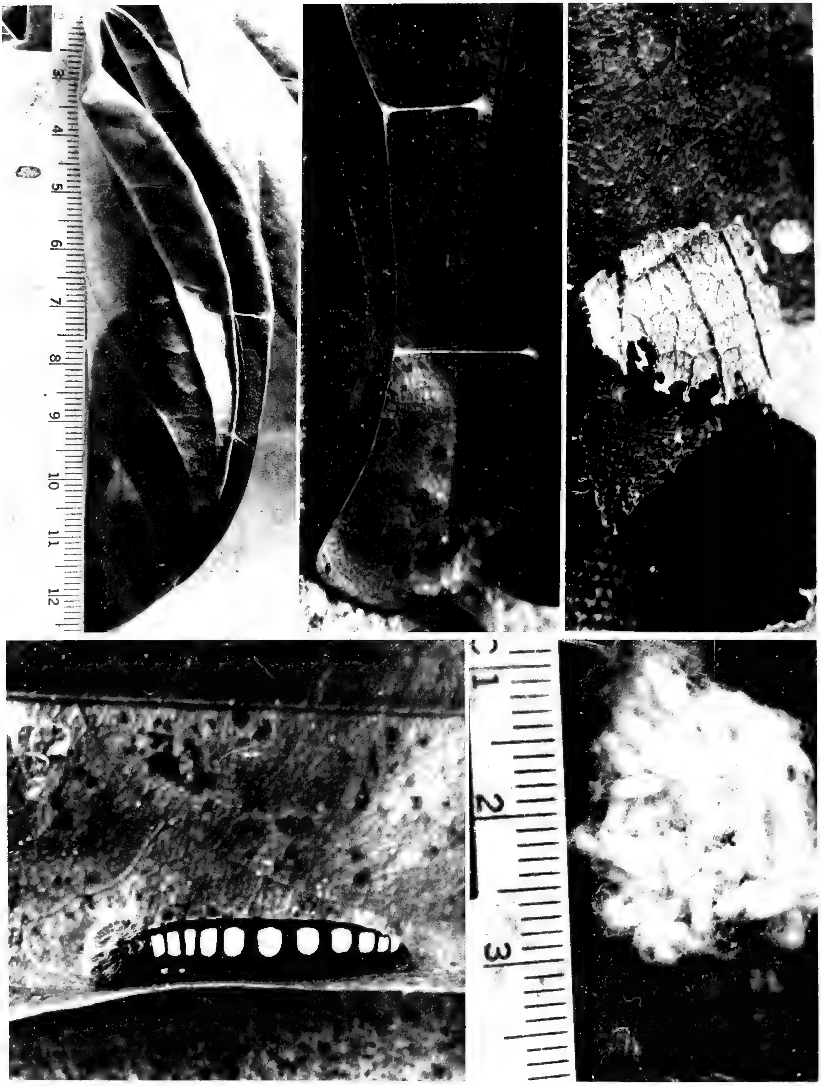

FIG. 6. Unidentified *Astraptes* species natural history. Above panel, left to right: tent shelter of fifth-instar caterpillar on *Mucuna* leaf and showing silken ties; close-up view of silken threads responsible for holding opposite sides of leaf together; tent shelter of an early instar at edge of leaf. Bottom panel, left to right: fifth-instar caterpillar, lateral view; mass of *Apanteles* cocoons on surface cuticle of fifth-instar caterpillar.

(Morphidae), have brightly colored early instar caterpillar stages and adults with iridescent blue wings (e.g., Young & Muyshondt, 1973, Carib. J. Sci. 13:1–49). In some lepidopterans associated as herbivores with plants possessing known toxic properties, some species are able to sequester the toxic compounds, while others, feeding on the same plants, are not able to do so (e.g., Rosenthal & Janzen, eds., 1979, Herbivores: Their interaction with secondary plant metabolites, Academic Press, New York and London, 717 pp.). Thus, the possibility exists that *Astraptes*, with brightly colored caterpillars and adults with iridescent blue wings, have evolved the ability to sequester presumed toxins in the leaves of legume food plants such as *Mucuna*, while *Urbanus* has not evolved such a trait. Further support for a presumed toxicity associated with *Astraptes* is afforded by the *Calea urticifolia* larval food plant record reported here: this plant is known to be extremely toxic owing to high concentrations of sesquiterpenes (L. Poveda, pers. comm.). To the best of my knowledge, *Urbanus* does not feed on Compositae or Trigoniaceae.

The discovery of mature caterpillars of *Astraptes* at the height of the tropical dry season at two localities indicates that these insects are able to exploit mature leaves at such times of the year when meristems are lacking or scarce. The cohort of adult skippers eclosing in the latter half of the dry season might "anticipate" a soon-to-be available supply of fresh meristems on which to place their eggs in the sense of *Phoebis* exhibiting such behavior on its *Cassia* food plant at this time (Young, in press). My data suggests that *Astraptes* will deposit eggs on both mature leaves and meristem leaves. To what extent, if any, does *A. fulgerator* exhibit a facultative seasonal switch in food plant families in Costa Rica awaits further field study. To what extent does *Mucuna* and other legume food plants, fully leafed-out in the rainy season, become inaccessible as larval food sources during the tropical dry season and inducing a switch to alternate food plant groups, remains to be studied. Food plant quality, and temporal changes in it, is a major determinant of food plant choice in some herbivorous insects (e.g., Marian & Pandian, 1980, Entomon 5:257–264; Rausher, 1981, Ecol. Monogr. 51:1–20; Hill, 1982, Zool. Jahrb. Abt. Syst. Okol. Geogr. Tiere 109:24–32; Lawson et al., 1982, Entomol. Exp. Appl. 32: 242–248; Messina, 1982, Oecologia 55:342–354; Miles et al., 1982, Aust. J. Zool. 30:347–355; Wint, 1983, J. Anim. Ecol. 52:438–450). Some skippers exhibit seasonal shifts in the use of their larval food plants (e.g., Nakasuji, 1982, Appl. Entomol. Zool. 17:146–148). A polyphagous insect such as *A. fulgerator* in Costa Rica may possess the complement of mixed-function oxidases within the guts of caterpillars to permit the expression of a generalist feeding behavior involving different food plant families exhibiting both qualitative and quantitative differences in the profiles of toxic compounds functioning to deter herbivorous attack (e.g., Ahmad, 1983, Ecology 64:235–243). Finally, within a relatively small region of the American tropics, a polyphagous species such as *A. fulgerator* may have undergone an evolutionary divergence in the use of different larval food plant families. Sometimes such geographical divergence reaches the point at which caterpillars from different populations cannot survive on food plants other than those found in their own habitats (e.g., Kaufmann, 1983, Proc. Entomol. Soc. Wash. 85:321–326). I was unable to detect any noticeable difference in coloration between the caterpillars of *A. fulgerator* from Ojo de Agua and Barranca, and the sample was very small. *Astraptes* caterpillars may use tent shelters on their food plants as a means of hiding from parasitoids such as *Apanteles* and Tachinidae, but such behavior does not always ensure survival as noted in this paper.

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INDEPENDENT EVOLUTION OF "FALSE HEAD" BEHAVIOR IN RIODINIDAE

Although "false head" wing patterns and behaviors, particularly hindwing movements along the sagittal plane, are well-known among Lycaenidae (Robbins, 1980, J. Lepid. Soc. 34:194–208; 1981, Am. Nat. 118:770–775), it is less well-documented that some Riodinidae have similar wing patterns. It is reported here for the first time that some have also independently evolved hindwing movements similar to those of lycaenids. This situation is intrinsically interesting as an example of convergent evolution and is additionally significant for its phylogenetic implications.

Probably the best-developed riodinid "false heads" occur in *Helicopis* Fabricius and some species of *Sarota* Westwood. These butterflies have multiple white-tipped tails and metallic markings at the anal angle of the ventral hindwing. They land with their wings folded over their backs, unlike many riodinids, and are often mistaken for Lycaenidae. Maj. Harold Harlan (Ohio State Univ., pers. comm.) first noted a specimen of *Sarota* (a species with hindwing tails) (Canal Zone, Panama) moving its hindwings while landed. In San Carlos de Rio Negro (Amazonas, Venezuela), I observed 11 specimens of *Helicopis cupido erotica* Seitz and two specimens of *Anteros formosus* Cramer (a species that lacks hindwing tails) moving their hindwings. Curtis J. Callaghan (Petropolis, Brasil, pers. comm.) has also observed this behavior in *Helicopis, Sarota,* and *Anteros* Hübner (and noted in addition that the long tails of *Helicopis* are easily moved by breezes). Hindwing movements were previously reported only among Lycaenidae.

Hindwing movements in riodinids, as in lycaenids, may occur sporadically. The literature on lycaenid behavior includes cases where one observer noted hindwing movements, whereas, another did not in the same species under similar circumstances (Robbins, 1980, op. cit.). The same appears to be the case in riodinids. Whereas, I did not observe specimens of Panamanian *Sarota* moving their hindwings, Harlan did. Whereas, I noted individuals of *Anteros formosus* moving their hindwings in southern Venezuela, Callaghan did not when he came upon a swarm of this species in Brasil's Mato Grosso. These examples point out the difficulties of interpreting negative evidence with regard to sporadically occurring behaviors.

Although "false head" wing patterns and behaviors of lycaenids and riodinids are superficially similar, they differ in detail. Lycaenid anal lobes are everted outwards while tails project inwards and cross (see fig. 12 in Longstaff, 1912, Butterfly-hunting in many lands, Longmans, Green, and Co.). In contrast, both tails and anal lobes of *Helicopis* flare outwards. Hindwing movements also differ. Lycaenids move both hindwings simultaneously; as one hindwing moves forward, the other moves backwards, and vice versa. In contrast, *Helicopis* and *Anteros* may move one or both hindwings. If both are moved, they need not be in opposite directions. In addition, their movements are "jerky" and of short duration in contrast to lycaenid movements, but I saw too few specimens to quantify this difference. These morphological and behavioral differences support taxonomic evidence that the "false heads" of lycaenids and riodinids are independently evolved.

The distribution of lycaenid "false heads" are phylogenetically significant. Eliot (1973, Bull. Brit. Mus. (Nat. Hist.) Entomol. 28:6) suggested that Theclinae, Polyommatinae, and Lycaeninae form a monophyletic clade. Among the Lycaenidae, "false heads" are known only in these subfamilies and are the only characters of which I am aware that are unique to them. This being the case, it is desirable to have better documentation of the distribution of hindwing movements within the Lycaenidae, particularly among the many Old World tribes.

Riodinid "false heads" are also phylogenetically significant. Stichel (1930–1931, Lepidopterorum catalogus, pars 40) and Clench (1955, Annals Carnegie Museum 33:261–274) placed *Helicopis* in its own tribe. Harvey (Univ. Texas, Austin, dissertation in prep.), on the other hand, proposes that *Helicopis, Sarota, Anteros,* and *Ourocnemis* Baker form a closely related group of genera. The behavioral evidence reported here supports Harvey's classification. Further, we can predict that specimens of *Ourocnemis* will be found to also move their hindwings.

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INTERACTIONS OF PARASITOIDS WITH AN *OPSIPHANES* (BRASSOLIDAE) CATERPILLAR IN COSTA RICA

Both hymenopteran and dipteran parasitoids are known to kill the caterpillars of *Opsiphanes* species (Brassolidae) in Central America (Harrison, 1963, Ann. Entomol. Soc. Amer. 56:87–94; Young & Muyshondt, 1975, Stud. Neotrop. Fauna 10:19–56). In these studies, wild-caught caterpillars on their monocot food plants (Musaceae and Palmae) are checked individually for emergence of parasitoids, with little or no direct observations on the ways in which these organisms interact with their host. In this note I describe some behavioral observations on both adult Tachinidae (Diptera) and Chalcidae (Hymenoptera) attempting to parasitize a single *Opsiphanes* caterpillar at the same time. Field observations on the interaction of hymenopteran and dipteran parasitoids on the same host are almost entirely absent in the entomological literature. Given the well-documented and studied roles of individual parasitoid species in the regulation of plant-associated insect populations in both the temperate and tropical zones (e.g., Jumalon, 1964, J. Lepid. Soc. 18:101–104; Herrebout, 1966, Z. Angw. Entomol. 58:340–355; Etchegaray & Nishida, 1975a, Proc. Hawaiian Entomol. Soc. 22:33–39; 1975b, Proc. Hawaiian Entomol. Soc. 22:41–49; Link, 1977, Dusenia 10:201–204; Zaucki, 1981, Aust. Entomol. Mag. 8:3–8; Olaifa & Akingbohungbe, Insect Sci. Appl. 3:73–77; Roth et al., 1982; Environ. Entomol. 11:273–277; Stamp, 1982, Environ. Entomol. 11:100–104; Courtney & Duggan, 1983, Ecol. Entomol. 8:271–278; Elzen et al., 1983, Environ. Entomol. 12:1872–1876; Grant & Shepard, 1983, Environ. Entomol. 12:1673–1677; Messina, 1983, Environ. Entomol. 12:807–809; Oatman et al., 1983, J. Econ. Entomol. 76:52–53; Thompson et al., 1983, Environ. Entomol. 12:1312–1314; Maier, 1984, Can. Entomol. 116:443–449; Marston et al., 1984, Ann. Entomol. Soc. Amer. 77:21–28), the field study of the ways in which different parasitoids "interact" at the same host may clarify certain aspects of how these organisms regulate populations of phytophagous species (e.g., Van Driesche, 1983, Environ. Entomol. 12:1611–1622).

A fifth instar caterpillar of *Opsiphanes* sp. was found partly concealed within a silken sleeve on a single pinna of a coconut palm (*Cocos nucifera* "dwarf" variety) on 7 March 1984 at "Finca Experimental La Lola," about 15 km east of Siquirres (10°06'N, 83°30'W), Limon Province, Costa Rica. From 7 to 16 March, I made daily observations at various hours on the presence of tachinids and hymenopterans with this caterpillar. These observations were initiated when, at 1745 h on 7 March, I observed a tachinid (described as "red eyes with gray and white striped body and wings held at about 45° angle to the body") "buzzing" around the caterpillar as the latter crawled towards the silken sleeve from an apparent feeding site elsewhere on the tree (about 2.0 m tall). On 16 March the caterpillar was collected and kept alive for rearing to adulthood, placing it in a clear plastic bag with a fresh cutting of the coconut palm leaf pinnae.

Between 7 and 12 March, the *Opsiphanes* caterpillar was found re-entering its "nest" on the same pinna, usually between 1600 and 1800 h; morning observations (0800–1100 h) on the same days indicated no activity; the caterpillar could clearly be seen resting motionless inside the nest. The nest was located on the distal-most third of the pinna, and the caterpillar either crawled directly into it, head-first (Fig. 1) or sometimes backed into it.

A single adult tachinid was observed attempting to land on the caterpillar on two dates: 7 March (1745 h) and 12 March (1500 h). Based upon the general appearance of the fly, it appeared to be the same species on both dates and it was collected on 12 March, following observations, and kept for a voucher determination. On 7 March, the fly made several attempts to alight directly on the caterpillar's body, usually in the proximal-most third region. Every time the fly made such an attempt (N = 18 instances) to land, the caterpillar jerked its head violently in broad swings through an imaginary circular axis, effectively chasing the fly away for a few moments. Between attempts, the tachinid often alighted on an adjacent pinna. For a total of 11 times, the fly intermittently perched alongside the caterpillar as it crawled towards the nest (Fig. 1), periodically trying to alight on the host again but always failing to do so. Once inside the nest, the tachinid walked over the silken surface (Fig. 1) of it, before flying off (by 1755 h). On 12 March at 1500 h, a tachinid was found walking on top of the silken nest again, when the caterpillar was motionless inside. At one point, the fly sat motionless immediately above the thoracic area of the caterpillar's body but on the outside of the thin silken layer between it and the host insect. The caterpillar was clearly visible through the fine lacework of silken mesh (Fig. 1). Periodically, the fly moved a bit and curled its abdomen under itself, as if attempting to oviposit either on the silk or through it and onto the body of the host. At 1700 h, I gently placed a dry glass vial over the tachinid as it perched above the caterpillar, and it did not move at all. The fly was collected in this manner a few minutes later.

On 11 March at 1545 h, I noticed a small black wasp securely fastened to the dorsal area of the thorax of the caterpillar. In spite of violent, head-thrashing movements identical to those exhibited in an apparent response to the presence of the tachinid, the caterpillar was unsuccessful in dislodging this wasp. At the time the caterpillar was about three cm from the entrance of the silken nest. It moved into the nest with the wasp still firmly attached. Once inside the nest, the wasp began crawling over the thoracic area of the *Opsiphanes* caterpillar. A few moments later, the big caterpillar backed out of the nest with the wasp still attached. At this time, in the good daylight, I noticed a few blackened spots on the caterpillar's thoracic area, easily spotted against the light green background color of the insect. The caterpillar, however, was not successful in removing the wasp. I collected the wasp a few moments later (using a glass vial).

The *Opsiphanes* caterpillar was collected at 1800 h on 12 March for rearing. Two days later, three tachinid pupae were found in the bottom of the rearing bag and caterpillar was dead. About a week later the tachinids eclosed and they matched the general appearance of the adult observed interacting with the caterpillar in the wild. No parasitic hymenopterans emerged.

The four tachinids were examined a few weeks later by Dr. Norman E. Woodley, Research Entomologist, Systematic Entomology Laboratory of the U.S. Department of Agriculture (Washington, D.C.), who told me that they were from a very poorly known group, making generic determination exceedingly difficult. The wasp was determined to be *Brachymeria* sp. (Hymenoptera: Chalcidae) by Dr. E. E. Grissell of the U.S. National Museum of Natural History. Species determination of the *Opsiphanes* was not confirmed since the adult was not reared.

These qualitative observations suggest that *Opsiphanes* caterpillars exhibit two types of defensive behavior against parasitoids and do so in the following order: (1) violent head-thrashings chase away tachinids some times, followed by (2) rapid movement into a silken nest. If a caterpillar is approached by a parasitoid some distance away from the nest, the second line of defense cannot be utilized. Given the fact that the caterpillar

FIG. 1. **Left:** *Opsiphanes* caterpillar entering silken nest on leaf pinna of the food plant, *Cocos nucifera* (Palmae) at Finca Experimental La Lola, Siquirres, Limon Province, Costa Rica (12 March 1984 at 1600 hr); **right:** adult tachinid perched on the silken "roof" of the caterpillar nest and directly over the thoracic region of the host's body (12 March 1984 at 1550 h).

died from tachinid attack, it is clear that the defensive behavior is not always successful. The close association of both kinds of parasitoids with the caterpillar at its nest site further suggests that chemical attractants associated with the nest itself might be involved in the host-searching behavior of the parasitoids. Volatiles are known to play important roles as chemical signals in attracting parasitoids to their hosts (e.g., Weseloh, 1980, Ann. Entomol. Soc. Amer. 73:593–601; Elzen et al., op. cit.; Kamm & Buttery, 1983, Entomol. Exp. Appl. 33:129–134; Thompson et al., op. cit.), although physical (structural) stimulants may also be involved in some instances (e.g., Cole, 1959, J. Lepid. Soc. 13:1–10; Tautz & Markl, 1978, Behav. Ecol. Sociobiol. 4:101–110). The possible role of lepidopteran silken nests as deterrents to parasitoids has not been studied in great detail, although Stamp (op. cit.) observed parasitoids attacking the gregarious caterpillars of the Baltimore checkerspot on the outside of their nests. The nesting habit of *Opsiphanes* has been known for some time (Jones, 1882, Proc. Liter. and Philosoph. Soc. Liverpool 36:327–377), but the functional role of this habit remains largely unstudied.

Young and Muyshondt (op. cit.) noted that *O. tamarindi* Fruhstorfer is parasitized by two different species of Tachinidae in El Salvador and Costa Rica, and it was assumed in that paper that adult parasitoids deposited their eggs on the food plants rather than on the host caterpillar. But one caterpillar of *O. tamarindi* in El Salvador was found with two eggs attached to the integument near the distal end of the trunk, and these might have been Tachinidae. Young and Muyshondt (op. cit.) found considerable parasitism of *O. tamarindi* by the braconid *Meteorus* sp. in El Salvador and by the chalcid *Spilochalcis nigrifrons* (Cam.) in Costa Rica. Ten of 11 pupae reared from wild-caught fourth and fifth instar caterpillars from Puntarenas, Puntarenas Province, Costa Rica eclosed as *S. nigrifrons* instead of adult *O. tamarindi* in that study. Tortricid and geometrid caterpillars associated with avocado foliage in southern California frequently exhibit "mixed" parasitism from both braconids (*Apanteles*) and chalcids (*Meteorus*) (Oatman et al., 1983, op. cit.). Young and Muyshondt (op. cit.) suggest that tachinids associated with *Opsiphanes* populations in Central America are most likely generalists on a broad range of lepidopterous hosts. Whether or not hymenopterous and dipterous parasitoids converging ecologically on the same individual host caterpillar actually engage in competition for the host remains to be studied quantitatively. And the *Opsiphanes* × Musaceae and Palmae interaction in Central America might be a good model system for such studies, given (1) the large body-size of the host caterpillars, (2) the exploitation of the caterpillars by braconids, chalcids, and tachinids (including the same individual host), (3) the relatively restricted monocot food plant association of the caterpillars, and (4) the apparent economic importance of some *Opsiphanes* (e.g., Harrison, op. cit.).

Other brassolids associated with Palmae in Central American forests may not be experiencing the same forms of selection pressure from parasitoids as *Opsiphanes*. Communally nesting aggregations of the caterpillars of *Brassolis isthmia* (Bates), which construct leaf and silken nests from adjacent palm leaf pinnae and which exhibit a strongly crepuscular feeding activity outside the nest, do not, for example, experience attacks from parasitoids such as Tachinidae and Chalcidae (A. M. Young, unpubl. observ. and field data).

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ON A PREVIOUS REPORT OF DIURNAL ROOSTING OF THE PIPEVINE SWALLOWTAIL, *BATTUS PHILENOR* (L.)

Gillaspy and Lara (1984, J. Lepid. Soc. 38:142–143) recently recounted their observations concerning a short-lived aggregation of *Battus philenor* (L.) in apparent response to an approaching rainstorm. They reported six butterflies flew to a branch of a mesquite, *Prosopis glandulosa* Torr., on 12 June 1981 near Laredo, Texas. Gillaspy and Lara (op. cit.) wondered if these butterflies would later return for a nocturnal roost, but they were unable to provide further observations. They also suggest that further, admittedly fortuitous, observations would be required to understand fully such temporary behavior.

Interestingly, observations by H. B. Parks (1935, Bull. Brooklyn Entomol. Soc. 30:196) on a similar occurrence provided some answers to questions raised by Gillaspy and Lara (op. cit.). On 7 June 1935, near Santa Rita in southern Brooks Co. (approximately 150 km southeast of Laredo), he observed 40 *B. philenor* (prior to commencement of rain) fly toward and hang underneath the limbs of a huisache, *Acacia smallii* Isely, with, "The thick leaves and branches thus giving complete protection." Of particular significance to one query presented by Gillaspy and Lara (op. cit.) is the report of a "Ranchman [who] stated that these butterflies came to this one tree . . . also to roost during the night."

Field workers in the southern Texas area should be aware of the need for observations on these nocturnal roosts, if they exist. Obviously, each butterfly rests at night at some location. The significant question is whether these butterflies rest individually or clumped in aggregations.

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NATURAL HISTORY NOTES FOR SOME *HAMADRYAS* BUTTERFLIES (NYMPHALIDAE: NYMPHALINAE; AEGERONINI) IN NORTHWESTERN COSTA RICA DURING THE TROPICAL DRY SEASON

The relatively small cluster of species belonging to the nymphaline genus *Hamadryas* are well known as "calicoes" or "crackers" in the adult stage throughout much of Central America, Mexico, and South America. The medium-sized gray-and-white speckled butterflies are pugnacious, fast-flying insects that commonly perch on the trunks of trees during the daytime, head downwards, and with the wings held pressed down in the open position. Their fast aerial antics coupled with loud clicking noises evident in both sexes, and often involving attack approaches to "intruders" into their areas, have made them the subject of behavioral studies (e.g., Ross, 1963, J. Res. Lepid. 2:241–246). As a group, the caterpillars feed on Euphorbiaceae, particularly vines and shrubby plants of the genus *Dalechampia* (e.g., Young, 1974, Z. Angew. Entomol. 76:380–393; Muyshondt & Muyshondt, Jr., 1975a, J. New York Entomol. Soc. 83:157–169; 1975b, J. New York Entomol. Soc. 83:170–180; 1975c, J. New York Entomol. Soc. 83:181–191; Jenkins, 1983, Bull. Allyn Mus. 81:1–146) and may function as significant selective agents in the evolution of herbivore resistance in these plants (Armbruster, 1982, Amer. J. Bot. 69:1429–1440). Adult butterflies are typically associated with open pastures and borders of dense vegetation (Ross, 1964, J. Res. Lepid. 18:11–26; 1967, J. Res. Lepid. 18:11–26; 1967, J. Res. Lepid. 15:109–128; Monroe et al., 1967, J. Lepid. Soc. 21:185–197). Because some species of *Hamadryas* occur in the seasonal tropical dry forest zones of Central America, they offer the chance to study the impact of tropical seasonality upon their natural history. In this note we report such preliminary field studies from the lowland tropical dry forest zone of northwestern Costa Rica as performed during the dry season. Herein, we describe some hitherto unreported features of adult behavior, including nocturnal perching relative to daytime perching, and evidence that, although females are mated during this period, they appear to be in a state of reproductive diapause.

From 2–4 March 1984 we studied and collected adult *Hamadryas* from these two localities: (a) about 1.5 km south of Liberia (10°40′N, 85°40′W), Guanacaste Province and along the Pan American Highway, and (b) "Barranca Site" (Orians, 1969, Ecology 50:783–801) about 6 km from Miramar (10°06′N, 84°44′W), Puntarenas Province. Both localities fall within the region of lowland tropical dry forest and experience a completely dry (no rainfall) season generally between December and May each year. Within a wide rectangular roadside area (approx. 50 m × 100 m) at the Liberia site, we studied the abundance and habits of adult *Hamadryas* on several mature forest canopy trees, mostly *Guazuma ulmifolia* Lam (Sterculiaceae). Approximately 75% of this area was covered by a dense patch of disturbed forest, consisting chiefly of a *Guazuma* "canopy" and fairly evergreen understory consisting of various Leguminosae, Flacourtiaceae, and other small trees and shrubs in varying degrees of "leafing out" at the time. We examined the distribution of adult *Hamadryas* perching on tree trunks within the forest patch and along its borders at various times of the day and night. As it was quickly apparent that the butterflies were most numerous along the strip of shade trees between the forest patch and the highway (Fig. 1), we concentrated our observations to that area which contained eight mature *G. ulmifolia*, one *Enterolobium cyclocarpum* Donn. Smith. (Leguminosae) and two palms (unidentified). We observed the occurrence of *Hamadryas* adults on the trunks of these and other trees during the daytime and also on two evenings; daytime observations were made intermittently from about 0800 and 1800 h on the two days. Evening or nocturnal observations were limited to 2000 to 2200 h. We searched tree trunks and foliage for resting butterflies at night, using head lamps and flashlights. On 3 March, we studied the movement of butterflies from tree trunks to other perching sites at 1700 to 1800 h.

Potential adult food sources were noted as well as the availability of *Dalechampia* within the immediate vicinity (the forest patch) to determine the presence of immature stages. On the first night of study (2 March), we collected a series of adults for species vouchers, and during the day we made every attempt to recognize different "morphospecies" of adults and later matched vouchers with these field observations. We measured air temperature patterns in both shaded and exposed areas during the late morning, as well as wind strengths. To do the latter, we determined the degree to which the bag of a standard insect aerial net would be inflated (held horizontally) at the edge of the forest acting as a wind break and also in the adjacent pasture. We did this to determine a possible relationship between adult perching sites and protection from the strong wind gusts characteristic of the Guanacaste dry season.

Three piles of rotting bananas were placed on the ground at the "Barranca Site" locality, a patch of semi-deciduous forest; these baits were placed along the foot path and the upper or southern end of this forest patch to attract adult *Hamadryas*. These three baits were scattered at 50–100 m intervals along the train, and the first one was placed at the base of a large *Samanea saman* (Leguminosae) tree, which is located about 10 m from a small grove of *G. ulmifolia* trees. The baits were distributed at about noon on 2 March and reexamined for butterflies between 1400–1600 h on 4 March. Our purpose was to determine the *Hamadryas* species active here to compare with Liberia specimens, and to collect females for evidence of mating and reproductive condition.

Adult female butterflies were stored in glassine envelopes and placed in a freezer upon return to Milwaukee a few days after the field work. The butterflies were then thawed and examined with a dissecting microscope to determine (a) the presence of spermatophores and mating plugs, and (b) the degree of development of ovary tissues. The number of ova, immature and mature, were counted. Species determinations were made following the keys of Jenkins (op. cit.).

Notes were taken on the presence and activity of other Papilionoidea at both localities to compare with *Hamadryas*.

At about 2100 h on 2 March we collected five *Hamadryas guatemalena guatemalena* (Bates), and two *H. glauconome glauconome* (Bates) and one *H. feronia farinulenta* from the foliage of two adjacent trees along the front edge of the forest patch facing the highway. Other butterflies collected perching in the same foliage included *Callicore pitheas* (Latreille) and *Opsiphanes cassina fabricii* (Boisduval) (Brassolidae). Unlike daytime perching on tree trunks, nocturnally perching *Hamadryas* are positioned on the undersides of leaves and with their wings tightly folded. The same is true for other butterflies found perching on foliage at night (see also Young, 1979, J. Lepid. Soc. 33: 58–60). In some instances, *Hamadryas* adults at night could be collected using fingers rather than a net.

On the following afternoon, we documented the movement of *Hamadryas* from tree trunk perching sites to nearby foliage for nocturnal roosting. Between 1741 and 1756 h, we observed a total of 13 butterflies (three species: *H. guatemalena guatemalena, H. glauconome glauconome* and *H. feronia farinulenta*) fly into a single evergreen bush within 3–5 m of nearby *G. ulmifolia* trees used as daytime perching sites. At approximately 1 to 2 minute intervals, 1–2 butterflies fluttered into the foliage from the surrounding area, and by 1758 h, all 13 individuals were perched on the undersides of leaves with wings closed, and all within 15 cm to 1.0 m of one another in the bush. Throughout the study period, the weather was hot, sunny and dry. During the dusk settling process, arrivals of some individuals resulted in others being temporarily disturbed, flying off and

FIG. 1. Clockwise, from upper left photograph: the western edge of the forest habitat at the Liberia locality—*Hamadryas* was commonly found perching on the trunks of the trees to the right during the day and on the foliage to the left (4 March 1984); *H. guatemalena* resting on the trunk of a tree at the Liberia locality; *Guazuma ulmifolia* fruits on the ground; *G. ulmifolia* trees in the open pasture immediately south of the forest patch at the Liberia locality (also 4 March 1984).

eventually returning. A check later that evening (about 2030 h) revealed no further additions. Butterflies did not perch on foliage during the daytime.

A search for *Hamadryas* butterflies on tree trunks throughout the study site at Liberia (4 March at about 0900 h) revealed none associated with trees within the forest, nor any along trees bordering the eastern, northern, and southern boundaries of this patch; all butterflies were found on a few trees along the western border of the patch. Of eight *G. ulmifolia* trees in this area, only three had one or more *Hamadryas* perching on them during the day. There was almost an equal number of both sexes, judging from field observations and collections made, but one species, *H. guatemalena*, was more commonly encountered than others at both localities (Table 1). Most of these butterflies appeared to be "fresh" in terms of the wing condition, and all but one female was mated (Table 1). Interestingly, only one species, *H. guatemalena*, was found at both localities, with an additional four species being distinct between them (Table 1).

We could not detect any species-specific differences in daytime or nocturnal perching behavior at Liberia. It appeared that all species were responding to prevailing environmental conditions in the same manner. Mid-morning measurements (1000 to 1030 h on 3 March) of air temperature in the shade at a *G. ulmifolia* tree frequently used for perching by *Hamadryas* and another individual of the same tree a few meters away and in direct sunlight revealed no differences (31.0°C at both trees at 1000 h and 30.6°C and

TABLE 1. Sex ratios, relative wing condition, and reproductive states for small samples of adult *Hamadryas* species at two localities in northwestern Costa Rica during the tropical dry season.*

Date(s)	Species	No. of adults			Wing condition**	Reproductive state
		Male	Female	Total		
	"Liberia, Guanacaste"					
2–4 March 1984	*H. guatemalena guatemalena* (Bates)	4	1	5	2mF, 2mI, 1fF	mated
	H. glauconome glauconome (Bates)	2	0	2	2mF	—
	H. feronia farinulenta (Fruhst.)	1	0	1	1mF	—
	"Barranca Site, Puntarenas"					
4 March 1984	*H. guatemalena guatemalena* (Bates)	0	2	2	2fF	mated; mated
	H. februa ferentina (Godart)	0	1	1	1fF	unmated
	H. iphthime ipthime (Bates)	0	1	1	1fF	mated

Total species (both localities): 5
Total individuals & overall sex ratio: 7 males + 5 females = 12

* Counts were made of adult butterflies found perched on trunks, branches, and leaves of trees at the study sites. Other species present at the "Liberia" locality trees were: *Callicore pitheas* (Latreille), *Eunica malvina* (Bates), *Siderone marthesia* (Cramer), and *Opsiphanes cassina fabricii* (Boisduval). Reproductive states were examined for female butterflies only.

** Lowercase letters refer to sex (m = male, f = female) while uppercase letters designate wing condition: F = fresh, I = intermediate-worn.

30.8°C for exposed and shaded trees, respectively, at 1030 h). We did discover that wind gusts quickly inflated the bag of the aerial insect net along the open pasture area immediately adjacent to the forest patch, but the bag remained almost completely deflated when positioned along the western edge of the forest at the point where butterflies were perching on tree trunks (tests performed 0930–1000 h on 3 March). This observation suggests a wind-sheltering factor in the choice of tree trunks by *Hamadryas*.

Counts of freshly fallen, sweet-smelling, *G. ulmifolia* fruits in four different one-by-one meter plots gave the following results: 70 and 73 fruits for two adjacent trees along the shaded western edge of the forest patch and 25 and 15 fruits each for two trees in the open pasture south of the forest patch. Since some butterflies in this region of Costa Rica feed on fallen *G. ulmifolia* fruits (e.g., Young, 1975, Rev. Biol. Trop. 23:101–123), we attempted to observe possible feeding by *Hamadryas* on these fruits at the Liberia locality, but this behavior was not observed. We searched for evidence of adult *Hamadryas* feeding on these fruits, fresh cattle dung, and sap flows at the Liberia locality, but none was seen in spite of checking at various hours of the day. Most of these observations took place after 0830 h and we might have, therefore, missed an early morning feeding period. Of four *Hamadryas* observed near one of the banana baits at the Barranca Site, one of these was found feeding on the bait (1400 h, 4 March) along with several *Caligo memnon* Felder; three of the *Hamadryas* were perched on the *S. saman* tree immediately behind the bait. No *Hamadryas* were found here on either of the two remaining baits or on *G. ulmifolia* fallen fruits nearby.

Of the five female specimens of *Hamadryas* collected for examination of reproductive condition, only one individual of *H. guatemalena* had a single mature (sculpted surface) egg and all others either had no ova at all or immature ova, in spite of (a) appearing in relatively "fresh" wing condition and (b) with one exception, being mated as evidenced by the presence of single spermatophore (Table 2). The spermatophore found in the

TABLE 2. Evidence for a lack of female reproductive activity (egg production) in *Hamadryas* species in northwestern Costa Rica during the tropical dry season.

Species*	Female no.	Condition of ovary	Spermatophore**	
H. guatemalena guatemalena (Bates)	1	no ova	one present, "fresh"	(mated)
	2	no ova	one present, "fresh"	(mated)
	3	one near full size egg only	one present, broken, "old"	(mated)
H. februa ferentina (Godart)	1	no ova	none	(unmated)
H. iphthime iphthime (Bates)	1	four immature ova	one present, "fresh"	(mated)

* With the exception of one female of *H. guatemalena*, all of these butterflies were collected at the "Barranca Site" locality.
** "Fresh" spermatophores appeared full and when pierced, exuded a milky fluid, and were intact within the bursae copulatrix; "old" spermatophore appears collapsed and fragmented.

individual with the single mature egg appeared "old" since it was easily fragmented during the dissection, whereas, other spermatophores appeared "fresh" (Table 2).

Our data, while preliminary and based upon small sample size, does point out some interesting new information about the natural history of *Hamadryas* in lowland tropical dry forest during the dry season: (1) occurrence of individual species may vary considerably over relatively small distances (e.g., 40 km); (2) behavioral posturing associated with nocturnal perching is very different from that of daytime perching, both in the site of perching and the posture of wings; (3) the choice of both daytime and nocturnal perching sites may be determined in part by the location of trees and foliage in wind-sheltered places and having little or nothing to do with thermoregulation in response to dryness; (4) by the middle of the lengthy dry season there may be little or no reproductive activity as indicated by the absence of mature ova in most female specimens examined; (5) adults active at or near the middle of the dry season may represent the final "wave" of adults to eclose during this season as seen by their "fresh" wing condition and that these individuals do mate; and (6) there may be little or no adult feeding at this time, and little or no egg placement as well. Young (op. cit.) studied the life cycle of *H. februa* at the Barranca Site early into the dry season (December) and observed egg placement and successful larval development on *Dalechampia*, which was still evergreen at this time. He might have been studying the immature stages of a crop of fresh adults that would be active later in the dry season at this locality. Ehrlich and Ehrlich (1978, J. Kansas Entomol. Soc. 51:666–697) collected a single female of *H. feronia* which had thirteen ova, a figure in sharp contrast with the ova-less females found in our study. We interpret this difference to highlight the lack of reproductive activity in these butterflies, as seen in our sample, during the latter half of the tropical dry forest lengthy dry season. Spermatophores present in these butterflies at this time appeared fresh (i.e., filled with milky white fluid) and perhaps are used to fertilize ova that may develop at the end of the dry season and early into the rainy season. As we did not find larval food plants at the Liberia locality and did not check for them at the Barranca Site, we can only tentatively speculate that they were in short supply at this time of the year. We suggest that *Hamadryas* undergo a reproductive diapause in ovarian development during the latter half of the dry season and that the presence of fresh spermatophores at this time is an adaptation to facilitate egg maturation and egg placement when the rainy season begins. The observed absence of mating plugs suggests that these females may mate again, perhaps at the end of the dry season or early into the rainy season, if they survive. Butterflies thriving in open areas and at the edges of forest habitats in the tropics may necessarily experience such cessations in breeding in response to diminished resources for immature stages. The association of *Hamadryas* with such habitats is well known (e.g., Ross, 1976, op. cit.; Jenkins, 1983, op. cit.; Schwartz, 1983, Mus. Nac. Hist. Nat.

Santo Domingo, 69 pp.). Adult butterfly populations in the seasonal tropics generally decline as the dry season advances, and there is less reproductive activity at this time, both in the New World and Old World tropics (e.g., Young, 1981, Oct. Oecol. Ecol. Gener. 2:17–30; Spitzer, 1983, J. Res. Lepid. 22:126–130).

Declines in butterfly populations with the dry season may reflect contracting supplies of larval food (Spitzer, 1983, op. cit.), and reproductive activity may be restored as deciduous larval food plants produce tender, new meristems in the latter half of the dry season (Young, 1983, J. Lepid. Soc. 37:313–317). In one forest patch along the Pan American Highway between Canas and Liberia, we observed the moth *Haemaorrhagia* (Sphingidae) carefully placing eggs singly on the small (2–5 mm long) folded leaf meristems of an unidentified understory tree near dusk (2 March). Adults of many butterfly species were seen at the Barranca Site at this time, including: *Morpho peleides* Kollar, *Caligo memnon* Felder, *Memphis morvus boisduvalo* Comstock, *Consul fabius* Doubleday, *Siproeta stelenes* Fruhst., *Zaretis itys* Cramer, *Taygetis andromeda* Cramer, *Philaethria dido* Linnaeus. *Parides arcas mylotes* Bates, *Battus polydamas* Linnaeus, and *Papilio anchisiades idaeus* Fabricius. Many plant species at this locality have small meristems at this time, and some butterfly species selectively oviposit on these tissues. For example, we observed *Itaballia demophile calydonia* Boisduval carefully placing eggs singly on very fresh leaf meristems of *Capparis* sp. (Capparidaceae) at 1530 h on 4 March. Cuttings of meristem stem tissues of this plant species quickly wither, even when confined to tightly closed plastic bags, whereas, cuttings of older stems do not wither as fast. We interpret these observations to mean that considerable moisture stress is operative on butterfly food plants at this time and that new meristems may be a very limited resource for egg placement in various plant groups present.

Our data suggest that *Hamadryas* adults devote considerable time daily to perching on tree trunks in sheltered places. Many insects living in moisture-stressed habitats carefully position themselves to minimize direct exposure to sustained dryness and related ambient factors (e.g., Egwuatu, 1980, Z. Angew. Entomol. 90:347–354; Toms, 1981, Zool. Zh. (U.S.S.R.) 60:1486–1494; Shelly, 1982, Physiol. Zool. 55:335–343; Gillis & Possai, 1983, Ecol. Entomol. 8:155–161; Findlay et al., 1983, Ecol. Entomol. 8:145–153; Chappell, 1983, Anim. Behav. 31:1088–1093; Shiffer, 1983, J. Med. Entomol. 20:365–370). Oftentimes, an insect species in a particular habitat will exhibit strong diurnal changes in distribution in response to day-night cycles of both temperature and illuminescence (e.g., Van Etten, 1982, Entomol. Exp. Appl. 32:38–45; Parker, 1982, Amer. Midl. Nat. 107: 228–237). The nymphalid butterfly *Anartia fatima* Fabricius forms loose "aggregations" of adults in wind-sheltered bushes for nocturnal perching during the Guanacaste dry season (Young, 1979, op. cit.). The observed tendency for adult *Hamadryas* to perch both day and night on the wind-sheltered edge of a forest patch may reflect a concentration of "nuclear" adult populations around such places during the dry season. Mediterranean fruit flies are present in higher densities in traps in dry areas than in wet areas in the Hawaiian Islands (Vargas et al., 1983, Environ. Entomol. 12:303–310). The same species of insect may selectively choose different plant parts as perching sites at different times of the diurnal cycle, as witnessed in our study. Tsetse flies in Africa perch on woody plant parts in the day and on leaves at night (Turner, 1980, Insect Appl. Sci. 1:15–21).

Our data clearly suggest a tenacity of *Hamadryas* to forest sites in the seasonal tropics, an adaptive response, we suggest, to increasing the survival of small populations of diapausing adults in protected places until the rainy season begins and larval food plants leaf out. Many Euphorbiaceae exhibit marked seasonal cycles in vegetative growth in the tropics (Lieberman, 1982, J. Ecol. 70:791–806). And while dry season weather conditions may have adverse effects on egg-laying activity in butterflies (e.g., Zalucki, Res. Popul. Ecol. 23:318–327), we suspect that severe larval food plant availability is the prime factor selecting for dry season diapause in adult *Hamadryas* during the later phases of the dry season in this region of Costa Rica. We do not extend these predictions to other, i.e., less seasonal, regions of Central America where these butterflies also occur. "Fresh" but mated female *Hamadryas* may exhibit a preference for staying in and near forest patches during the dry season and may move away from these sites in search of oviposition sites when older. Older, mated tsetse flies exhibit different habitat preferences from new females in the Ivory Coast (e.g., Gouteux, 1982, Cah. Orstom. Ser. Entomol. Med. Parasitol. 20:41–61). In short, we might have missed finding older female *Hamadryas* (with "worn" wings) since our census program was very limited. But, both "fresh" and "worn" males and females of *Morpho peleides* Kollar (Morphidae) exhibit confined movements in the Barranca Site forest throughout the dry season (Young & Thomason, 1974, op. cit.).

We were surprised to find no evidence of adult feeding in our brief study, with the exception of observing one adult on the banana bait at the Barranca Site. While these butterflies are known to feed on sweet smelling rotting fruits (e.g., Schwartz, 1983, op. cit.) as well as on tree sap (Ross, 1976, op. cit.) and horse dung (Jenkins, 1983, op. cit.), we did not observe feeding on naturally occurring food sources. The cattle trail that runs to one side of the trees along the highway had piles of fresh dung (cattle and horse). Jenkins (1983, op. cit.) suggests a preference for horse dung over cattle dung by these butterflies. Whether or not there is a cessation of adult feeding in the dry season physiologically linked to a probable reproductive diapause, remains to be studied. Subsequent to this study, one of us (A.M.Y.) observed *H. amphinome mexicana* (Lucas) feeding on freshly fallen "guava" fruits at "Finca La Tirimbina," near La Virgen (10°23'N, 84°07'W; 220 m), Sarapiqui District, Costa Rica on 2–4 August 1984. Several butterflies were seen inserting their probosci into small wounds in the fruits (1100–1400 h).

Because shaded pockets of forest in highly seasonal tropical localities are refugia for many animals during the dry season, predation upon adult *Hamadryas* may be exceedingly high at these times, further selecting for avoidance of feeding, particularly on the ground. Lizards and birds figure prominently as predators on adult *Hamadryas* (Jenkins, 1983, op. cit.). Different types of predators, attacking different life stages, may act at different seasons to exploit *Hamadryas* populations. If predation on adults is high during the dry season, it might be lower in the rainy season and replaced at these times by increased mortality of immature stages. In the seasonal tropics, some insect populations are "regulated" by varying sets of mortality factors associated with seasonality (e.g., Page, 1980, Bull. Entomol. Res. 70:621–633). At times of the year when both larval and adult food resources are abundant, immature stages of *Hamadryas* populations may build up most intensely in the vicinity of adult resources, as suggested by some temperate zone butterfly studies (Murphy, 1983, Environ. Entomol. 12:463–466). When this occurs, *Hamadryas* caterpillars may become a major herbivore of *Dalechampia* situated near adult feeding sites (Armbruster, 1982, op. cit.). However, such an interaction is predicted, on the basis of our preliminary results, to be inoperative during the latter half of the dry season in the lowlands of northwestern Costa Rica.

This study was made possible by a grant from The Friends of the Museum of the Milwaukee Public Museum. We thank Joan P. Jass for field assistance.

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DONATION OF BLANCHARD LEPIDOPTERA COLLECTION TO THE SMITHSONIAN INSTITUTION

Until recently, few regions of comparable diversity in the United States had been as little surveyed for Lepidoptera as the State of Texas. Thus, it is with considerable gratitude and respect that the Smithsonian Institution acknowledges the donation of the largest and finest prepared collection of Lepidoptera ever assembled from this region, as well as the total accomplishments of Mr. André Blanchard, the man responsible.

The fascinating life of André Blanchard consists of a sequence of successful careers too diverse to summarize adequately in this short note. During his earliest career with the French Navy, he served in numerous capacities, ranging from a seaplane pilot to the commander of the research ship Les Eparges. Following a distinguished military career, he eventually became head of the Physics Laboratory of the Michelin Tire Company, transferring in 1943 to Schlumberger, where he rose to Vice President of Research and Development. Interspersed between these responsibilities was a brief career during World War II when Blanchard served as a translator for the War Department.

Of most concern to entomologists were Blanchard's activities following his retirement from Schlumberger in 1961. It was then that he began to survey the Lepidoptera, moths in particular, of his adopted state, Texas. He had previously collected Lepidoptera in his native France, but never with such dedication nor determination. His accomplishments since 1961 must surely be an inspiration to anyone contemplating retirement. Not content with amassing a fine and valuable collection, Blanchard quickly assumed an active research interest on the moths of Texas. Thus far, he has authored or co-authored 51 papers in this series, mostly treating the Pyralidae and Tortricidae.

The Blanchard Collection totals 76,852 specimens of which 60,233 are Lepidoptera and 16,305 are Coleoptera. The Macrolepidoptera are the best represented, particularly the Noctuidae (over 18,500 specimens) and Geometridae (ca. 8000). The Pyraloidea (over 9000) and Tortricoidea (ca. 4000), which became a major focus of his over the last decade, are also strongly represented. Some of the larger Microlepidoptera (e.g., Acrolophinae) are likewise present in large series. Included in the collection are 82 holotypes and over 700 paratypes. The research value of the Blanchard Collection is further enhanced by more than 4600 microslides, mostly of genitalia.

Mr. Blanchard continues to reside in Houston, Texas with his second wife May Elise, who was instrumental in assisting her husband in his collecting efforts.

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BOOK REVIEW

THE LIFE HISTORIES OF THE BUTTERFLIES IN JAPAN, Volume II and III (1984), by H. Fukuda, E. Hama, T. Kuzuya, A. Takahahi, M. Takashi, B. Tanaka, M. Tanaka, M. Wakabayashi, and Y. Watanabe, Hoikusha Pub. Co. Ltd., Osaka, 540 Japan.

These books are part of a series describing the life histories of Japanese butterflies. Volume II is devoted to the Nymphalidae and Libytheidae and Volume III to the Lycaenidae. Both books are published in Japanese with English summaries.

The books begin with a series of excellent color plates showing the adult, egg, larva, pupa, host plant and often the habitat for each butterfly species covered in the book.

The text describes the distribution, habitat, food plants, flight period, and early stages of each species found in Japan, including common migrants. Next comes the English summary of the text which covers the same material in less detail. The text is referenced to the plates by the name of the butterfly and plate number.

There are distribution maps and an index to generic and specific names, both in English. The Table of Contents is in English and Japanese and gives the plate number and text location for each butterfly.

These books are well bound and have two cloth bookmarks attached to the spine. The front covers have an excellent color photograph of a native butterfly. Volume II costs 4500 yen and Volume II 5000 yen.

I found the English summaries sparse, and it was obvious that more data are contained in the Japanese text. However, each summary contained a complete capsule of information about the butterfly. The pictures are excellent and show the butterflies in their habitats and on their food plant.

These books are obviously aimed at a Japanese reading audience. However, the English summaries and plates make them a welcome addition to the library of any butterfly collector.

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EUREMA NISE IN JAMAICA

One of the most fascinating accounts of butterfly rediscovery in recent years is that of *Eurema nise nise* in Jamaica (Klots & Heineman, 1957, Proc. R. Entomol. Soc. Lond. (B)26:206–214, Plate I). *E. nise,* originally described and figured from Jamaica by Cramer in 1775, eluded collectors in Jamaica until a young enthusiast, G. Irving Latz, accompanying experienced lepidopterist Bernard Heineman, netted one in March 1951 in St. Ann Parish. In the 175 years between the description and the capture by Latz, there was much discussion in lepidopterological literature regarding the true origin or identity of Cramer's *nise.* During that time, also, *nise* was widely and commonly found in other Antillean Islands and on the continent from the extreme southern USA to Uruguay and mid-Argentina and was described under various names, a number of which are considered today as valid subspecies.

Since 1951, a quantity of *nise* specimens have been collected in Jamaica. Riley in his popular guide (1975, A field guide to the butterflies of the West Indies, p. 120) states, "Reported only in January and February, i.e. the winter brood, but a summer brood must also occur." This, however, is not true, since Klots and Heineman (1957) and Brown and Heineman (1972, Jamaica and its butterflies) cite known specimens from Jamaica dated June, July, August and September, some of which are figured and are clearly of the summer phenotype. What is true, is that the great majority of the specimens collected there were found in the winter months (when most collectors visit Jamaica) and are of the winter phenotype.

I have had many years' experience with, and have handled hundreds of specimens of, *Eurema nise tenella* (Boisduval) 1836 from northwestern Argentina. There, the winter phenotypes are affected in two ways: (1) There is a progressive reduction of the upperside black borders, and (2) there is an augmentation of the rusty-brown scaling and blotching on the ventral hindwings. These same phenomena also take place in nearly all the other species of *Eurema,* as well as many other coliadine Pieridae flying in Argentina. What is of special interest is that these two phenomena do not necessarily occur simultaneously, which results in a number of distinct winter phenotypes. The literature in recent years has contained many opinions and a number of serious studies (some of which are contradictory) as to the causes of these phenomena in various species of the Coliadinae. Decrease in temperature, decrease in humidity, decrease in photoperiod or a combination of two or more of these factors during the immature stages have all been suggested as the cause. It is not the purpose of this note to add another field-based opinion to the confusion. Whatever the causes, the result is the great diversity of forms of *E. nise* both in Jamaica and Argentina, as are in part illustrated in the works mentioned above.

This note reports the collection of 14 specimens of *E. nise nise* in St. Andrew, Trelawny and Manchester parishes of Jamaica between 22 and 26 November 1983 and that these are basically of what I call the "autumn" phenotype, comparable to specimens of *E. nise tenella* captured in lowland northwestern Argentina in the month of May. This phenotype is very close to the summer one, differing by having a very slight reduction of the dorsal wing borders, but like the summer phenotype showing no or very minimal rusty-brown scaling on the ventral hindwing. Voucher specimens from Jamaica have been deposited in the Allen Museum of Entomology and the National Museum of Natural History (Smithsonian).

The specimens taken in St. Andrew Parish constitute a new parish record. Other *Eurema* collected in Jamaica during November 1983 were *E. daira palmira, E. messalina, E. nicippe* (St. Andrew Parish—record), *E. adamsi, E. proterpia, E. lisa euterpe* and *E. dina parvumbra.* A number of these are considered in the literature to be scarce. Most were seen, though not captured, in quantities. This would indicate that November is an exceptionally good month for *Eurema* in Jamaica.

I thank Dr. Lee D. Miller and Dr. Robert K. Robbins for their helpful criticisms of the manuscript.

Robert C. Eisele, *Casilla de Correo 90, 4107 Yerba Buena (Tecuman), Argentina.*

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NOTICE TO CONTRIBUTORS

Contributions to the *Journal* may deal with any aspect of the collection and study of Lepidoptera. Contributors should prepare manuscripts according to the following instructions.

Abstract: A brief abstract should precede the text of all articles.

Text: Manuscripts should be submitted in *triplicate*, and must be typewritten, *entirely double-spaced*, employing wide margins, on one side only of white, 8½ × 11 inch paper. Titles should be explicit and descriptive of the article's content, including the family name of the subject, but must be kept as short as possible. The first mention of a plant or animal in the text should include the *full scientific name*, with *authors* of zoological names. Insect measurements should be given in *metric units*; times should be given in terms of the *24-hour clock* (e.g. 0930, not 9:30 AM). Underline only where *italics* are intended. References to footnotes should be numbered consecutively, and the footnotes typed on a separate sheet.

Literature Cited: References in the text of articles should be given as, Sheppard (1959) or (Sheppard 1959, 1961a, 1961b) and all must be listed alphabetically under the heading LITERATURE CITED, in the following format:

SHEPPARD, P. M. 1959. Natural selection and heredity. 2nd. ed. Hutchinson, London. 209 pp.

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

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Cover illustration: Micropylar end view (×130) of the egg of *Sericosema* sp. (probably *juturnaria*) (Geometridae). The scanning electronmicrograph was taken by Thomas D. Eichlin, Sacramento, of eggs furnished by Ron Robertson, Santa Rosa, California.

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BIRD PREDATION ON LEPIDOPTERA AND THE RELIABILITY OF BEAK-MARKS IN DETERMINING PREDATION PRESSURE

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ABSTRACT. Visually hunting predators such as birds are thought to have influenced the evolution of the wing markings and colorations of Lepidoptera. Although studies have been conducted to quantify and characterize predation by birds on butterfly populations, field observations of bird predation on butterflies have rarely been reported. A request for information on predation yielded 50 previously unpublished accounts of bird predation on butterflies.

The combination of laboratory interactions of *Pieris rapae* and blue jays and field collections of *P. rapae* allowed several variables to be examined which affect the reliability of using frequency of beak-marks on lepidopteran wings as an index of predation pressure. Beak marks occur four times more frequently during attacks on flying *P. rapae* than on ones at rest and blue jays were five times more efficient at capturing resting butterflies than capturing flying butterflies. Variation in wing strength makes the area where the ipsilateral wings overlap and the costal vein area of the forewing more resistant to beak-marks than the marginal areas of the fore- and hindwings and the distal tip of the forewings. These differences in wing strength may confound the use of beak-marks as an index of predation pressure.

Finally, predation efficiency and the frequency of occurrence of beak-marks during attacks, as determined in the laboratory, were used in conjunction with field data to estimate avian predation pressure on *P. rapae* populations.

Although birds have long been thought to be the major predators on adult Lepidoptera (Poulton, 1890, 1913; Fryer, 1913; Swynnerton, 1915; Dover, 1920; Carpenter, 1937), field observations of bird predation on butterflies in temperate North America have rarely been reported. The short time that it takes birds to capture and manipulate butterflies while feeding may account for the rarity of field observations (Bowers & Wiernasz, 1979; Collins & Watson, 1983). There is strong circumstantial evidence in the form of beak-marks and tears on wings of Lepidoptera to indicate that birds act as significant predators on butterflies (e.g., Wheeler, 1935; Carpenter, 1937; Kolyer, 1968).

TABLE 1. Avian–lepidopteran interactions.

Lepidoptera	Bird	Notes	Location	Reference
Family—Danaidae				
Subfamily—Danainae				
Danaus plexippus (Monarch)	*Falco peregrinous* (Peregrine Falcon)	Fledgling seen repeatedly chasing, catching, and often releasing monarchs	Minnesota	Evans, pers. observ., 1983
D. plexippus	*Parus rufescens barbei* (Chestnut-backed Chickadee)	Captured, pecked, and released monarch	Santa Cruz, Mexico	Tuskes and Brower, 1978
D. plexippus	*Athene cunicularia* (Burrowing Owl)	Wings found at burrow entrance with other prey remains	Southern Idaho	Reil, pers. observ., 1981
D. plexippus	*Buteo platypterus* (Broad-winged Hawk)	Captured in flight in talons, eaten in flight	Hawk Mountain, Pennsylvania	Braun, pers. observ., 1974–1975
D. plexippus	*Falco sparvervus* (American Kestrel)	During butterfly migration, four aerial captures while soaring, captured in beak	Salton Sea National Wildlife Refuge, Indigo, California	Abbott, pers. observ., 1973
D. plexippus	*Icterus parisorum* (Scott's Oriole) *I. abeillei* (Lesson) (Black-backed Oriole) *Pheucticus melanocephalus* (Black-headed Grosbeak)	37% of the captured monarchs were handled, damaged, and released by the birds	Mexico	Calvert et al., 1979
D. plexippus	*Toxostoma rufum* (Brown Thrasher)	110 of 112 wingless monarchs consumed from a dish outdoors	Milford, Iowa	Petersen, pers. observ., 1964

TABLE 1. Continued.

Lepidoptera	Bird	Notes	Location	Reference
D. plexippus	*Aphelocoma coerulescens* (Scrub Oak Jay)	27 winged monarchs consumed in winter from a dish outdoors	Colorado Springs, Colorado	Petersen, pers. observ., 1964
Family—Satyridae				
Subfamily—Satyrinae				
Cercyonis pegala (Wood Nymph)	*Falco sparverius* (American Kestrel)	Captured in air	Salt Marsh, Rouley, Massachusetts	Schlinger, pers. observ., 1982
Family—Nymphalidae				
Subfamily—Nymphalinae				
Vanessa atalanta (Red Admiral)	*Tyrannus tyrannus* (Eastern Kingbird)	Attacked while Red Admiral was sunning, missed	Pt. Pele, Canada	Pilkington, pers. observ., 1983
V. atalanta	*Sayornis phoebe* (Phoebe)	Handling observed, Red Admiral escaped, was pursued and recaptured	Baltimore, Maryland	Blackbill, pers. observ., 1951
V. cardui (Painted Lady)	*Empidonax trailli* (Flycatcher)	Captured and perched. Some wings removed and consumed—no unpleasant reaction	Austin, Travis County, Texas	Johnson, pers. observ., 1983
V. cardui	*Melospiza melodia* (Song Sparrow)	Butterflies migrating. Sagebrush Swift (Reptilia) captured and consumed the body. Most evidence of wing damage suggests birds are the major predators	Tooele and Box Elder County, Utah	Knowlton, 1953

TABLE 1. Continued.

Lepidoptera	Bird	Notes	Location	Reference
Euphaydras chalcedona (Checkerspot)	*Toxostoma redivivum* (California Thrasher)	Attacked and ate several tethered butterflies	San Mateo County, California	Bowers et al. (unpubl. ms.)
E. c. kingstonensis	*Tyrannidae* (Flycatcher)	Several observations	Providence Mts., San Bernardino County, California	Shields, pers. observ., 1983
Nymphalis antiopa (Mourning Cloak)	*Myiarchus crinitus* (Great Crested Flycatcher)	Captured from behind in flight. Body in beak hit and killed on branch prior to eating	Pt. Pele, Ontario, Canada	Pilkington, pers. observ., 1980
N. antiopa	*Iridoprocne bicolor* (Tree swallow)	Pursued only. BF dropped to water surface just as swallow closed in. Attacked 4 times	Cedar Creek, Essex County, Ontario	Pilkington, pers. observ., 1982
Subfamily—Argynninae				
Speyeria edwardsii (tent. I.D.)	*Contopus sordidulus* (Western Wood Peewee)	Taken in flight and carried to perch	El Paso Co., Colorado	Johnson, pers. observ., 1963
Family—Lycaenidae				
Subfamily—Plebejinae				
Lycaenopsis argiolus (Spring Azure)	*Passer domesticus* (House Sparrow)	Captured in flight and consumed entirely	New York, New York	Zirlin, pers. observ., 1976
L. argiolus	*Melospiza melodia* (Song Sparrow)	Hawking	Florissant, Missouri	Olson, 1962
Everes comyntas	*Melospiza melodia* (Song Sparrow)	Hawking	Florissant, Missouri	Olson, 1962

TABLE 1. Continued.

Lepidoptera	Bird	Notes	Location	Reference
Strymon spp.	*Melospiza melodia* (Song Sparrow)	Hawking	Florissant, Missouri	Olson, 1962
L. americana	*Melospiza melodia* (Song Sparrow)	Hawking (also took unidentified moths)	Florissant, Missouri	Olson, 1962
Lycaenids	*Melospiza melodia* (Song Sparrow)		Otsego County, Michigan	
Family—Pieridae				
Subfamily—Colladinae				
Colias eurytheme (Orange Sulfur)	*Tyrannus verticalis* (Western Kingbird)	One attack in flight	Sacramento Valley, California	Shapiro, 1974
Colias spp. (Sulfur Butterfly)	*Sayornis phoebe* (Phoebe)	Consumed all	Baltimore, Maryland	Blackbill, pers. observ., 1944
Subfamily—Pierinae				
Pieris rapae (Cabbage White Butterfly)	*Sturnus vulgaris* (Starling)	Tried to catch by hopping off ground but missed	Baltimore, Maryland	Blackbill, pers. observ., 1950
P. rapae	*Passer domesticus* (House Sparrow)	Male House Sparrow with butterfly in beak, fed to young, no adverse reaction	Fenway Gardens, Boston, Massachusetts	Wourms, pers. observ., 1983
P. rapae	*Passer domesticus* (House Sparrow)	Female House Sparrow pursued butterfly in air, no contact, no capture	Fenway Gardens, Boston, Massachusetts	Wourms, pers. observ., 1983
P. rapae	*Pipilo erythrophthalmus* (Rufous-sided Towhee)			Morris, pers. observ., 1953, to Adler, 1982

TABLE 1. Continued.

Lepidoptera	Bird	Notes	Location	Reference
P. rapae	*Quiscalus quiscula* (Common Grackles)			Morris, pers. observ., 1953 to Adler, 1982
Pieris protodice	*Progne subis* (Purple Martin)	Pursuit, no capture BF dove into grass and stayed there	Austin, Travis County, Texas	Johnson, pers. observ., 1979
Pieris spp.	Fringillidae (Sparrows no I.D.)	Pursued and captured	Black Donald Lake, Ontario	Holliday, pers. observ., 1983
Pieris or *Colius*	*Myiarchus crinitus* (Great Crested Flycatcher)	Captured in air at perch dropped but captured before hit ground. 1 wing removed and consumed	Baltimore, Maryland	Blackbill, pers. observ., 1938
C. eurytheme *P. rapae* *P. protodice*	*Eupagus cyanocephalus* (Brewer's Blackbird) *Sturnella neglecta* (Western Meadowlark)	21 attacks on resting Pierids in open alfalfa fields	Sacramento Valley, California	Shapiro, 1974
Family—Papilionidae				
Subfamily—Papilioninae				
Papilio glaucus (Tiger Swallowtail)	*Myiarchus crinitus* (Great Crested Flycatcher)	Captured in flight consumed wings and all at perch	South Charleston, Kanawha County, West Virginia	Adler, pers. observ., 1968
P. glaucus	*M. crinitus*	Capture and consumption not observed, held by thorax or abdomen	Reelfoot Lake, National Wildlife Refuge, Obion County, Tennessee	Pitts, pers. observ., 1983

TABLE 1. Continued.

Lepidoptera	Bird	Notes	Location	Reference
P. g. canadensis	*Zonotrichia leucophrys* (White Crowned Sparrow)	Seen pecking at puddling BF and many wings found nearby	Fairbanks, Alaska	Rawson, 1953
Papilio polyxenes (Black Swallowtail)	*Cyanocitta cristata* (Blue Jay)	Female captured while ovipositing	Ithaca, New York	Erickson, 1973
	Dumetella carolinensis (Catbird)	Male taken on wing just after taking flight	Ithaca, New York	Erickson, 1973
Family—Hesperiidae				
Subfamily—Pyrginae				
Erynnis juvenalis (Skipper)	*Pipilo erythrophthalmus* (Rufous-sided Towhee)		Location not provided	Morris, 1953, pers observ. to Adler
	Spizella passerina (Chipping Sparrow)			
	Melospiza melodia (Song Sparrow)			
	Zonotrichia leucophrys (White Crowned Sparrow)			
Butterflies not identified	*Lanius ludovicianus* (Loggerhead Shrike)	29 successful attacks out of 30 attempts	Whittier Narrows, Nature Center, Los Angeles Co., California	Morrison, pers. observ., 1977–1978
Family—Geometridae				
Subfamily—Brephinae				
Brephos infans *Leucobrephos brephoides*	*Melospiza melodia* (Song Sparrow)	4 observed captured while puddling, bird ran and captured them		Donahue and Newman, 1967

TABLE 1. Continued.

Lepidoptera	Bird	Notes	Location	Reference
Lomographa semiclarata	*Pipilo erythrophthalmus* (Rufous-sided Towhee)			Morris, pers. observ., 1953–1982
Adler	*Spizella passerina* (Chipping Sparrow) *Melospiza melodia* (Song Sparrow) *Zonotrichia leucophrys* (White Crowned Sparrow)			
Family—Saturnidae				
Subfamily—Attacinae				
Callosamia promethia (painted yellow-like tiger swallowtail)	*Melanerpes erythrocephalus* (Red-headed Woodpecker)	Moth attempted evasive flight, but captured in flight, bird flew off	Monticello, N.Y.	Jeffords, 1979
	Richmondens cardinalis (Cardinal)	Attempted to capture moth in air, grasped one wing, wing tore, moth got away		Jeffords, 1979
Actias luna (Luna Moth)	*Cyanocitta cristata* (Blue Jay)	Captured in flight, handled on perch—wings removed	Middlesex Co., New Jersey	Zirlin, pers. observ., 1979
A. luna	*Melanerpes erythrocephalus* (Red-headed Woodpecker)	Luna hand released, captured in air seconds later	Southern Wisconsin	Reil, pers. observ., 1972
Hyalophora cecropia (Cecropia Moth)	*Passer domesticus* (House Sparrow)	Killed on ground, 2 observations	Black Donald Lake, Ontario	Holliday, pers. observ., 1983
H. cecropia	*Passer domesticus* (House Sparrow)	Chased but not captured (2 obs.), Cecropias dove at moment of imminent capture	Black Donald Lake, Ontario	Holliday, pers. observ., 1983

TABLE 1. Continued.

Lepidoptera	Bird	Notes	Location	Reference
Virgo Tiger Moths	*Tyrannus tyrannus* (Eastern Kingbird)	Wings neatly clipped off	Black Donald Lake, Ontario	Holliday, pers. observ., 1935–1939
Various small diurnal moths	*Passer domesticus* (House Sparrow)	Fly-catching	Black Donald Lake, Ontario	Holliday, pers. observ., 1975
Dryocampa rubicunda *Nadata gibbosa* *Lapara coniferarum* Geometridae Arctiidae Noctuidae Notodonitidae	*Piranga rubra* (Summer Tanager)	Captured moths at rest on side of building, 2–5 seconds handling time, two occasions	Piedmont National Wildlife Refuge, Jones Co., Georgia	Lee, pers. observ., 1983

Predation by birds on Lepidoptera have been reported in studies that have been concerned with interactions between European Lepidoptera and birds (Carpenter, 1933, 1937, 1941; Collenette, 1935) or tropical Lepidoptera and birds (Fryer, 1913; Young, 1971; Brown & Neto, 1976; Smith, 1979; Collins & Watson, 1983). This study reports on the interactions between North American Lepidoptera and birds and investigates the reliability of butterfly wing-damage frequencies as a predictor of predation pressure in the European cabbage butterfly, *Pieris rapae* L.

METHODS

A request for information from professional and amateur lepidopterists and ornithologists regarding butterfly-bird interactions yielded 50 previously unpublished accounts of predation by birds on butterflies in temperate North America (Table 1). The results of a literature survey of the frequency of beak-marks reported in butterfly populations is summarized in Table 2 and a survey of defensive compounds found in adult Lepidoptera is presented in Table 3.

In order to document avian predation on *P. rapae* in the field *P. rapae* adults were collected for a 30 minute period every seven to 10 days in Boston, Suffolk Co., Massachusetts (Fenway Victory Gardens) and for a one hour period every seven to 10 days at two sites in Lexington, Middlesex Co., Massachusetts (Dunback Meadows and Carroll Field, 71° West, 42° North). The difficulty of moving through the Middlesex Co. sites, due to dense vegetation, *Phragmites* spp. and goldenrods, *Solidago* spp., necessitated the longer collection time per period. Captured butterflies were sexed, and the presence and location of bird-attributable wing damage were recorded for each specimen. Initially, nine possible locations of attack were identified. These were condensed to represent three directions of attack; from the front, side, or from behind (Fig. 1).

One factor that may influence the reliability of beak-marks as an index of predation is the strength of the wings. The strengths of (1) three areas on the forewing, (2) one area on the hindwing, and (3) the area where the ipsilateral fore- and hindwing overlap, were measured on 25 specimens of *P. rapae* (Fig. 2). Strength measurements were obtained by removing the wings from the specimen, and positioning one wing at a time in the testing device (Fig. 3). The device slowly increased the force on the wing until tearing occurred. Data were analyzed with a single factor repeated measures analysis of variance and a Student Newman-Keuls multiple pairwise test (Zar, 1974).

To observe predatory behavior and to quantify the frequency and

TABLE 2. Frequency of bird-attributable damage on the wings of Lepidoptera.

Lepidoptera	Family	Frequency of bird damage	Comments and references
Colias eurytheme	Pieridae	4.8%	Sacramento Valley, California, Shapiro (1974)
Pieris rapae	Pieridae	5.1%	Sacramento Valley, California, Shapiro (1974)
P. rapae	Pieridae	7.9% males 9.9% females	Boston, Massachusetts, Wourms (this study)
Pieris protodice	Pieridae	6.8%	Sacramento Valley, California, Shapiro (1974)
Pieris coenia	Pieridae	6.8%	Sacramento Valley, California, Shapiro (1974)
Ascia monuste	Pieridae	22.8%	Everglades Nat. Park, Florida, Pought and Brower (1977)
Lycaenid spp.	Lycaenids	10%	Malaya, Robbins (1978)
	Hairstreaks	7.9%	Colombia, Robbins (1978)
Lycaenid spp.	Lycaenids	7.9%	Colombia, Robbins (1978)
Lycaenid spp.	Lycaenids	7.0%	Panama, Robbins (1978)
Euphydryas chalcedona	Nymphalidae	5.4% males 8.1% femlaes	San Mateo Co., California, Bowers, Brown and Wheye, submitted, 1983
Danaus plexippus	Nymphalidae	2%	Santa Cruz, Mexico, Tuskes and Brower (1978)
D. plexippus	Nymphalidae	40%	Mexico, Calvert et al. (1979)
D. plexippus	Nymphalidae	30.7%	Mexico, Carpenter and Hope (1941)
Danaus chrysippus	Nymphalidae	7.3%	Tanzania, Smith (1979)
Hypolimnas misippus	Nymphalidae	3.2%	Tanzania, Smith (1979)
Morpho amathonte centralis	Morphidae	0%	Costa Rica, Young (1971)
Morpho granadensis polybaptus	Morphidae	65.3% 83%	Costa Rica, three locations, Young (1971)
Morpho peleides limpida	Morphidae	83%	Costa Rica, three locations, Young (1971)
Cercyonis pegalia	Satyridae	10% 7.1%	Massachusetts, two sites, Bowers and Wiernasz (1979)
Maniola jurtina L.	Satyridae	8% males 13% females	Southern Sweden, Bengston (1981)
Catocala spp.	Noctuidae	4%	Massachusetts, Sargent (1973)

TABLE 3. Secondary compounds sequestered by Lepidoptera.

Lepidoptera	Compound sequestered	Food plant	Reference
Family—Papilionidae (Swallowtails)			
Battus philenor	aristtolochic acids	Dutchmans Pipe, *Aristolochia* spp.	Bowers, 1980
B. polydamas			
Pachlioptera aristolochiae			
Troides aeacus	acetylcholine-like		Rothschild et al., 1970
Family—Nymphalidae			
Danaus plexippus	cardiac glycosides	Milkweeds, *Asclepias* spp.	Reichstein et al., 1968
D. chrysippus			Brower et al., 1968
Subfamily—Ithiomiinae	alkaloids	Solanaceous plants, tomatoes, potatoes	Bowers, 1980
Subfamily—Acraeinae Heliconiinae	cyanogenic glycosides and alkaloids	Passion Flower, Passafloraceae	Hegnauer, 1969
Heliconius erato			
Family—Pieridae (Cabbage Whites)			
Pieris rapae	sinigrin and mustard oils	Cruciferaceae, wild mustard, cabbage	Marsh and Rothschild, 1974 Aplin et al., 1975
P. brassicae			
Family—Zygaenidae			
Zygaena filipendulae	histamine	*Jenecio* spp.	Rocci, 1916
Family—Arctiidae			
Arctia caja	acetylcholine, hydrocyanic acids		Frazer and Rothschild, 1960 Morley and Schachter, 1963 Rothschild et al., 1970

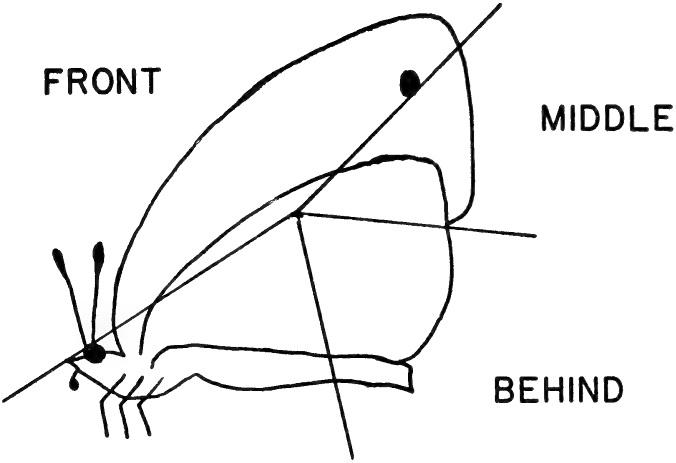

FIG. 1. Front, middle, behind locations of bird damage for field collected *Pieris rapae*.

type of butterfly wing damage that occurs during attacks, *P. rapae* adults were brought into the laboratory in a wire cage (25 cm high × 15 cm in diameter), where they were released into a 1 × 0.5 × 1 m holding cage made of mosquito netting. Sugar water and wild flowers were provided *ad libitum*. Four blue jays, *Cyanocitta cristata*, were captured in mist nets and baited traps. They were housed individually in 1 × 1 × 1 m wire screen cages under a long-day light cycle (18 h light, 6 h dark). All birds were provided water and sunflower seeds *ad libitum*, and were given canned dog food, fresh chopped vegetables, and 5–10 mealworms each morning. Two weeks prior to trials with live *P. rapae*, one bird was placed in a flight cage (3 × 4 × 3 m). The experimental procedure consisted of (1) placing a single live *P. rapae* in a 4 cm box, (2) introducing the box into a flight cage through a slot in the side of the cage, and (3) releasing the butterfly by pulling a string attached to the lid of the box.

The activities of the butterfly and the blue jay were monitored for 15 minutes with a video recorder. If the butterfly was not consumed during the 15 minute trial it was removed and another individual was presented after a 15 minute interval. No more than six trials were conducted per day. Video tapes were analyzed with slow motion and freeze-frame to identify attacks and contact points. A new blue jay was transferred to the flight cage and trained, after the previous bird had had 10 days of live presentations.

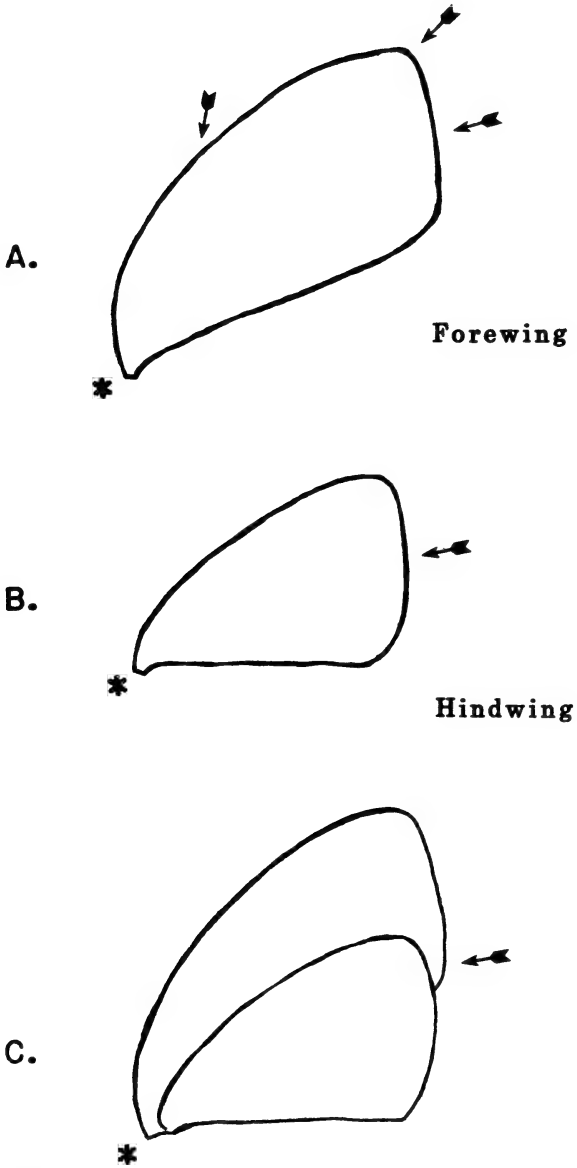

FIG. 2. The areas of *Pieris rapae* wings where resistance to tearing was measured. (* indicates points of anchoring during measurements.) **A.** The arrows indicate points of strength measurements, the forewing costal vein, wing tip, and distal margin. **B.** Distal margin of the hindwing. **C.** Ipsilateral overlap of fore and hindwings.

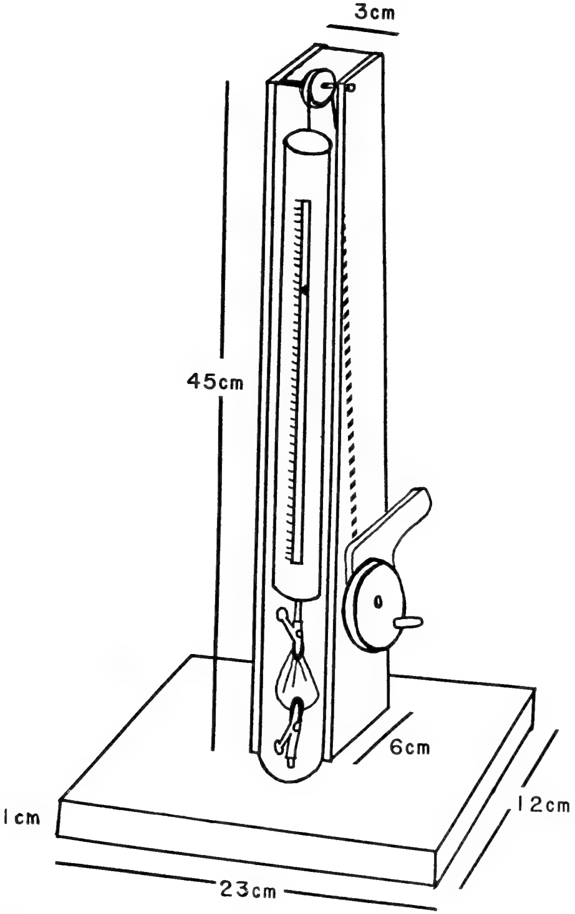

FIG. 3. Wing strength (resistance to tear) measurement device. The wing was anchored by the clip of the Pesola scale, and the area measured by the lower clip. The crank was turned pulling upward. The resistance (g) was shown on the Pesola scale, and was recorded to the nearest 0.5 g the moment the wing tore apart.

RESULTS

Of the 1179 *P. rapae* collected during the three field seasons, an average of 7.2 ± 0.28% (S.D.) of the specimens had beak-marks or beak tears. There were no significant differences in frequency of bird damage among sites or within sites over different seasons (Table 4, 6 × 2 Chi-square contingency table; $\chi^2 = 0.49$, df = 4, $P > 0.05$). Only two of the 91 specimens collected showing bird damage had impressions of a bird's beak on the wings of the butterfly; the other 89 specimens

TABLE 4. Butterfly sampling and beak-mark frequencies.

Year	Site	Collected	Beak-marked	% damaged
1981	Fenway	182	12	6.2
1982	Fenway	351	28	7.4
	Lexington	104	8	7.1
1983	Fenway	241	17	6.6
	Lexington	247	22	8.2
	Carroll	54	4	6.9
Totals		1179	91	7.2 ± 0.28

had beak tears. Henceforth, unless otherwise stated, "beak-marks" implies both marks and tears.

In 1981, sex was not distinguished during the collection of *P. rapae*. In 1982 and 1983, 838 (78.2%) males and 238 (21.8%) females were collected (Table 5). Chi-square analysis reveals that in 1982 and 1983 the frequency of bird damage on *P. rapae* was independent of sex (Table 5).

No specimen showed evidence of more than one attack. Symmetrical damage on both sets of wings suggests that the damage occurred while the butterfly was at rest with wings folded. Butterflies with damage on one wing or on an ipsilateral forewing and hindwing were assumed to have been attacked in flight (Bowers & Wiernasz, 1979; Sargent, 1973). Two specimens from 1982 and one from 1983 were omitted because symmetrical or single wing damage could not be determined.

Of the 76 bird-damaged *P. rapae* collected in 1982 and 1983, 51 (67%) were damaged in flight, and 25 (33%) were damaged at rest (Table 6). Significantly more specimens were damaged in flight than at rest (expected values are calculated as half of the total number of damaged specimens; $\chi^2 = 4.4$, df = 1, $P < 0.05$). The distributions of attacks from the front, side and from behind are presented in Table 6. There was no significant difference between the distribution of attack positions occurring in flight from the distribution of attack positions occurring at rest (Table 6; 3 × 2 Chi-square contingency table; $\chi^2 = 2.44$, df = 2, $P > 0.05$). Regardless of whether the butterfly was in flight or at rest, significantly more bird damage occurred from behind than from the side or from the front (expected values are calculated assuming equal numbers from each of the three directions: Table 6; flight, $\chi^2 = 25.52$, df = 2, $P < 0.05$; rest, $\chi^2 = 18.39$, df = 2, $P < 0.05$).

Analysis of variance indicated a significant difference in strengths of the five wing areas ($F = 68.3$, df = 96, $P < 0.05$). The costal vein area and the ipsilateral overlap were three times stronger than the distal margin of the hindwing and twice as strong as the distal margin

TABLE 5. Comparison of the sex ratios of bird damaged and undamaged specimens for each year.

	Damaged	Undamaged	Total
	1982		
Male	27	345	372
Female	9	110	119
Total	36	455	491
	$\chi^2 = 0.012$, df = 1, $P > 0.05$		
	1983		
Male	32	434	466
Female	11	108	119
Total	43	542	585
	$\chi^2 = 0.82$, df = 1, $P > 0.05$		

of the forewing (Table 7). Using Student-Newman-Keuls multiple pairwise test, we found no significant difference between the costal vein area and the ipsilateral overlap area, and no significant difference between the margins of the fore- and hindwings and the tip of the forewing, but there was a significant difference between these two groups of wing areas ($P < 0.01$).

The presentation of 104 *P. rapae* to four blue jays in a flight cage resulted in 182 attacks and 69 butterflies captured (Table 8). Sixty-nine percent (57/83) of the attacks on resting butterflies resulted in captures, while only 12% (12/99) of the attacks on flying *P. rapae* resulted in captures. The blue jays were significantly more efficient in capturing butterflies at rest than in flight. (Table 8; $\chi^2 = 27.73$, df = 1, $P < 0.05$).

Few of the butterflies that were attacked showed wing damage. Of the 83 butterflies attacked at rest, only one of the 21 *P. rapae* which escaped had wing damage. Only four of the 87 *P. rapae* which escaped attacks in flight received wing damage.

DISCUSSION

Despite the presence of mustard oils (Rothschild et al., 1970; Aplin et al., 1975) *P. rapae* were acceptable prey to blue jays in the field and laboratory and to house sparrows, *Passer domesticus*, purple martins, *Progne subis subis*, and various other avian species in the field (Table 1). In this study, an average of 7.2% of the *P. rapae* collected showed evidence of attacks by birds in the form of beak imprints and beak tears, and no specimen showed evidence of being attacked more than once. In California, Shapiro (1974) collected *P. rapae* and found 5.6% of the specimens bird-damaged, and between 0.33% and 0.50% of the

TABLE 6. Frontal and rear attacks on *P. rapae*.

		Attacked in flight from			Attacked at rest from		
Year	Site	Behind	Side	Front	Behind	Side	Front
1983	Fenway	8	3	0	3	0	2
	Lexington	8	1	4	6	1	2
	Carroll	0	1	1	2	0	0
1982	Fenway	14	2	4	5	0	2
	Lexington	4	1	0	2	0	0
Total		34	8	9	18	1	6

damaged specimens had multiple beak-marks. The percentages of bird damage reported by Shapiro (1974) and this study fall within the range of damage found in other lepidopteran species studied (Table 2).

At least four variables can affect the relationship between beak-marks and predation pressure (Benson, 1972; Shapiro, 1974; Robbins, 1980, 1981): 1) Damage may occur more readily during attacks on flying Lepidoptera than during attacks on resting Lepidoptera; 2) different avian predators may be many times more successful during attacks on resting prey than during attacks on flying prey; 3) different avian predators may vary significantly in capture efficiency on Lepidoptera; and 4) the strength of various butterfly wing areas differs, and this may influence the probability of obtaining beak-marks.

The live presentations of cabbage butterflies to blue jays indicates that bird damage may occur up to four times more readily during attacks on flying butterflies than during attacks on resting butterflies. Therefore, if equal numbers of butterflies are attacked in flight and at rest, a field sample would reveal a greater number of specimens showing evidence of being attacked in flight due to the higher frequency at which damage occurs (Table 6). This was also found by Bowers and Wiernasz (1979) in *C. pegala* and is expected if avian predators are less efficient during attacks in flight than at rest. The reliability of a beak-mark predation index is seriously jeopardized by unequal chances of obtaining beak-marks in flight and at rest. If most predation occurs while the butterflies are in the vegetation and few beak-marks result, the index would underestimate the amount of predation occurring. Likewise, if most attacks occur in flight the amount of damage may be overestimated if many prey are damaged and few captured. No previous study had quantified the relative occurrence of beak-marks due to attacks at rest and in flight.

Live trials support the hypothesis that avian predators may be much more efficient at capturing resting butterflies than at capturing butterflies in flight (Table 8). The attack efficiency of blue jays on flying *P.*

TABLE 7. The strengths of *P. rapae* wing areas.

Area	Strength (g ± S.D.)
Forewing tip	9.24 ± 2.4[a]
Forewing margin	8.28 ± 2.6[a]
Hindwing margin	6.95 ± 2.5[a]
Costal vein	19.76 ± 6.0[b]
Overlap of ipsilateral wings	20.16 ± 4.2[b]

The strength of wing areas with identical superscripts were not significantly different from each other. Groups with the 'a' superscript were significantly different from those with 'b' at the $P < 0.01$ level.

rapae was 12%. This was lower than that of an aerial insectivore, the spotted flycatcher, *Muscicapa striata,* which was reported in the field to have captured four flying *P. rapae* in 17 attempts for a success rate of 23.5% (Davies, 1977) and was still lower than the success rate of 100% on flying butterflies reported for a hunting northern shrike, *Lanius borealis* (Morrison, 1980; and pers. comm.). The predation index could be complicated by differences in the composition of avian communities in different habitats. For example, if shrikes were common in one habitat and relatively rare in another, many butterflies could have been consumed in the first area with little damage occurring, while the second area might have shown a high frequency of beak-marks but with little actual predation occurring. In this study, the avian communities of all three field sites were predominated by house sparrows, *Passer domesticus,* song sparrows, *Melospiza melodia,* and European starlings, *Sturnus vulgaris.*

Avian predators not only show variation in their probability of attacking butterflies, but may preferentially attack different areas on the butterfly in response to butterfly wing-markings. Butterflies attacked in stronger wing areas may show fewer beak-marks if they escape. Therefore, due to species differences in strengths of the areas of the wings, the frequencies of beak-marks may not be a reliable index of predation pressure for comparisons among species.

The percentage of bird-damaged specimens actually represents only the number of individuals which successfully survived attacks and escaped with bird damage. No data exist from field observations on the percentage of escaped butterflies showing no bird damage or on the percentages of attacked butterflies actually killed or eaten. If the laboratory efficiencies of blue jays preying on *P. rapae* are extrapolated to the field, avian predation on Lepidoptera becomes a much more significant selective force than previously suspected. Of the 1179 *P. rapae* collected, 76 had wing damage. Fifty-one specimens were attacked in flight, and 25 specimens were attacked at rest. In the laboratory only 4% of butterflies attacked in flight actually showed wing

TABLE 8. Live presentations of *P. rapae* to blue jays.

	Presented		Attacked		Captured		Efficiency (%)	
Bird	Rest	Flight	Rest	Flight	Rest	Flight	Rest	Flight
1	29	11	41	22	28	3	68.3	13.6
2	23	0	22	25	16	4	72.7	16.0
3	11	12	18	41	11	5	61.1	12.2
4	5	6	2	11	2	2	100	0
	68	36	83	99	57	12	68.7	12.1

damage. Therefore, given the 4% probability of obtaining a beak-mark, the 51 specimens collected in the field that were attacked in flight may represent attacks in flight on approximately 1275 individuals.

Blue jays consumed 12% of the *P. rapae* they attacked in flight in the laboratory. If this efficiency is extrapolated to the field, 12% of approximately 1275 *P. rapae* attacked or 153 would have been consumed after capture in flight.

Blue jays damaged only 1% of the butterflies attacked at rest in the laboratory. The 25 field-collected specimens which had damage from attacks while at rest would represent 2500 butterflies attacked at rest in the field. However, 68% of the resting *P. rapae* attacked in the laboratory were consumed. Therefore, according to this extrapolation, approximately 1700 *P. rapae* would have been consumed in the field after capture while at rest.

The disparity in predation pressure in flight and at rest suggests that the major selective force of avian predation is directed at the butterfly wing surface that is exposed while the butterfly is at rest. This is the ventral surface of the wings for most butterflies (Platt et al., 1971) but may be the dorsal surface of the wings of most moths (Sargent & Keiper, 1969; Endler, 1978) and for butterflies which expose the dorsal surfaces of the wings during basking, nectaring, and other activities. Rawlins and Lederhouse (1978) found that in the *Battus philenor* mimicry complex, the resemblance of model and mimic is closest on the ventral wing surface. They suggest that selection may be most intense on the underside of the wings, which are exposed while the butterflies are at rest, rather than on the dorsal surface of the wings which is only exposed in flight. This hypothesis previously had not been evaluated critically, and in fact, is not supported by accounts of avian predation on Lepidoptera (Table 1). Attacks on resting butterflies may be less noticeable than attacks in flight because they occur rapidly and are often obscured by vegetation.

Laboratory data obtained in the present study on predation by blue jays on *P. rapae* are the first to quantify differential predation pressure on the ventral and dorsal surfaces of the wings of *P. rapae* due to variation in success rates of attacks on flying and resting butterflies. Recently, this has been supported by work on *Euphydryas chalcedona* (Bowers et al., unpubl. manuscript). *Euphydryas chalcedona* males which had less red on the dorsal surface of their wings were under greater predation pressure when their wings were spread while resting, basking, and nectaring. Although the ventral surfaces of the wings were essentially identical in both groups, avian predation appears to favor dorsally red males. Realistic estimates of predation pressure on Lepidopteran populations are impossible due to the lack of field data. Yet, the extrapolation of laboratory and field data supports the concept that bird predation on butterflies may be a more significant selective force on Lepidopteran populations than previously assumed.

Many variables can influence the reliability of using the frequency of beak-marks on the wings of butterflies as an index of predation pressure. Thus, the interpretation of beak-mark frequencies is complicated and may not provide a reliable index of the amount of avian predation pressure on Lepidoptera.

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A NEW SPECIES OF CLEARWING MOTH, *CARMENTA LAURELAE* (SESIIDAE), FROM FLORIDA

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ABSTRACT. A new species of clearwing moth, *Carmenta laurelae,* was discovered in west-central Florida using the synthetic pheromone, (Z,Z) 3, 13-octadecadien-1-ol acetate and is herein described. The type series consists of 75 male specimens which were taken only in cypress swamps and the adjacent forested floodplain habitats. The flight period of the adult males occurred from 1100–1400 h daily. Adults were captured only between 13 May to 3 June 1985 in the Tampa Bay area.

Although the North American sesiids have been the subject of two monographs (Beutenmuller, 1901; and Engelhardt, 1946), the fauna is still imperfectly known. The development of several chemical sex attractants by Tumlinson and colleagues (1974) and Schwarz and colleagues (1983) has greatly aided the collecting of clearwing species and also helped elucidate their ecological and taxonomic relationships (Duckworth & Eichlin, 1977).

While using a variety of sesiid sex attractants to survey for the moths in the Tampa Bay area of west-central Florida during 1985, a new species of clearwing moth was captured in May and early June. The description of this species follows.

Genus *Carmenta* Hy. Edwards

Carmenta laurelae, new species

Male (Fig. 1): **Head.** Front brown-black, white laterally; vertex brown-black; occipital fringe yellow laterally, orange-yellow and brown-black mixed dorsally; labial palps smoothly scaled, dark brown dorsally and laterally, orange-yellow ventrally; antennae brown-black, some pale yellow powdering dorso-medially.

Thorax. Brown-black with narrow subdorsal orange-yellow stripes; orange-yellow patch beneath wings. Legs brown-black, with much orange-yellow on forecoxa, near tibial spurs, on first tarsal segments and at tarsal joints.

Wings. Forewing slightly more than one-half hyaline but with broad brown-black apical region, leaving small circular hyaline area just distad of discal spot, discal cell and region below Cu hyaline, no light scaled powdering dorsally; ventrally with costal margin orange-yellow and some orange-yellow powdering between veins on apical region. Hindwing hyaline; ventrally with some orange-yellow on costal margin. Forewing length: 9–10 mm.

FIG. 1. *Carmenta laurelae,* adult male.

Abdomen. Mostly brown-black, dorsally with narrow orange-yellow band at posterior edge of segment 2, broader but still narrow band on posterior margin of segment 4, very narrow band on posterior edge of segment 7; ventrally with narrow orange-yellow bands on posterior margin of segments 4–7; anal tuft somewhat wedge-shaped but truncate at apex, with some orange-yellow at tips of lateral scales and ventrally on tip of abdomen.

Male genitalia. As illustrated (Fig. 2), with saccus somewhat uncharacteristic for species of *Carmenta,* being only about one-third total length of valve and bilobed apically but with other features typical for the genus.

Female. Unknown.

Host plant. Unknown.

Distribution. Florida.

Types. Holotype: Male, University of South Florida Ecological Research Area, Tampa, Hillsborough County, Florida, V-13-1985, Coll. L. N. Brown, ZZ-3, 13 ODDA pheromone; deposited in National Museum of Natural History (NMNH), Washington, D.C. Paratypes: 74 males, deposited in NMNH; California Department of Food and Agriculture (CDFA), Sacramento; Florida State Collection of Arthropods, Gainesville; and author's collection, University of South Florida, Tampa.

Discussion. This species is only known from the 75 male specimens of the type series, which were taken at five different localities in Hillsborough County, Florida. The first specimen appeared in a sticky trap on 13 May 1985, and the last individual was taken 3 June 1985 (a flight

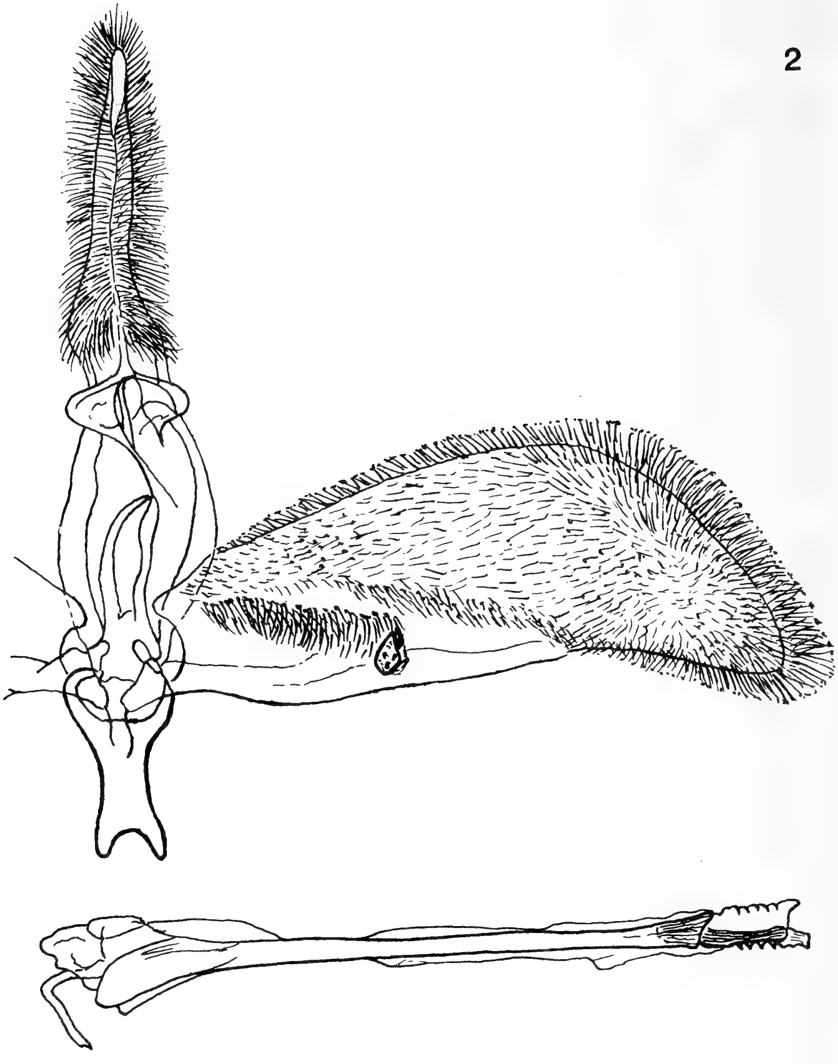

FIG. 2. *Carmenta laurelae,* male genitalia (ventral view, left valve removed).

period of three weeks). All individuals were captured within cypress swamps and adjacent floodplain forests. *Carmenta laurelae* was never taken at any pheromone isomer other than (Z,Z) 3, 13-ODDA, although several other sex attractants were constantly available.

Pheromone traps were checked at hourly intervals for several days to determine the duration of the daily flight period of male *C. lauralae.*

They came to traps only between 1100–1400 h, with the greatest flight activity occurring around noon.

This moth is named in honor of Laurel Brown, only daughter of the collector of the new clearwing species.

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THE HOST PLANT, *ERYTHROXYLUM* (ERYTHROXYLACEAE), OF *AGRIAS* (NYMPHALIDAE)

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ABSTRACT. A male of *Agrias amydon philatelica* DeVries was reared from its host plant, *Erythroxylum fimbriatum* Peyritsch, in the wet Caribbean lowland forests of Heredia Province, Costa Rica. This is the first host plant record for *Agrias amydon.*

A male of *Agrias amydon philatelica* DeVries (DeVries, 1980) was reared from its host plant *Erythroxylum fimbriatum* Peyritsch, at Finca La Selva, an Organization for Tropical Studies field station in the wet Caribbean lowland forests of Heredia Province, Costa Rica. This is the first host plant record for *Agrias amydon.*

In March 1979, a penultimate instar larva was found feeding on a 2.5 m individual of *E. fimbriatum* in the forest. The plant was a member of a clump of five individuals of *E. fimbriatum* within a space of 100 m along the Holdridge Trail. The plants have been vouchered and deposited in the Duke University Herbarium, Hammel 8929, Kress 76-526. The larva was fed in the lab on leaves from the same plant. Pupation occurred on the upper surface of the cage. The adult emerged in April. The last larval shed skin and head capsule, the empty chrysalis, and the preserved adult were deposited in the collections of the Museum of Comparative Zoology of Harvard University. The specimen was designated a paratype by DeVries (1980).

Previous records of the subspecies, all since 1977, were from the Pacific lowland dry forests in Guanacaste Province, Costa Rica, the Caribbean lowland wet forests of Herrera Province, Panama, and Finca La Selva (DeVries, 1980). This suggests that the butterfly has a wide geographical distribution and occurs in widely varying habitats, though it must be very rare.

Subsequent to my observations, D. Janzen and W. Hallawachs (pers. comm.) raised *A. amydon philatelica* from *Erythroxylum havanense* Jacq., at Parque Santa Rosa in Guanacaste. In Guanacaste, *E. havanense* is one of the most common shrubs; thus, the rarity of *Agrias* in Guanacaste cannot be explained in light of the abundance of its host plant. However, the recent discovery of *Agrias* in Guanacaste marks the first record of *Agrias* outside of wet forests.

In view of the long history of collecting in Costa Rica, it is surprising that *Agrias amydon* was first collected there in 1977, although there have been at least nine subsequent records (DeVries, 1980) from Central America. This suggests that there may have been a recent increase

FIG. 1. Developmental stages of *Agrias amydon philatelica* (left to right): adult (top), larva (bottom), adult emerging from chrysalis, and chrysalis.

in abundance, and/or possibly a range extension. We know that *Agrias* is capable of using two species of *Erythroxylum* as its host plant. It may also be possible that *Agrias* is capable of using the commercial species *Erythroxylum coca* Lam. and *E. novogranatense* (Morris) Hieron. as its host plants. This is very speculative, and it must be considered that the commercial species have higher alkaloid contents. However, it has been noted that *Agrias* is very common in the Tingo Maria region of Peru (C. Pringle, pers. comm.), known as a hot spot for the production of cocaine. *Agrias sardanapalus claudina* "claudianus" is reported to feed on *Quiiana glaziovi* (Barselou, 1983).

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EGG DISPERSION PATTERNS AND EGG AVOIDANCE BEHAVIOR IN THE BUTTERFLY *PIERIS SISYMBRII* BDV. (PIERIDAE)

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ABSTRACT. Egg dispersion patterns of the pierid butterfly, *Pieris sisymbrii* Bdv., were studied in the Mojave Desert, San Bernardino County, California. A census of eggs found on its cruciferous hostplant, *Arabis pulchra,* revealed a clumped egg dispersion pattern. This is an unexpected result if females of *P. sisymbrii* avoid conspecific eggs. An egg removal experiment suggested that *P. sisymbrii* females avoided plants bearing eggs, selecting egg-free hosts instead. In times of limited egg-laying sites, extended female flights due to successive rejections of egg-bearing plants may be a cue to inhibit egg-avoidance behavior, causing females to select egg-bearing hosts more frequently.

Ovipositing females of some inflorescence or infructescence-feeding pierid butterflies avoid those cruciferous host plants bearing conspecific eggs. Females which can recognize the presence of conspecific eggs on potential host plants apparently avoid host overload by assessing their egg-load and if necessary, adjusting their oviposition behavior, accepting only plants without eggs (Shapiro, 1980). When sufficient host plants are available, egg-load assessment and egg avoidance behavior should lead to a uniform egg dispersion pattern. Supporting studies have been obtained from laboratory work with *Pieris brassicae* L. (Rothschild & Schoonhoven, 1977), and field work with *Anthocaris sara* Lucas (Shapiro, 1980), *Euchloe hyantis* Edw. (Shapiro, 1981a), and *Anthocaris cardamines* L. (Wiklund & Ahrberg, 1978).

Prevention of host overload is adaptive in that the amount of food plant on a single plant or stem is usually enough for only the first hatched larva, and any subsequent larvae may have little or no food plant available to consume (Rausher, 1979). Older larvae may also exhibit cannibalistic tendencies toward eggs and younger larvae (Stamp, 1980). When plants free of eggs are available, it would seem maladaptive for assessing butterflies to utilize plants already bearing eggs.

Several investigators, however, have found clumped or aggregated egg dispersion patterns, usually as a consequence of female butterflies utilizing isolated plants or plants found along the margins of host plant clumps (Mackay & Singer, 1982; Cromartie, 1975; Jones, 1977; Courtney & Courtney, 1982). The use of a few isolated plants by females can leave individual hosts with far more eggs than they can support.

The California white, *Pieris sisymbrii* Bdv., is a member of a large group of pierid butterflies that feed preferentially on inflorescences; however, the favorite oviposition sites are on stems and undersides of cauline leaves. In the Mojave Desert, *P. sisymbrii* lays blue-green eggs on its host plant, *Arabis pulchra* Jones (Brassicaceae). The eggs then turn a conspicuous bright orange within a day. Many assessing pierid butterflies have brightly colored orange-to-red non-cryptic eggs, perhaps to facilitate egg recognition by females (Shapiro, 1981a).

This study examines egg-load assessment and egg avoidance behavior in *P. sisymbrii* in the Mojave Desert. I attempt to answer two questions: (1) Is the initial egg dispersion pattern in the field the expected uniform distribution, and if not, are there explanations for deviations from uniformity? (2) Does *P. sisymbrii* avoid egg-bearing host plants when egg-free plants are available, thus suggesting a discriminatory behavior?

Study Area

The study site consisted of low rolling hills approximately 1000 m in elevation and located 30 km south of Baker, San Bernardino County, California (Mojave Desert). Dominant shrubs include Joshua tree (*Yucca brevifolia* Engelm.) and creosote bush (*Larrea divaricata* Cav.) and their associates. The area supports large populations of crucifers, including *Caulanthus cooperii* (Wats.) Pays., *Descurainia pinnata* Walt., as well as *A. pulchra*. *Arabis pulchra* occurs primarily along washes between adjacent hills. The plant is perennial and may be woody or herbaceous, depending on its age and growing conditions. Its habit is variable; occasionally a single plant may have up to 15 stems while other plants may have only a single stem.

Pieris sisymbrii adults are found in open, exposed areas where solar radiation is high and are most active in the mid-morning (Emmel & Emmel, 1973).

METHODS

A sample of 60 specimens of *A. pulchra* was selected for an egg-removal experiment. Plants were chosen based on the following criteria: (1) High relative conspicuousness; some plants occurred in the center of shrubs, making their inflorescences and flowers difficult to see. These plants were excluded. (2) Plants with only a minimal amount of herbivore damage. No plants with chewed-up leaves or flowers were selected. (3) Satisfactory number of flowers and flower buds. Females may utilize only those plants with a sufficient food resource for the larvae.

All sampled plants were inspected initially for *P. sisymbrii* eggs, and the number of eggs per plant was recorded. Egg color and egg position on the plant were also tabulated. Plants were assigned to a control group and an experimental group. Plants bearing at least one egg were tagged and assigned to the control group, with their eggs left in place.

TABLE 1. Distribution of *Pieris sisymbrii* eggs on *Arabis pulchra* on a per-plant basis.

All eggs		Orange eggs only	
No. eggs/plant	No. of plants	No. eggs/plant	No. of plants
0	23	0	40
1	22	1	15
2	8	2	2
3	2	3	2
4	3	4	1
5	1		60
6	0		
7	1		
	60		

Plants without eggs were tagged and assigned to the experimental group. No apparent morphological differences between egg-free and egg-bearing plants were observed. Thirty-seven plants were initially found to bear eggs, and to simplify the statistics involved, eggs were removed from seven randomly selected control plants, and these plants were added to the experimental group. In this way, each group included 30 plants. Eggs were removed from the plants by teasing with an insect pin and a camel hair brush.

The study site was visited for six consecutive days, 27 March through 1 April 1983. Inspection for newly laid eggs started at 1000 h each day just as butterfly activity was peaking. If new eggs were found on the control plants they were noted and left on the plant; if new eggs were found on the experimentals, they were noted and removed from the plant, as described above. A variance-to-mean ratio ($s^2/\bar{x}$) was used to measure dispersion patterns.

RESULTS

Sixty-eight eggs were found initially on 37 sample plants, with 15 of these plants bearing more than one egg. Distribution of eggs on a per plant basis appears on Table 1. One individual plant (with a single stem) bore seven eggs, all of which were a few inches from one another.

A variance-to-mean ratio was calculated on a per-plant basis and was significantly greater than one, indicating an aggregated egg distribution (Table 2). This suggests that *P. sisymbrii* was not assessing its egg-load on *A. pulchra*. If egg color is an indication of the age of the egg, females may be avoiding orange eggs only since these would be the first to hatch, and the resulting larvae would have a considerable head start in development. The variance-to-mean ratio for orange eggs only, however, still deviates toward an aggregated distribution, albeit not as extreme a deviation as on a per-plant basis (Table 2).

TABLE 2. Dispersion of *Pieris sisymbrii* Bdv. eggs found on *Arabis pulchra* Jones. Variance-to-ratios ($s^2/\bar{x}$) were calculated on a per-plant and per-inflorescence basis.

	N	$\bar{x}$	s^2	$(s^2/\bar{x})$[a]	χ^2
Per-plant					
All-eggs	60	1.13	1.98	1.75	103.25[1]
Orange eggs only	60	0.55	0.73	1.33	78.50[2]
Per-inflorescence					
All-eggs	190	0.36	0.68	1.89	359.10[3]
Orange eggs only	190	0.15	0.24	1.60	302.40[3]

[a] Any value ≪1 indicates a uniform distribution; ≫1 indicates an aggregated distribution; ≃ indicates a random distribution.

[1] $0.005 > P$; df = 59.

[2] $0.10 > P > 0.05$; df = 59.

[3] $0.005 > P$; df = 189.

Shapiro (1980) suggests that assessment works on a per-inflorescence basis, where multiple ovipositions occur on plants with many stems. Females may perceive individual stems as individual oviposition sites and flowers from single inflorescences as adequate food resource for one developing larva. In such cases, many eggs may be found on multi-stemmed plants. A total of 190 stems were counted from the 60 sample plants (Table 3). The deviation toward an aggregated distribution, however, was the most extreme in this treatment (Table 2). Over 50% of the eggs occurred on stems with at least one other egg.

The result of the egg removal experiment indicates that *P. sisymbrii* prefers to oviposit on host plants without eggs. During the week, 27 new eggs were found on the experimental plants compared with 10 on the controls ($\chi^2 = 7.81$, df = 1, $0.010 > P > 0.005$). This suggests that females can recognize eggs and discriminate against those plants bearing eggs, thus effectively avoiding possible larval competition and increasing larval survivorship.

DISCUSSION

In all treatments, *P. sisymbrii* eggs in the field failed to correspond to the uniform dispersion pattern expected if females show egg-load assessment and egg avoidance behavior. The variance-to-mean ratios based on a per-plant, egg color, and inflorescence basis all deviated toward aggregated egg distributions. Such concentration of eggs on a few host plants has been shown to result in lower larval survival in the papilionid *Battus philenor* feeding on *Aristolochia* (Rausher, 1979). The use of a single stem or plant by many larvae will affect their chances of survival, especially if the amount of foodplant available to an individaul offspring is small relative to its food requirements, or if the needed resource is limited by certain age and physiological con-

TABLE 3. Distribution of *Pieris sisymbrii* eggs on *Arabis pulchra* on a per-inflorescence basis.

All eggs		Orange eggs only	
No. eggs/inflor.	No. of inflor.	No. eggs/inflor.	No. of inflor.
0	146	0	169
1	28	1	15
2	12	2	4
3	3	3	2
4	0		190
5	0		
6	0		
7	1		
	190		

ditions, as inflorescences are. Any positive preference for plants bearing conspecific eggs would cause intense intraspecific competition and lowered larval survivorship. Such behavior would be maladaptive and result in a reduced fitness and therefore should not evolve.

Several authors have found that individual host plants along the margins of clumps may receive a disproportionate number of eggs relative to inner plants (Courtney & Courtney, 1980; Mackay & Singer, 1982; Cromartie, 1975; Jones, 1977). Shapiro (1975) suggests that the use of these margin plants would be a selected response to defend against parasitoids which key in on high host plant density. Courtney and Courtney (1982) studied aggregated egg patterns of *Anthocaris cardamines* but did not prove any single factor as causing disproportionate egg concentrations. Several aspects of female behavior, they believe, contribute to the large egg loads on individual margin plants—or the 'edge-effect' as they call it. Such behaviors include (1) a tendency of *A. cardamines* to oviposit on its host plant after flying a long distance, even if conspecific eggs are already present, and (2) a host searching behavior in which females sample plant clumps as if plant density is low or plants are widely dispersed. These behaviors may be adaptive if host plant populations undergo periodic fluctuations in total biomass. The selective disadvantage of laying eggs on plants with conspecific eggs would be counterbalanced by successful discovery of hosts during times of low plant density, with females accepting even those which have conspecific eggs.

At the Mojave site, *A. pulchra* occurred almost exclusively along dry washes where plants were distributed in a linear fashion making it difficult to visualize a margin. Interplant distance was approximately 20 m, implying no true area with a high concentration of plants. This high interplant distance, however, may cause females to perceive individual hosts as isolated plants, and large egg loads may be expected. Shapiro (1981a) found isolated host plants of *Barbarea verna* (Mill.) Asch. to bear up to 15 eggs of *Anthocaris sara*. Mackey and Singer (1982) found that the probability of *Euptychia libye* L. (Satyridae) ovipositing on a sprig of *Panicum* sp. increased as the spatial isolation of the plant increased. They interpreted their results as being a consequence of random initiation of search pattern by the female after an oviposition period, rather than an active preference for isolated plants. It was difficult to judge if any particular plant at the Mojave site was more isolated than others. All plants, however, were within sight of each other, and no plants were found outside the wash.

Despite the initial aggregated egg dispersion pattern, *P. sisymbrii* preferred to oviposit on host plants free of eggs, according to the results of the egg removal experiment. The experimental plants received 27 new ovipositions within the week compared with 10 on the controls. One experimental plant received a new oviposition on three consecutive days. Two other experimental plants, on the second and fifth day respectively, bore two new green eggs during the day; both were counted as a single oviposition event.

The aggregated egg dispersion patterns and the apparent egg avoidance behavior seem to offer conflicting evidence. Yet, aggregated dispersion patterns need not disprove some degree of egg avoidance behavior (Singer & Mandracchia, 1982). My data is consistent with the selective behavior proposed by Courtney and Courtney (1982) where long flight distances by females could cause them to lose their discriminating behavior and lay more eggs on normally avoided plants. When suitable host plants are sparse due to adverse environmental conditions, such as a flood or drought, females have abnormally long oviposition flights to find the few plants available and ignore any eggs that are present. Therefore, indiscriminate egg-laying behavior after lengthy oviposition flights may be advantageous in habitats with great environmental extremes where the probability of encountering egg-free plants is sometimes low. The consequence of encountering and rejecting egg-laden plants consecutively is an increase in flight time and flight distance. This could be the cue which serves to inhibit assessment behavior and increase the probability of a female accepting an oviposition site that would normally be disregarded.

Possible coevolutionary results of egg-load assessment and egg-avoidance behavior can be seen on a local race of one of *P. sisymbrii*'s northern California host plants, *Streptanthus brewerii* Gray (Shapiro, 1981b). These plants produce pigmented callosites which appear to be "egg-mimics." Females were shown to be more apt to oviposit on plants which had their callosites removed, thus, suggesting a visual cue for egg avoidance (see also Williams & Gilbert, 1981).

My study assumes that assessment behavior is primarily based on visual cues, although pheromonal ovipositional deterrents have been observed in a butterfly species (Rothschild & Schoonhoven, 1977) and in a few dipteran species (Prokopy, 1975; Zimmerman, 1979) and therefore cannot be ruled out.

Other possible responses exist besides the inhibition of avoidance behavior. In times of limited optimal oviposition sites, females may disperse to another suitable area or choose alternative hosts. Further study is needed to check for any relationships between extended ovipositional flights and the degree of host selectivity by the females. It is suggested, however, that *P. sisymbrii* may avoid those plants bearing conspecific eggs as long as egg-free plants are available as alternatives. Once all or most of the available hosts have been taken, females may cease their discriminatory behavior and oviposit on plants with eggs instead of not laying eggs at all.

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THE FOOD PLANTS OF *JALMENUS DAEMELI* SEMPER (LYCAENIDAE) WITH NOTES ON OTHER BUTTERFLIES AND *ACACIA* FOOD PLANTS

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ABSTRACT. The literature providing larval food plant data for *Jalmenus daemeli* Semper (Lycaenidae) is summarized. A new larval host plant, *Acacia leucoclada* Tindale subsp. *argentifolia* Tindale (Mimosaceae) is recorded from the Warwick district, southeastern Queensland. One previously overlooked host, *A. pendula* A. Cunn. ex G. Don, is included here from the published literature. The name *Acacia cunninghamii* Hook. is no longer valid as the food plant for four butterflies, *Jalmenus evagoras* (Donovan), *J. daemeli* Semper, *J. ictinus* Hewitson and *Hypochrysops delicia delicia* Hewitson, since the revised classification of *Acacia* in Queensland does not allow accurate determinations for the food plants referred to under the name *cunninghamii*. Comments are made on a new host recorded for *J. evagoras*. The known larval hosts for *J. daemeli* are 12 and for *J. evagoras* 15.

Jalmenus daemeli Semper (Damel's blue) occurs from Cairns to Brisbane in scattered localities along the coast and also in certain inland localities such as Eidsvold, Gayndah, Toowoomba, Stanthorpe and Milmerran (Common & Waterhouse, 1972, 1981). Atkins (1976) recorded *J. daemeli* from various localities in central Queensland, while De Baar (1977) recorded it from an area between Bunya Mountains and Archookoora State Forest in southeastern Queensland. The species is noteworthy in usually having large, isolated populations. Little has been published on its biology. Following the convention of an earlier paper on the larval food plants of *Jalmenus evagoras* (Donovan) (Hawkeswood, 1981), the known larval hosts of *J. daemeli* are listed and discussed below.

Larval Host Plants

The first records of *Acacia* (Mimosaceae) being listed as larval food plants appears to be those of Lucas (1889) and Illidge (1898). They noted that *J. daemeli* (*Ialmenus illidgei* Lucas, in the case of Lucas, 1889) fed on wattles in the Brisbane area, southeastern Queensland. Gurney (1911) also stated the species fed on wattles. However, none of these authors provided specific determinations for these plants. Illidge (1921) recorded myall (*Acacia pendula* A. Cunn. ex G. Don) as a larval food plant from the Jandowae district, southeastern Queensland. This record was overlooked by Common and Waterhouse (1972, 1981). Illidge (1921) noted that the butterfly was abundant in all stages on young myall trees and were attended by ants. Manski (1960) recorded *Acacia cunninghamii* Hook. as a food plant from Maryborough, Scarborough and Redcliffe (the latter two localities are now outer suburbs of Brisbane). Waterhouse (1932:190) recorded brigalow (*Acacia harpophylla* F. Muell. ex Benth.) as a host, while Common (1964: 92) recorded *A. harpophylla* and "other wattles" and *Heterodendrum* (Sapindaceae). Macqueen (1965) recorded *J. daemeli* as occasionally attacking *Heterodendrum diversifolium* F. Muell. (Sapindaceae). He also noted that in the Toowoomba district, southeastern Queensland, *J. daemeli* fed solely on the silver-leaf ironbark, *Eucalyptus melanophloia* F. Muell. (Myrtaceae) and another unidentified species of bloodwood, *Eucalyptus* sp., despite *Acacia* being plentiful in the district. Harslett (1965) recorded *Acacia neriifolia* A. Cunn. ex Benth., *A. decurrens* (Wendl.) Willd. and *A. irrorata* Sieb. ex Spreng. as food plants from Stanthorpe, southeastern Queensland. It should be noted that *A. decurrens* (green wattle) is endemic to New South Wales and Victoria and is naturalized near Toowoomba and Stanthorpe (Pedley, 1978; Stanley & Ross, 1983). Atkins (1975) recorded *Acacia bidwillii* Benth. (erroneously cited as *Acacia bidwelli* Benth.) as a larval host from four localities in central Queensland, viz. Rockhampton, Thompson's Point, Wycarbah and Broadsound Range. He also recorded *A. bancroftii* Maiden and *A. macradenia* Benth. as food plants from the Expedition Range, central Queensland. Lane (1979) noted, "It is of interest that *Acacia bidwillii* has also been observed as a food plant of *J. daemeli* Semper in numerous localities between Rockhampton and Mackay, Queensland," but he did not provide a reference. Presumably his comments are based on observations by Atkins (1975). I have also observed larvae and pupae on the leaves and stems of young *A. bidwillii* plants (about 1 m high) growing on the James Cook University campus, Townsville, north Queensland, during 16–26 November 1981. They were associated with large numbers of an *Iridomyrmex* (Hymenoptera: Formicidae). Adult butterflies visited the open flowers of *A. bidwillii* (Hawkeswood, 1985). Mr. M. De Baar (June 1984, pers. comm.) has recorded large numbers of larvae and pupae of *J. daemeli* on *Acacia leucoclada* Tindale subsp. *argentifolia* Tindale, 25 km south of Warwick, southeastern Queensland during January 1983. This is a previously unrecorded host for this butterfly.

Manski (1960) recorded *A. cunninghamii* Hook. as a larval host for four species of Lycaenidae—*Hypochrysops delicia delicia* Hewitson, *Jalmenus evagoras evagoras* (Donovan), *J. ictinus* Hewitson and *J. daemeli* Semper (noted above). (Waterhouse (1932) originally recorded this *Acacia* for *H. d. delicia*). However, in a recent revision of the Queensland *Acacia* species, Pedley (1978) noted that the name *A. cunninghamii* had been applied loosely to six *Acacia* species, viz. *A. tropica* (Maiden et Blakely) Tindale, *A. cretata* Pedley, *A. longispicata*

Benth. (ssp. *longispicata* and *velutina* Pedley), *A. crassa* Pedley (ssp. *crassa* and *longicoma* Pedley), *A. concurrens* Pedley and *A. leiocalyx* (Domin) Pedley (ssp. *leiocalyx* and *herveyensis* Pedley). (As a result of Pedley's revision, the name *cunninghamii* should not be used for any *Acacia*). Therefore, the records of *A. cunninghamii* as a host could apply to any of the above six species. In respect to *J. daemeli*, *J. evagoras* and *J. ictinus*, the observations by Manski (1960) were made in the Maryborough and Brisbane districts, while those of *H. d. delicia* were restricted to Maryborough. Of the six *Acacia* species noted above, only two, *A. crassa longicoma* and *A. leiocalyx leiocalyx*, are known to occur naturally in the Maryborough district, while *A. concurrens* and *A. leiocalyx leiocalyx* grow in the Brisbane district (from Pedley, 1978). Since *A. leiocalyx* is usually more common in both districts, it is possible that the name *A. cunninghamii*, referred to in Manski (1960), refers to this species. Whether *J. daemeli* and the other butterflies utilize *A. concurrens*, *A. leiocalyx* and *A. crassus*, or a combination of these, must await the results of further field work. In the meantime, the name *A. cunninghamii* listed in Waterhouse (1932), Manski (1960), Common and Waterhouse (1972, 1981) and Hawkeswood (1981) should be disregarded.

For *J. daemeli*, there are 12 known larval host plants, viz. *Acacia bancroftii, bidwillii, decurrens, harpophylla, irrorata, leucoclada* subsp. *argentifolia, macradenia, neriifolia, pendula, Heterodendrum diversifolium, Eucalyptus melanophloia* and *Eucalyptus* sp.

In reference to *Jalmenus evagoras*, Dunn (1984) recently recorded a new larval host, *Acacia diffusa* Ker (erroneously cited as *Acacia diffusa* Lindl.). This species is regarded as a synonym of *Acacia genistifolia* Link (Jacobs & Pickard, 1981). With *A. cunninghamii* omitted from my list (i.e., Hawkeswood, 1981) and *A. genistifolia* included, the number of larval hosts remains at 15, all of which are *Acacia* species.

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PREDATION ON *CATOCALA* MOTHS (NOCTUIDAE)

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ABSTRACT. *Catocala* adults are preyed upon by flying squirrels; tree and fence lizards; bats and birds, commonly in man-made situations.

I was born in the last century, in a family with natural history interests on the Ozark Mountain uplift in southwest Missouri. My first interest was ornithology/oology, then collecting insect and plant materials for sale, exchange and my collections. From the back porch I could look across a small field at the edge of 320 acres of "wild land," never cut, never fenced. The upland tree community was largely post, black and blackjack oak; the hollows had hickory, white and red oak with other trees especially along streams. The woods were commonly burned each spring, it was said, to kill the ticks, snakes and to rejuvenate the grass. The burning resulted in many of the trees having basal fire scars. On poor soil with a deficiency of rain, the timber was small, open and more widely spaced with limited underbrush. This presented an ideal situation in which to observe animal and insect life. Oats were sown in March and, like winter wheat, cut and shocked in June. Then, there was much time for me to be afield on my interests, in near continuously warm sunny days. That was *Catocala* country every year. Without electricity, light and baits yielded few specimens, and so, daylight collecting was carried on.

I have over 200 predator-injured *Catocala*, including every one of the larger eastern species. Injuries to their wings are various. I think Dr. T. Sargent did a good job of illustrating in his book "Legion of Night, The Underwing Moths" a theoretical injury which could be produced by the attack of a bird. But, in all of my injured *Catocala*, there is not one injury I think was produced by a bird peck. I once saw a flycatcher fly near a fluttering *Catocala* while popping its beak, probably because the bird's nest was near. The *Catocala* I have found resting on trees in depressions in the bark on oak trees draw their wings down tight, and I have said that a bird would need a vanadium steel lower mandible to bite a piece out of the wing or wings on one side. In the big woods of northwest Maine I once saw a scarlet tanager up in the top of a tall white birch, and the wings of a *Catocala* fluttered down. The tanager may have devoured the moth. A. J. Snyder says that he saw a *Catocala* "snapped" out of a tree by a scarlet tanager and immediately torn to pieces. Of utmost importance, fully 70% of all specimens of some lots injured have similar injuries in all four wings or in the two hindwings, most of these obviously made at the same moment by the predator. These types of injury were not made by birds, even to flying moths.

Flying squirrels, genus *Glaucomys,* seem ideally fitted to attack *Catocala* as they live in the same situations. They are the most active voracious predators I know. One year I prepared a stupifying bait, fed through wicks, with a screen wire basket below to catch the moths which fell. All I could get were wings, and all I found accountable were flying squirrels, which I knew to be strongly insectivorous. I took jump-steel traps, attached noctuid moths to the pan and hung them on the tree trunks above the bait outlet. In these traps I caught flying squirrels, one after another, until I gave up that collecting method. They are widespread along with *Catocala,* where old trees remain in some numbers. The above mentioned injuries to the *Catocala* spp. are common.

In the Ozarks I have watched skinks or tree lizards flushing out the moths up on the limby portion of tree trunks, where *Catocala* tend to rest in the morning and on overcast days. Wings were found on the ground in such areas. These lizards are well fitted to attack moths and produce in an instant the torn pairs of wings which are so prevalent where the lizards live. Florida collectors have spoken of these. A considerable number of moths which Dean Berry sent me from Florida had over 40% with serious injury to their wings.

Conditions are different in other parts of the country. John W. Johnson of Corona del Mar, California, a shrewd experienced worker, writes: ". . . in fifty years of field collecting *Catocala* I have seen little evidence of predation. I have never witnessed an attack by birds on a flying *Catocala,* nor observed them searching tree boles for the moths. Nor have I ever collected moths showing the types of wing damage figured in Sargent's "Legion of Night" that has been ascribed to birds. An experienced observer in the 1920's and 1930's, Janet Riddell, saw a lizard, *Sceloporus* sp. hunting over a tree hole, encountering a *Catocala* at rest which it seized by the body, bit off the wings close to the body and swallowed the body whole. I have frequently observed *Sceloporus* sp. lizards climbing about tree boles as high as 15–20 feet above the ground, and have found sets of *Catocala* wings clipped off close to the body at the base of trees in groves where *Catocala*s were present and resting, which I supposed due to lizard predation." He has repeatedly mentioned the fact that the smaller western *Catocala* regularly fly from one thick clumped scrub oak to another two feet or less above ground, thus avoiding most predators. He collected a *Catocala californiensis* Brower with a spine of a low cactus driven 4 mm into its thorax.

Dave Baggett has kindly forwarded an extensive account of numerous experiences with predation on *Catocala* in Florida. His experiences usually include man's changes and their effects on both predatory life and *Catocala,* which differ greatly from my experiences while in my teens and twenties in the Ozark mountain area. He says: ". . . while eating lunch several *C. ilia* Cramer wings filtered down from the tree tops near me, and another specimen from which the abdomen had been chewed off, but the wings and thorax were still intact—the moth still quivering. The birds eating them were blue jays, but we never saw one of these birds catch one." He says that in Jacksonville his bait trap area was a regular feeding area for mockingbirds, English sparrows and blue jays. As his traps were emptied of insects early each morning, the birds would rapidly snap up the majority of the moths as they flew away. The birds preferred smaller moths as a rule; preferring *Catocala amica* Hübner and *micronympha* Gueneé over *ultronia* Hübner, *ilia, muliercula* Gueneé, etc., all common species. He says he has seen many wild specimens with bird beak patterns. He suspects the heaviest predation is by lizards, especially anoles and fence swifts. Even though they are relatively small, they will readily grab at large *Catocala* like *ilia, lacrymosa* Gueneé, *agrippina* Strecker, etc., frequently getting completely yanked off the tree trunk by the frantic flapping of the moth to get away, and most of the larger ones probably do. One rarely finds the smaller species with the rounded "lizard-type" bites on the wings. He has repeatedly seen American anoles capture and eat *Catocala* moths, including species as large as *ultronia*; and the anoles try to catch larger species, frequently leaving their marks. While trying to collect *C. jair* Strecker, an eastern fence swift on an oak was observed catching and eating one of these moths which, when flushed out, had settled near the lizard. Flying squirrels in Florida most definitely catch and eat *Catocala* and sometimes also gray squirrels. Some who have used bait traps or have baited trees will confirm this. Dave Baggett says on numerous occasions while watching lighted sheets he has seen bats and owls capture larger moths and *Catocala* spp., also at city lights, always catching the moths in mid-air. He has seen red-shouldered hawks catch the larger saturniid moths. He thinks birds do not aggressively seek out *Catocala* selectively. Certainly, that is not the case in Florida. Presumably, the greater number of mangled *Catocala* in collections have been attacked by lizards and not by the more powerful flying squirrels which can destroy a much larger number of the insects. At Ithaca, New York, skunks visited both the Cornell light trap and baited *Crataegus* shrubs.

Flying squirrels and tree and fence lizards are the important predators on *Catocala.* Moths at light and coming to bait attract skunks and other animals. Bats are important predators around man-lighted areas. Instances of bird predation are reported for blue jays, scarlet tanagers and man-flushed *Catocala* by wood pewee. Many common species of birds are attracted to the insects which are flushed from light, bait and artificial traps. Birds sieze numerous small insects when traps are cleared releasing the insects, attracted as to bird feeders. Hornets and wasps also take part.

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AN ANNOTATED LIST OF THE BUTTERFLIES AND SKIPPERS OF LAWRENCE COUNTY, OHIO

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ABSTRACT. Until recently, only 23 species of butterflies and skippers were known from Lawrence County. In 1983–1984 a study was conducted to increase our knowledge of these insects in the county. As a result, 60 additional species were recorded. One species, *Euchloe olympia*, was recorded in Ohio for the first time. For each species listed, the following data are provided: relative abundance, habitat and nectar sources, extreme dates, and localities. Species recorded prior to this study are accompanied by historic collection data. A list of 21 additional species which should be looked for in Lawrence County is included. Twenty-four species are not known from the adjacent counties in Kentucky or West Virginia. Thirteen species showed differences in abundance between 1983 and 1984 and potential reasons are discussed. Curves are also provided to illustrate relative species diversity during the study. The county possesses characteristics more typical of regions to the south of Ohio and the Appalachian uplands, and several resident species of butterflies and skippers reflect these aspects. A list of species found in Lawrence County, Ohio allows for a more complete understanding of the butterfly and skipper fauna of southern Ohio, northeastern Kentucky and southwestern West Virginia.

Two lists have dealt with the butterflies and skippers of southeastern Ohio (Parshall, 1983; Shuey, 1983). Although Vinton and Athens counties have received attention, other counties in the region have virtually been ignored. The natural history of Lawrence County is poorly known, and Albrecht (1982) recorded only 23 species of butterflies and skippers from the county. The southernmost county in Ohio, Lawrence County is relatively inaccessible and remains insufficiently understood. In 1983 a study was conducted to increase our knowledge of the butterfly and skipper fauna of Lawrence County. As a result, 41 additional species were recorded. The study was continued in 1984 and 19 previously unrecorded species were collected, bringing the total number of species known from the county to 83. One species, *Euchloe olympia* (W. H. Edwards), represents a state record and brings the total number of species recorded from Ohio to 137 (Riddlebarger, 1984). The present paper describes the results of this study and provides historic collection data on the butterflies and skippers of Lawrence County, Ohio.

Lawrence County is situated on the Ohio River, bordering the states of Kentucky and West Virginia (Fig. 1). The average annual temperature of the county is approximately 13°C (Gordon, 1969). The average annual precipitation ranges from 102–112 cm with snowfall measuring approximately 38–64 cm (Collins, 1975). Frost dates for spring (dates after which there is a 50% or less chance that temperatures will fall to 0°C or lower) are 20–25 April, and for fall (dates by which there is a 50% chance that the first 0°C temperature will have occurred) are 15–20 October (Collins, 1975). Thick river fogs may contribute to a mod-

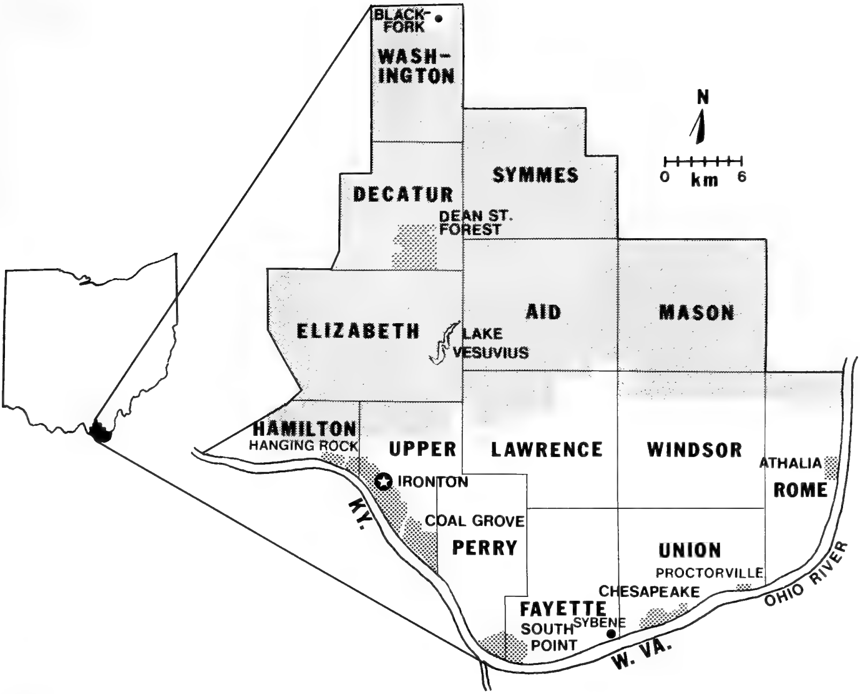

FIG. 1. The location, political divisions, cities, and collecting localities of Lawrence County, Ohio. Land within the boundaries of Wayne National Forest is shaded.

eration in climate immediately along the Ohio River (Cusick & Silberhorn, 1977).

Lawrence County lies within the Unglaciated Allegheny Plateau Region of Ohio. Relative relief ranges from 91–152 m (Gordon, 1969). Underlain by a bedrock of Pennsylvanian shale and sandstone, the original vegetation of the county at the time of the earliest land surveys consisted of mixed oak (*Quercus* spp.) forests with limited tracts of mixed mesophytic and bottomland hardwood forests (Fig. 2). Mixed oak forests covered knobs and ridgetops and were composed of a chestnut oak (*Quercus montana* Willd.)–chestnut (*Castanea dentata* (Marsh) Borkh.) forest type (Gordon, 1969). Yellow pines (*Pinus rigida* Mill., *Pinus virginiana* Mill., and *Pinus echinata* Mill.) occurred locally (Cusick & Silberhorn, 1977). Mixed mesophytic forests greatly varied in composition and were dominated mostly by broad-leaved species, with no single species comprising a large fraction of the dominants (Gordon, 1966). This forest type was found on less well drained north and northeast facing slopes (Cusick & Silberhorn, 1977). Bottomland hardwood forests were variable in composition and occurred in older

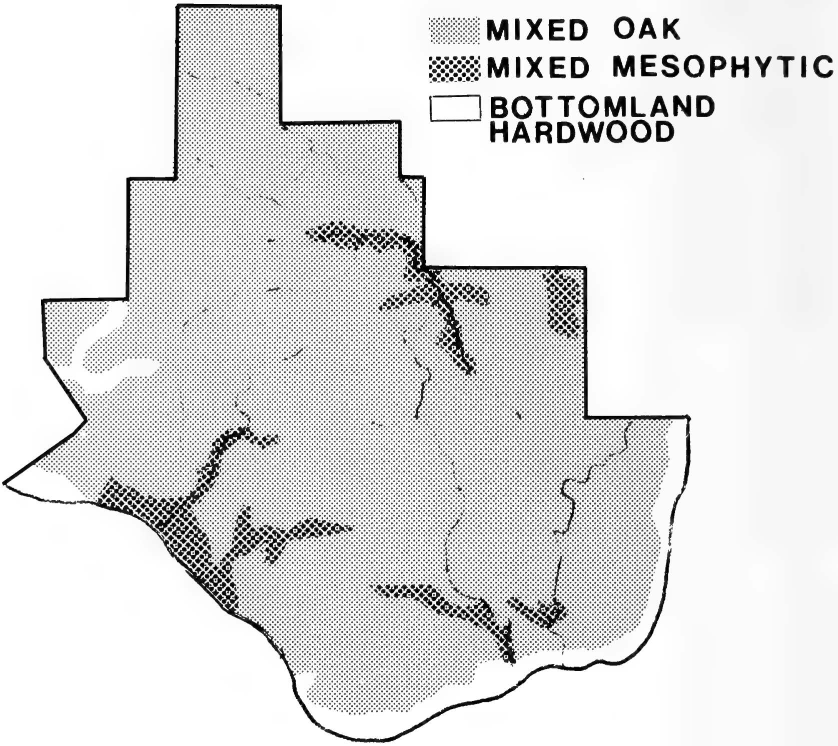

FIG. 2. The original vegetation of Lawrence County (adapted from Gordon, 1966).

valleys and on recent alluvium and terraces of major streams (Gordon, 1966). Intense lumbering during the 19th century, developmental pressures, and agricultural activities have significantly altered and fragmented these forests. Consequently, no pristine woodland communities remain. Today, the county is more than 70% forested and composed of oak–hickory (*Carya* sp.), Virginia pine (*Pinus virginiana*)–pitch pine (*Pinus rigida*), and oak–pine forest types (Fig. 3).

Dean State Forest and the Ironton District of Wayne National Forest presently contain the most extensive tracts of mature secondary woodland in Lawrence County. Here, controlled clear-cutting and strip mining have created many habitats of various successional stages. The federally administered Lake Vesuvius Recreation Area possesses a man-made lake surrounded by a forest with a rich floral composition. Elsewhere in the county private woodlots of secondary forest, cropland, pastures, and fallow fields are the principal types of vegetational communities (Fig. 4). Wetlands are few, but several buttonbush, *Cephalanthus occidentalis* L., and cat-tail, *Typha* sp., marshes and thinly

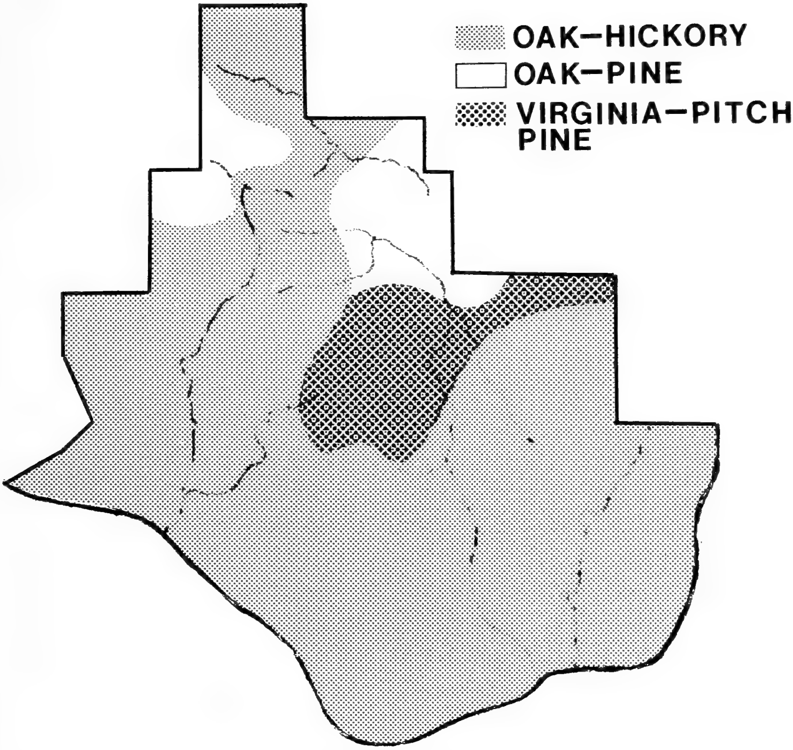

FIG. 3. The current major forest types of Lawrence County (adapted from Ohio Dept. of Nat. Res., 1984).

wooded swamps of willow, *Salix* spp., and river birch, *Betula nigra* L., exist in the northern portion of the county.

Due to its location, Lawrence County possesses characteristics more typical of regions south of Ohio. As a result of a long growing season and low winter precipitation, a few species of plants are known in Ohio only from bluffs along the Ohio River in Lawrence County and the adjacent counties of Gallia and Scioto (Cusick & Silberhorn, 1977). One southern species, American holly, *Ilex opaca* Ait., is believed to occur naturally in Ohio only in Lawrence and Scioto counties (Braun, 1961). Lawrence County also exhibits affinities to the Appalachian uplands. Several species of *Rhododendron*, limited in Ohio to the more rugged part of the Unglaciated Allegheny Plateau, occur locally in the county (Braun, 1961).

The butterfly and skipper fauna of Lawrence County was undoubtedly modified when the original vegetation was destroyed. Prior to

FIG. 4. Habitats in Lawrence County. (**Top**) Ridgetop oak-pine forest (Wayne National Forest). (**Bottom**) Disturbed area along the Ohio River (South Point).

settlement, species adapted to forest habitats probably predominated. Presettlement Athens County was also heavily forested and Shuey (1983) speculated that species characteristic of open areas possibly were absent or inhabited ephemeral areas. A comparable situation could have existed in Lawrence County. Today, the county has a more diverse flora and thus, probably supports a more diverse butterfly and skipper fauna as well.

METHODS

The results are based upon 30 visits to Lawrence County during 19 July–7 October 1983 and 27 April–11 October 1984. Historic records were gathered from Stehr (1945), Albrecht (1982; pers. comm., 1983), and the 1979 Lepidopterists' Society Season Summary (News of the Lepid. Soc., No. 2. Mar/Apr, 1980). Although collecting was done throughout the county, Wayne National Forest and areas along the Ohio River received the most attention.

The results are presented in the following format: species name, relative abundance, habitat and nectar sources, extreme dates, and localities. Designations of relative abundance are adapted from Covell (1984). These designations apply only when weather conditions are favorable and individuals are most active. "Abundant" means that a species can be expected in great numbers in the correct habitat and season. "Common" indicates that a species can be expected in the correct habitat and season, and several specimens can be anticipated. "Uncommon" means that a species may or may not be found in the proper habitat and season; or that very few specimens might be found on a given visit to a specific location. "Rare" species are seldom encountered. Distinct differences in the abundance of a species between 1983 and 1984 are shown by listing two abundance designations, one for each year, separated by a slash symbol. Habitat information is based upon observations made by the author in Lawrence County. Nectar source information is provided for species seen visiting flowers and helps to indicate correct habitat associations. Participation in mud puddling behavior is also noted. Extreme dates are given to show the approximate length of flight periods during the study but are not conclusive. Dates are organized as day/month/year. Only positive identifications of specimens captured or observed in the field were used in compiling extreme dates. Specific localities are given for species usually encountered singly or that exist in very localized colonies. Localities refer to those on Fig. 1. Species recorded from Lawrence County prior to the 1983–1984 study are accompanied by historic collection data in parentheses. The taxonomy and nomenclature follow *A Catalogue/Checklist of the Butterflies of America North of Mexico* (Miller and

Brown, 1981), and each species listed is preceded by the number used in that publication. An asterisk (*) denotes a species that Albrecht (1982) and Opler (1983) do not record from the adjacent counties in Ohio (Gallia, Jackson, and Scioto), Kentucky (Boyd and Greenup), or West Virginia (Cabell and Wayne). However, one of these species, *Staphylus hayhurstii* (W. H. Edwards), was discovered by the author in Jackson County, Ohio in 1984. Specimens collected by the author are contained in his private collection and the Ohio Historical Society collection in Columbus, Ohio.

Results

HESPERIOIDEA
HESPERIIDAE

7a *Epargyreus c. clarus* (Cramer). Abundant. Hayfields, forest clearings, roadsides; red clover (*Trifolium pratense* L.), common milkweed (*Asclepias syriaca* L.); mud puddles. 11.vi.84–8.x.83. Throughout. (1944, Hanging Rock, A. W. Lindsey).

40 *Autochton cellus* (Boisduval and LeConte). Uncommon. Ridgetop trail through oak forest, forest margins, roadsides; New Jersey tea (*Ceanothus americanus* L.), wild ipicac (*Gillenia stipulacea* (Muhl. ex Willd.)), purple milkweed (*Asclepias purpurascens* L.), common milkweed; mud puddles. 19.vi.84–2.vii.84. Blackfork, Decatur Twp., Lake Vesuvius. (16.vi.71, D. K. Parshall).

42 *Achalarus lyciades* (Geyer). Uncommon. Dry fields, brushy roadsides, margins of oak forests; red clover, common milkweed. 11.vi.84–30.viii.83. Throughout. (29.v.1899, collector unknown).

47 *Thorybes bathyllus* (J. E. Smith), Uncommon/common. Disturbed areas near oak forest; red clover. 11.vi.84–29.viii.83. Throughout. (26.vi.32, J. S. Thomas).

48 *Thorybes pylades* (Scudder). Common. Disturbed areas near woods; red clover. 11.vi.84–17.vii.84. Throughout. (17.vi.1899, J. S. Thomas).

*70 *Staphylus hayhurstii* (W. H. Edwards). Uncommon. Gardens, wooded stream banks, and trails near the foodplant, *Chenopodium album* L.; yellow wood sorrel (*Oxalis* sp.); mud puddles. 29.vii.84–9.viii.83. Sybene, South Point, Coal Grove.

83 *Erynnis icelus* (Scudder and Burgess). Rare. Margins of oak forest; mud puddles. 11.vi.84–19.vi.84. Blackford, Decatur Twp.

84a *Erynnis b. brizo* (Boisduval and LeConte). Rare. Margins of oak forest; mud puddles. 25.iv.84–28.iv.84. Washington Twp.

85a *Erynnis j. juvenalis* (Fabricius). Common. Oak forest and margins; mud puddles. 25.iv.84–5.v.84. Throughout.

90 *Erynnis horatius* (Scudder and Burgess). Common/uncommon. Oak forest and margins; wild ipicac; mud puddles. 25.iv.84–29.viii.83. Washington Twp., Decatur Twp., Lake Vesuvius.

92 *Erynnis martialis* (Scudder). Rare. One female in a dry ridgetop clearing near the foodplant, *Ceanothus americanus*. 12.vi.84. Decatur Twp.

*97 *Erynnis baptisiae* (Forbes). Rare. Disturbed areas along the Ohio River; ironweed (*Vernonia* sp.), red clover, 9.viii.83–8.x.83. Proctorville, South Point.

115 *Pholisora catullus* (Fabricius). Common. Hayfields and gardens near the foodplant, *Chenopodium album*; alfalfa (*Medicago sativa* L.), dogbane (*Apocynum* sp.), red clover. 26.vi.84–4.ix.84. Throughout. (1.vi.1899, Collector unknown).

131 *Nastra lherminier* (Latreille). Rare. Brushy field and roadside where the foodplant, *Andropogon scoparius* Michx., is common. 11.vi.84–23.viii.83. Washington Twp.

*142 *Ancyloxypha numitor* (Fabricius). Common. Wet fields, wooded clearings near streams; red clover. 11.vi.84–17.ix.84. Throughout.

*151 *Hylephila phyleus* (Drury). Rare. Disturbed areas along the Ohio River; white *Aster* sp., alfalfa. 4.viii.84–8.x.83. Proctorville, South Point, Ironton.

161 *Hesperia leonardus* Harris. Rare/Locally common. Ridgetop old fields, clearings, pastures; thistle (*Cirsium* sp.), ironweed. 14.viii.83–12.ix.84. Blackfork, Washington Twp., Decatur Twp.

174 *Polites coras* (Cramer). Abundant. Any open area; red clover, alfalfa, ironweed; mud puddles. 11.v.84–8.x.83. Throughout.

179 *Polites themistocles* (Latreille). Uncommon. Hayfields, roadsides; red clover. 11.v.84–23.viii.83. Throughout.

180a *Polites o. origenes* (Fabricius). Uncommon/common. Hayfields, dry old fields, forest clearings; red clover. 11.vi.84–12.ix.84. Throughout.

185 *Wallengrenia egeremet* (Scudder). Rare. Oak ridgetop clearings, margin of oak forest; mud puddles. 25.vi.84–5.viii.84. Decatur Twp., Lake Vesuvius. (30.vi.34, J. S. Thomas).

*186 *Pompeius verna* (W. H. Edwards). Common. Fallow fields, clearings, brushy roadsides; red clover, common milkweed. 19.vi.84–29.vii.84. Throughout.

187b *Atalopedes campestris huron* (W. H. Edwards). Abundant/common. Any open area; red clover, ironweed, asters; mud puddles. 17.vii.84–11.x.84. Throughout in 1983, only along Ohio River in 1984. (2.viii.82, Union Twp., J. V. Calhoun).

197 *Poanes hobomok* (Harris). Rare. Grassy clearings, oak forest margins. 11.vi.84–26.vi.84. Blackfork, Lake Vesuvius.

198 *Poanes zabulon* (Boisduval and LeConte). Uncommon. Grassy clearings, oak forest margins. 26.vii.83–5.viii.84. Blackfork, Lake Vesuvius, Ironton. (21.v.1899, A. W. Lindsey).

*217b *Euphyes ruricola metacomet* (Harris). Uncommon. Hayfields, old fields, roadsides; red clover, common milkweed; mud puddles. 11.vi.84–17.viii.84. Throughout.

*219a *Atrytonopsis h. hianna* (Scudder). Rare. Ridgetop oak forest clearings where the foodplant *Andropogon scoparius*, occurs. 11.vi.84–12.vi.84. Decatur Twp.

*245 *Amblyscirtes vialis* (W. H. Edwards). Rare. Trail through ridgetop oak forest; mud puddles. 5.v.84. Lake Vesuvius.

*259 *Panoquina ocola* (W. H. Edwards). Rare. One specimen in disturbed area along Ohio River; white *Aster* sp. 7.x.83. South Point.

PAPILIONOIDEA

PAPILIONIDAE

297a *Battus p. philenor* (Linnaeus). Uncommon/common. Forests, forest margins, hayfields, roadsides; joe-pye-weed (*Eupatorium fistulosum* Barratt), red clover, common milkweed; mud puddles. 25.iv.84–17.ix.84. Throughout. (26.vi.32, C. F. Walker).

300 *Eurytides marcellus* (Cramer). Rare. Forests, forest margins; purple loosestrife (*Lythrum salicaria* L.), wild ipicac. 25.iv.84–2.viii.83. Washington Twp., Lake Vesuvius, Coal Grove. (27.vi.79, F. Bower).

303a *Papilio polyxenes asterius* Stoll. Uncommon. Hayfields, pastures; red clover. 11.vi.84–12.ix.84. Throughout.

*314 *Heraclides cresphontes* (Cramer). Rare. Forest margins, hayfield; red clover, common milkweed. 4.viii.84–14.viii.83. Lake Vesuvius, Proctorville.

320a *Pterourus g. glaucus* (Linnaeus). Abundant. Forests, forest margins, hayfields, roadsides; dandelion (*Taraxacum officianale* Weber), red clover, thistle, common milkweed, joe-pye-weed; mud puddles. 25.iv.84–12.ix.84. Throughout. (27.vi.79, F. Bower).

325a *Pterourus t. troilus* (Linnaeus). Abundant. Forests, forest margins, hayfields, roadsides; red clover, thistle, common milkweed, joe-pye-weed; mud puddles. 25.iv.84–12.ix.84. Throughout.

PIERIDAE

*334 *Pontia protodice* (Boiduval and LeConte). Uncommon. Disturbed areas along the Ohio River; red clover, dogbane, ironweed. 17.vii.84–11.x.84. Athalia, South Point.

338 *Artogeia rapae* (Linnaeus). Common. Nearly any open area; red clover, alfalfa, asters; mud puddles. 25.iv.84–11.ix.84. Throughout.

*344 *Euchloe olympia* (W. H. Edwards). Rare. Oak forest ridgetop. 28.iv.84–5.v.84. Lake Vesuvius.

349b *Falcapica midea annickae* dos Passos and Klots. Uncommon. Forests, forest margins, 27.iv.84–5.v.84. Decatur Twp., Lake Vesuvius. (18.iv.76, Washington Twp., C. W. Albrecht).

351a *Colias p. philodice* Godart. Common. Hayfields, vacant lots, roadsides; red clover, alfalfa, asters; mud puddles. 25.iv.84–11.x.84. Throughout. (18.iv.76, Washington Twp., C. W. Albrecht).

352 *Colias eurytheme* Boisduval and LeConte. Common. Hayfields, vacant lots, roadsides; red clover, alfalfa, asters; mud puddles. 5.v.84–11.x.84. Throughout.

383a *Pyrisitia l. lisa* (Boisduval and LeConte). Common/rare. Clearings, dry fields, roadsides; mud puddles. 19.vii.83–11.x.84. Throughout in 1983, only South Point in 1984.

*388 *Abaeis nicippe* (Cramer). Rare. Brushy field near the foodplant, *Cassia hebecarpa* Fern., trail through ridgetop oak forest, grassy roadside. 5.v.84–12.ix.84. Washington Twp., Decatur Twp., Lake Vesuvius.

LYCAENIDAE

391a *Feniseca t. tarquinius* (Fabricius). Uncommon. Clearings and sunlit stream banks and lanes near common alder (*Alnus serrulata* (Ait.) Willd.) and hawthorns (*Crataegus* sp.) infested with wooly aphids (Eriosomatidae); mud puddles. 19.vi.84–5.viii.84. Decatur Twp., Lake Vesuvius, South Point.

393a *Lycaena phlaeas americana* Harris. Rare. One specimen in disturbed area along Ohio River. 8.x.83. South Point.

*398 *Hyllolycaena hyllus* (Cramer). Rare. Wet fields and marshes. 11.vi.84–4.ix.83. Symmes Twp., Decatur Twp.

417b *Harkenclenus titus mopsus* (Hubner). Uncommon. Oak forest clearings, clearing on wooded stream floodplain; common milkweed. 25.vi.84–2.viii.84. Blackfork, Lake Vesuvius.

424b *Satyrium calanus falacer* (Godart). Uncommon. Oak forest clearings and margins; common milkweed. 19.vi.84–2.vii.84. Blackfork, Decatur Twp., Lake Vesuvius. (26.vi.32, J. S. Thomas).

*427b *Satyrium liparops strigosum* (Harris). Rare. Oak forest clearing and margin. 19.vi.84–25.vi.84. Blackfork, Lake Vesuvius.

441 *Calycopis cecrops* (Fabricius). Uncommon. Oak forest clearings and disturbed areas near the foodplant, *Rhus copallina* L. 11.vi.84–12.ix.84. Blackfork, Lake Vesuvius, South Point.

468a *Incisalia h. henrici* (Grote and Robinson). Common. Oak forest clearings and margins where the foodplant, redbud (*Cercis canadensis* L.) occurs; redbud; mud puddles. 25.iv.84–5.v.84. Blackfork, Decatur Twp., Lake Vesuvius.

470a *Incisalia n. niphon* (Hubner). Uncommon. Ridgetops near the foodplant, *Pinus virginiana*; mud puddles. 25.iv.84–29.iv.84. Decatur Twp.

478b *Strymon melinus humuli* (Harris). Rare. Oak forest margins, hayfields; red clover, common milkweed. 26.vi.84–4.ix.84. Decatur Twp., Coal Grove. (16.vi.71, D. K. Parshall).

503a *Everes c. comyntas* (Godart). Abundant. Hayfields, pastures, roadsides; red clover. 5.v.84–11.x.84. Throughout. (18.iv.76, Washington Twp., C. W. Albrecht).

505a *Celastrina l. ladon* (Cramer). Rare/common. Forests, forest margins, clearings; redbud; mud puddles. 25.iv.84–4.ix.84. Throughout. (16.vi.71, D. K. Parshall).

506 *Celastrina ebenina* Clench. Uncommon. Margins of lowland forest; mud puddles. 25.iv.84–5.v.84. Lake Vesuvius.

514d *Glaucopsyche l. lygdamus* (Doubleday). Common. Oak forest margins, clearings, and roadsides near the foodplant, wood vetch (*Vicia caroliniana* Walt.); wood vetch; mud puddles. 25.iv.84–5.v.84. Blackfork, Decatur Twp., Lake Vesuvius.

RIODINIDAE

*529 *Calephelis borealis* (Grote and Robinson). Locally abundant. Lowland oak forest margins along south-facing roadbank where the foodplant, *Senecio obovatus* Muhl. is common; black-eyed susan (*Rudbechia hirta* L.), butterfly-weed (*Asclepias tuberosa* L.). 25.vi.84–17.vii.84. Lake Vesuvius.

LIBYTHEIDAE

*552a *Libytheana b. bachmanii* (Kirtland). Uncommon/rare. Margins of cropland, sunlit streambanks and wooded lanes near the foodplant, *Celtis occidentalis* L.; tickseed-sunflower (*Bidens* sp.), asters; mud puddles. 26.vii.83–11.x.84. Lake Vesuvius, South Point, Coal Grove, Hamilton Twp.

NYMPHALIDAE

*562 *Euptoieta claudia* (Cramer). Uncommon. Hayfields, brushy fields; red clover, ironweed, asters; mud puddles. 12.vi.84–11.x.84. Symmes Twp., Sybene, South Point.

565a *Speyeria c. cybele* (Fabricius). Uncommon/abundant. Hayfields, old fields, forest clearings, pastures, roadsides; red clover, common milkweed, ironweed, thistle. 11.vi.84–11.x.84. Throughout. (27.vi.79, F. Bower).

566a *Speyeria a. aphrodite* (Fabricius). Rare. Oak forest clearings, pastures; common milkweed, ironweed. 19.vi.84–4.ix.83. Blackfork, Decatur Twp.

580a *Clossiana b. bellona* (Fabricius). Common. Wet hayfields, vacant lots; red clover. 17.vii.84–11.x.84. Throughout. (27.vi.79. F. Bower).

606a *Charidryas n. nycteis* (Doubleday and Hewitson). Common. Forest margins, sunlit streams and lanes; common milkweed; mud puddles. 11.vi.84–25.viii.83. Throughout. (16.vi.71, D. K. Parshall).

623b *Phyciodes t. tharos* (Drury). Abundant. Hayfields, brushy fields, forest clearings, roadsides; red clover, alfalfa, common milkweed, butterfly-weed, asters; mud puddles. 11.vi.84–11.x.84. Throughout.

635a *Euphydryas p. phaeton* (Drury). Locally common. Thinly wooded swamp, edges of cat-tail marsh; mud puddles. 11.vi.84–25.vi.84. Blackfork, Washington Twp.

636 *Polygonia interrogationis* (Fabricius). Uncommon. Oak forests and their margins; mud puddles. 19.vi.84–11.x.84. Throughout.

637 *Polygonia comma* (Harris). Common. Oak forests and their margins; mud puddles. 25.iv.84–11.x.84. Throughout.

*648a *Nymphalis a. antiopa* (Linnaeus). Rare. Margins of ridgetop oak forests. 27.vi.84. Decatur Twp.

*650 *Vanessa virginiensis* (Drury). Uncommon. Hayfields, old fields, roadsides; red clover, ironweed, thistle, asters. 25.iv.84–11.x.84. Throughout.

*651 *Vanessa cardui* (Linnaeus). Uncommon/absent. Hayfields, roadsides; red clover, alfalfa. 19.vii.83–4.ix.83. Throughout.

653a *Vanessa atalanta rubria* (Fruhstorfer). Uncommon. Hayfields, oak forest margins, old fields, roadsides; mud puddles. 25.iv.84–5.viii.84. Throughout.

*656 *Junonia coenia* Hubner. Common. Hayfields, vacant lots; red clover, ironweed, asters; mud puddles. 17.vii.84–11.x.84. Throughout in 1983, only along Ohio River in 1984.

663c *Basilarchia arthemis astyanax* (Fabricius). Common. Forest margins, sunlit lanes; mud puddles. 11.vi.84–4.ix.83. Throughout.

*664a *Basilarchia a. archippus* (Cramer). Uncommon. Wet fields and marshes near the foodplant, *Salix* sp.; mud puddles. 11.vi.84–17.ix.84. Washington Twp., Symmes Twp., Decatur Twp., South Point. (16.vi.71, D. K. Parshall).

APATURIDAE

698 *Asterocampa celtis* (Boisduval and LeConte). Uncommon. Forest margins and lanes near the foodplant, *Celtis occidentalis*; mud puddles. 11.vi.84–29.viii.83. Symmes Twp., South Point, Elizabeth Twp. (1930's or early '40's, W. C. Stehr).

704 *Asterocampa clyton* (Boisduval and LeConte). Rare. Forest margins and lanes near the foodplant, *Celtis occidentalis*; mud puddles. 19.vi.84–29.viii.83. Decatur Twp., Lawrence Twp., South Point.

SATYRIDAE

711 *Enodia anthedon* A. H. Clark. Common. Lowland forests and margins, shaded grassy swamps; mud puddles. 25.vi.84–29.viii.83. Decatur Twp., Lake Vesuvius, Coal Grove. (16.vi.71, D. K. Parshall).

*718a *Cyllopsis g. gemma* (Hubner). Rare/uncommon. Ridgetop oak forests, shaded grassy swamps; mud puddles. 5.v.84–29.viii.83. Lawrence Twp., Lake Vesuvius. (30.vi.34, Dean State Forest, J. S. Thomas).

720 *Hermeuptychia sosybius* (Fabricius). Common. Lowland forest clearings, wooded stream banks, shaded grassy swamps; mud puddles. 11.vi.84–30.viii.83. Throughout.

723a *Megisto c. cymela* (Cramer). Uncommon/common. Forest margins and clearings. 11.vi.84–5.viii.84. Throughout. (30.vi.34, J. S. Thomas).

732c *Cercyonis pegala alope* (Fabricius). Uncommon. Hayfields, old fields, vacant lots. 25.vi.84–17.ix.84. Throughout.

DANAIDAE

760 *Danaus plexippus* (Linnaeus). Common. Hayfields, pastures, vacant lots; red clover, common milkweed, ironweed, asters. 25.vi.84–11.x.84. Throughout.

HYPOTHETICAL SUPPLEMENTARY LIST

The following list suggests species that should be looked for in Lawrence County. Required habitats and foodplants are available in the county and these species may occur as breeding residents or strays from other regions. An asterisk (*) denotes species that Albrecht (1982) and Opler (1983) record from adjacent counties in Ohio, Kentucky, and/or West Virginia.

HESPERIIDAE

96 *Erynnis lucilius* (Scudder and Burgess).
100b *Pyrgus centaureae wyandot* (W. H. Edwards).
104 *Pyrgus communis* (Grote).
150 *Thymelicus lineola* (Ochsenheimer).
165a *Hesperia m. metea* Scudder.
189a *Atrytone l. logan* (W. H. Edwards).
*235 *Amblyscirtes hegon* (Scudder).

PIERIDAE

337 *Artogeia virginiensis* (W. H. Edwards).
368a *Zerene c. cesonia* (Stoll).
371b *Phoebis sennae eubule* (Linnaeus).
389 *Nathalis iole* Boisduval.

LYCAENIDAE

423 *Satyrium edwardsi* (Grote and Robinson).
*425 *Satyrium caryaevorum* (McDunnough).

*460a *Mitoura g. gryneus* (Hubner).
464c *Incisalia augustus croesoides* Scudder.
*474a *Euristrymon o. ontario* (W. H. Edwards).
477 *Parrhasius m-album* (Boisduval and LeConte).
*491 *Erora laeta* (W. H. Edwards).

NYMPHALIDAE

567 *Speyeria idalia* (Drury).
*645 *Polygonia progne* (Cramer).

APATURIDAE

695 *Anaea andria* Scudder.

DISCUSSION

Thirteen species exhibited distinct differences in abundance between 1983 and 1984. Two species (*Hesperia leonardus* and *Polites origenes*) showed an increase in 1984 that may be attributed to a lack of collecting in the proper habitats in 1983. Conversely, another species (*Libytheana bachmanni*) showed a decrease in 1984 that may be attributed to a lack of collecting in the proper habitats in 1984. Four multivoltine species (*Thorybes bathyllus, Celastrina ladon, Cyllopsis gemma,* and *Megisto cymela*) are more common during their first brood, which was not observed in 1983 and consequently, showed a marked increase in 1984. Three additional species (*Atalopedes campestris, Pyrisitia lisa,* and *Vanessa cardui*) are migratory and known for their sporatic occurrences in Ohio. All showed a drastic decrease in 1984, suggesting that 1983 was a peak year for migrants or 1984 was poor, or both. The remaining three species either showed a considerable increase (*Battus philenor* and *Speyeria cybele*) or a considerable decrease (*Erynnis horatius*) for reasons unknown.

Fig. 5 presents curves constructed to illustrate seasonal patterns of relative diversity during the study period. Visits lasting more than one day and visits made on consecutive days are treated as single visits. Although several habitat types were sampled during each visit, differential collecting undoubtedly caused slight variations in the number of species recorded. The curves reveal that the fewest number of species occurred in the spring and fall with the greatest number occurring in mid to late summer. The lowest total was 11 species observed 1–2 October 1983, and the highest total was 48 species observed 14–15 August 1983. Although data on 1983 are incomplete, the relative diversities of the two years are very similar from mid-July through mid-October.

Two species are scarce and very local in occurrence in Ohio yet were found in atypically high concentrations in Lawrence County. Although listed as uncommon, approximately two dozen individuals of *Autochton cellus* were observed in the county during 1984. This species

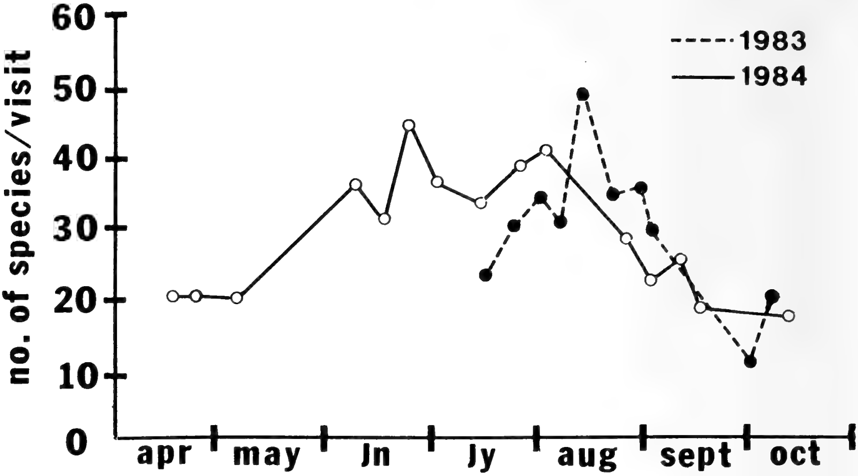

FIG. 5. Relative diversity during the study.

is usually encountered singly in Ohio. Previously, only a rich valley in Hocking County, Ohio called "Neotoma" has yielded a large number of specimens from one locality. In Lawrence County, the presence of *A. cellus* was difficult to predict, but up to 11 individuals were seen at each of two locations. *Calephelis borealis* is widespread in Ohio but is usually found in low numbers at any given location. However, at the single known Lawrence County colony, nearly 100 individuals were observed in a single day. Another species, *Hesperia leonardus*, is most often found singly or in very low numbers in Ohio except in the northwestern portion of the state where large colonies occur. In Lawrence County a colony was discovered which contained at least 50 individuals in an area approximately 1 hectare in size. In addition, *Pontia protodice* has nearly disappeared from Ohio, and the Lawrence County record is only the third record in the state since 1966. The county is also the only known Ohio location for *Atrytonopsis hianna* beyond Lucas and Fulton counties in the northwestern corner of the state.

The southern and Appalachian aspects of Lawrence County are reflected in the presence of several resident species of butterflies and skippers. *Calycopis cecrops, Hermeuptychia sosybius,* and *Autochton cellus* are found near the northern limits of their respective distributions. The Lawrence County population of *Glaucopsyche lygdamus* is included in the Appalachian distribution isolate of the species recognized by Opler and Krizek (1984). Long suspected to occur in Ohio, *Euchloe olympia* is known in the state only from Lawrence County. The population of this species in the county should be included in the more southern Appalachian distribution isolate of the species recognized by Opler and Krizek (1984). *Celastrina ebenina* is closely associated with rich forested Appalachian slopes in the eastern portion of its range (Wagner & Mellichamp, 1978).

Sixty-one percent of the 137 species of butterflies and skippers recorded in Ohio are represented in Lawrence County. One additional species, *Celastrina neglectamajor* Tutt, has recently been recognized as distinct from *Celastrina ladon* (Opler & Krizek, 1984) and may occur in Lawrence County. Specimens resembling this species were occasionally observed but not collected during 1984, hence this species was not included in the list. It is possible that another species, *Speyeria diana* (Cramer), was present in the county prior to settlement and subsequently was extirpated. An old specimen of this species labeled "southeastern Ohio" is contained in the collection of the Carnegie Museum of Natural History. This species inhabits old-growth hardwood forests and suffered a decline within its range when much of the habitat was destroyed due to logging and agriculture (Clark & Clark, 1951). Today, this species may be expanding (Hammon & McCorkle, 1983(84)). If once present in Lawrence County, it is undoubtedly no longer a breeding resident but could become re-established in the future, especially in the maturing woodlands of Wayne National Forest.

The butterfly and skipper fauna of northeastern Kentucky and southwestern West Virginia is still only remotely known. Since similar habitats exist throughout the region, a list of species known to occur in Lawrence County, Ohio facilitates a more thorough understanding of the butterflies and skippers, not only of southern Ohio, but also of the corresponding portions of Kentucky and West Virginia.

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SKIPPERS: POLLINATORS OR NECTAR THIEVES?

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ABSTRACT. The hypothesis that butterflies as a group are primarily nectar thieves, rather than pollinators, of many flowers that they visit was tested by observing skippers and quantifying their pollen loads. Two species of skippers, *Atalopedes campestris* and *Epargyreus clarus*, were studied.

Adult *A. campestris* visited 23 flower species and *Epargyreus clarus* visited 27 flower species. Fifty-nine male and female *E. clarus* carried a mean of 45.1, and 283 male and female *A. campestris* carried a mean of 68.4 pollen grains from eight species of very frequently visited flowers. Skippers carried most of the pollen in their facial cavities and on their proboscides. At least one skipper of each species carried pollen from each of these flowers in its genital cavity, a newly documented pollen-carrying structure for butterflies.

The skippers may have occasionally pollinated their nectar flowers, because they were constant to particular species during foraging bouts; they transported pollen; and they contacted stigmas with their pollen-bearing proboscides. Nevertheless, the skippers evidently functioned mainly as nectar thieves. They foraged mostly on asteriads rather than other kinds of flowers, primarily probing innermost (male-stage) disk florets, and they tended not to contact the outermost (female-stage) florets with their more pollen-laden parts. Moreover, they carried pollen loads that were too small to make them significant pollinators. Thus, our skipper data do not reject the above hypothesis.

Many butterfly species visit flowers from which they imbibe nectar (Faegri & van der Pijl, 1966; Shields, 1972; Barrows, 1976, 1979; Schemske, 1976; Wiklund et al., 1979; Schemske & Horwitz, 1984). For example, 197 butterfly species found in eastern North America use at least 5.9 ± 0.55 SE (1–15) genera of flowers as nectar sources (Opler & Krizek, 1984). Butterflies undoubtedly pollinate some flower species (Grant & Grant, 1965; Levin, 1972; Levin & Berube, 1972; Barrows, 1979; Cruden & Hermann-Parker, 1979), and they are definitely nectar thieves of others (Spears, 1983; Schemske & Horvitz, 1984). An individual nectar thief is an animal that takes nectar through a natural orifice of a flower without pollinating it (Inouye, 1980). Further, if an animal species thieves nectar during more than 50% of its visits to a particular flower species, the entire animal species could be classified as a thief species with regard to this plant species.

Delpino (1874) suggested that male butterflies are likely cross pollinators of their nectar plants, but decades later Robertson (1924: 100–101) stated that butterfly "relations to flowers are often that of nectar thieves." Subsequently, Wiklund et al. (1979) studied the flower visiting of the pierid *Leptidea sinapsis* L. in Sweden. From this species they generalized that, "Butterflies as a group may have evolved to occupy a parasitic mode of life as adults, feeding on the nectar of flowers without pollinating them," but they did not refer to Delpino's or Robertson's assertions. All in all, however, pollination effectiveness and efficiency of butterflies is little known (Gilbert & Singer, 1975; Kevan & Baker, 1983; Spears, 1983). In an attempt to test further the butterflies-as-nectar-thieves hypothesis, we studied foraging behavior of two common skippers, *Atalopedes campestris* (Boisduval) and *Epargyreus clarus* (Cramer), in Washington, D.C. The identities and relevant characteristics of the skippers' nectar flowers, skipper foraging behavior, and the locations and amounts of pollen that skippers carried were examined to test the hypothesis. Both skipper species that we studied are native to the Washington, D.C., area, where they have three broods per season (Clark, 1932). *Atalopedes campestris* fly in the garden from mid-July through September; *E. clarus,* from mid-June to early August. A future paper will discuss whether butterflies, in general, are nectar thieves or pollinators.

MATERIALS AND METHODS

In our study, we define "foraging bout" as a skipper's feeding activity on one or more flower species, starting when it was first discovered on a flower until it could no longer be followed due to its flying out of sight. A "visit" is a skipper's alighting upon or near a flower, extending its proboscis into it for at least 1 sec, and presumably feeding. An "infrequently visited flower species (IVFS)" is a flower that we saw only one individual skipper visit during only one of the ten 2-week observation periods of our study. A "frequently visited flower species (FVFS)" is a flower that we saw two to four conspecific skippers visit, and a "very frequently visited flower species (VFVFS)" is a flower that we saw five to hundreds of skippers visit during two or more of the 2-week observation periods. A "clear day" is one over 75°F, with no rain, and with less than 20% cloud cover. A "facial cavity" is a concavity into which a skipper's proboscis coils; a "genital cavity," one at the end of a skipper's abdomen, formed in a female by scales surrounding her papilla analis above and lamella antevaginalis below and in a male by scales surrounding his uncus above and valvae below.

Skippers were studied from May through October 1982 in the 0.9-ha vegetable and flower garden where Lazri and Barrows (1984) investigated flower visiting in *Pieris rapae* L. The garden is a community garden used in 1982 by about 146 gardeners, and it contains about 265 species of entomophilous plants, including vegetables, ornamentals, herbs, wildflowers, and weeds.

Flowers visited by the skippers and the relative numbers of skippers present at each species were noted during a total of 12 30-min meandering walks made through the garden twice each month in June, July, August, and September. The walks were made once every 2 weeks on a clear day, every hour on the hour, from 0800 to 2000 h (EDT). At each skipper-frequented flowering plant or group of such plants, we made short (10 sec) counts to standardize the amount of time spent at a plant or group of plants. A total of 564 skippers of both species was counted during the entire census.

To measure flower corolla lengths, we collected flowers in plastic bags and kept them moist until they could be examined. Dial calipers, accurate to 0.01 mm, were used to measure corollas (Lazri & Barrows, 1984). We made a pollen reference collection from pollen collected in the study area.

In studying possible flower constancy, frequency of flower use, and pollen deposition of skippers, we observed 22 foraging *A. campestris* and 60 foraging *E. clarus.* A stopwatch and tape recorder were used when needed. To discriminate focal individuals from other nearby skippers when they were common, we marked forewings of focal individuals with small spots of enamel paint, which did not appear to affect their behavior. Forty additional skippers were each observed for 10 min as they foraged at asteriad disk and ray florets.

In examining possible pollen transport and deposition, we collected 285 *A. campestris* and 77 *E. clarus*; 3 to 23 males and 5 to 25 females were taken from each VFVFS. Before it was captured, each skipper was followed as it visited two consecutive flower heads, extending its proboscis into a flower in each head for at least 1 sec. After it was netted, a skipper was paralyzed by carefully pinching the sides of its thorax between a thumb and forefinger and then placed into a glassine envelope on which relevant data were recorded. The enveloped skipper was immediately put into an insulated bag filled with frozen cold packs. Within the hour, all skippers in the bag were put into a cooler filled with more frozen cold packs. At the end of a collecting day, the skippers were put into a freezer until they could be examined for pollen (Turnock et al., 1978).

In searching for pollen on a skipper, we removed its legs and proboscis, placed them on a clean glass slide, and covered them with a drop of Permount® and a coverslip. The rest of the skipper was placed on a watchglass. Its proboscis, legs, body, glassine envelope, slide, and watchglass were examined for pollen under a compound microscope (up to 400 power), a dissecting microscope (up to 30 power), or both. Pollen adhering to the skipper's labial palpi were included in its facial cavity count. Free floating pollen grains on the slide and watchglass and in the envelope were also counted. Adult skipper age was estimated to be young, middle-aged, or old, based on the amount of scale loss and wing tattering that was present on a skipper's wings and body. A young skipper was one that was almost totally intact; a middle-aged one had slight wing tattering and a few scales missing; and an old one had very tattered wings and many scales missing.

Quantitative analyses were made with the Statistical Analysis System (SAS) computer package (Ray, 1982a, b). Pollen count and corolla depth values were log transformed to obtain homoscedastic data for the Duncan's multiple range test (DMRT). Possible differences between groups were analyzed with the *t*-test (TT) or paired *t*-test (PTT) corrected for heteroscedasticity when necessary, the Fisher exact probability test (FEPT), and the Chi-square test (CST). Kendall's rank correlation coefficient (KRCC) was used to test for significant correlations.

RESULTS AND DISCUSSION

Flowers Visited

Atalopedes campestris visited 23 species of flowers (including two hybrids), in eight plant families (Table 1). Thirteen of these flowers (57%) were in Asteraceae, making it the most visited family. All but one of *A. campestris*' eight very frequently visited flower species (VFVFS) were asteriads. The other VFVFS was the dipsacaciad *Scabiosa atropurpurea* which has florets that are morphologically similar to asteriad disk flowers. *Atalopedes campestris* also abundantly visited the asteriad *Cosmos sulphureus*, but since they did so for only 1 week, this flower was not classified as a VFVFS.

Epargyreus clarus visited 28 species of flowers (including three hybrids), in 16 plant families (Table 1). Eight of the flowers (29%) were asteriads. This skipper used only two VFVFS, both also VFVFS of *A. campestris*. Seven frequently visited flower species (FVFS) were used by *E. clarus*. Of these, *Consolida orientalis* and *Dianthus barbatus* were visited early in the season when few other flowers were in bloom. *Epargyreus clarus* visited *Phaseolus vulgaris* and *Cucurbita* sp. in mid-season when its VFVFS were commencing to bloom. All of the flowers visited by the skippers are introduced ones, except for *Oenothera biennis*, upon which only one *E. clarus* was seen and *Eupatorium coelestinum* which was visited by many *A. campestris*.

Based on the censuses made during walks through the garden, we found three *A. campestris* adults in June, 40 in July, 65 in August, and 176 in September on its VFVFS. These observed frequencies were significantly different from a hypothetical situation with equal monthly frequencies of 71 (the 4-month average) skippers ($P < 0.001$, CST). Twenty *E. clarus* visited their VFVFS in June; 34 in July; 72 in August, and 18 in September. These empirical frequencies were also different from a hypothetical situation with equal monthly frequencies (36) of skippers ($P < 0.001$, CST). These observed differences from equal

TABLE 1. Flowers visited by *Atalopedes campestris* (AC) and *Epargyreus clarus* (EC). Flower species are listed in systematic order by families (Bailey and Bailey, 1976) and alphabetical order by genera.

Family Species, common name	Butterfly visitors
Liliaceae	
Allium vineale L., field garlic	EC
A. schoenoprasum L., chives	AC
Amaryllidaceae	
Amaryllis belladonna L., belladonna lily	EC
Caryophyllaceae	
Dianthus barbatus L., sweet william	AC, EC
Ranunculaceae	
Consolida orientalis (J. Gray) Schrödinger, larkspur	AC, EC
Oxalidaceae	
Oxalis corniculata L., creeping oxalis	AC
Bassicaceae	
Rhaphanus sativus L., radish	EC
Fabaceae	
Phaseolus vulgaris L., snap bean	EC
Balsaminaceae	
Impatiens balsamina L., garden balsam	EC
Impatiens wallerana Hook., "Liegnitzia"	EC
Violaceae	
Viola × wittrockiana Gams., garden pansy	EC
Lythraceae	
Lythrum salicaria L., purple or spiked loosestrife	EC
Onagraceae	
Oenothera biennis L., evening primrose	EC
O. fruticosa L., sundrops	EC
Boraginaceae	
Myosotis scorpioides L., true forget-me-not	EC
Laminaceae	
Lavandula sp., lavendar	EC
Mentha × piperita L., peppermint	AC
M. spicata L., spearmint	AC, EC
Ocimum basilicum L., common or sweet basil	AC, EC
Origanum vulgare L., marjoram or oregano	AC, EC
Solanaceae	
Capsicum sp., bell pepper	AC
Petunia × hybrida Hort. Vilm.-Andr., petunia	EC
Dipsacaceae	
Scabiosa atropurpurea L., sweet scabious	AC,[a] EC[a]

TABLE 1. Continued.

Family	Butterfly visitors
Polemoniaceae	
Phlox paniculata L., phlox	EC
Asteraceae	
Ageratum houstonianum Mill., floss flower	EC
Aster cv., aster	AC,[a] EC
Callistephus chinensis (L.) Nees., China aster	AC[a]
Centaurea cyanus L., bachelor's button	AC, EC
Chrysanthemum leucanthemum L., ox-eye daisy	AC, EC
Chrysanthemum sp., chrysanthemum	AC
Cosmos bipinnatus Cav., cosmos	AC, EC
C. sulphureus Cav., cosmos	AC
Dahlia pinnata × *coccinea* Cav., dahlia	AC,[a] EC
Eupatorium coelestinum L., hardy ageratum	AC,[a] EC
Rudbeckia fulgida Ait., gloriosa daisy	AC
Tagetes erecta L., African marigold	AC[a]
T. patula L., French marigold	AC[a]
Zinnia elegans Jacq., zinnia	AC,[a] EC[a]

[a] Very frequently visited flower species.

frequencies are expected due to seasonality of flowering and fluctuating skipper population levels.

The skippers used VFVFS of different colors and similar shapes. Corolla tubes of many of these flowers were significantly different in length (Table 2).

Flower Constancy

Seventy-eight of the 82 observed skippers showed flower species constancy by visiting individual conspecific flowers or capitula twice in a row. This is significantly different from a hypothetical group in which by chance, 41 skippers visited conspecific flowers and 41 visited heterospecific flowers in sequence ($P < 0.001$, CST). All four of the skippers that visited heterospecific flowers were *E. clarus* foraging early in the season at their FVFS or IVFS (*Dianthus barbatus* and *Lythrum salicaria*, respectively).

Further, 32 of the 82 skippers were observed as they made up to 14 consecutive visits to flowers or capitula (Table 3). Fourteen of these skippers visited only 1 flower species; 14, 2 species; and four, 3 to 4 species. Thus, the skippers tended to visit less than three flower species during a foraging bout.

In asteriads, skippers preferred disk florets to ray florets. Forty randomly chosen *A. campestris* were each observed foraging for at least 10 min on the flowers of *Aster* cv., *Eupatorium coelestinum*, *Tagetes*

TABLE 2. Corolla depths of very frequently visited flower species of *Atalopedes campestris*. Disc florets were measured for all flowers except *Scabiosa atropurpurea* for which regular florets were measured. Means followed by the same letter are not significantly different from one another ($P < 0.05$, DMRT).

Flower species	Corolla depth (mm)
	Mean ± S.E., range, n
Tagetes patula	26.74 ± 0.214, 23.7–29.0, 34
T. erecta	20.87 ± 0.237, 17.7–25.0, 35
Scabiosa atropurpurea	12.73 ± 0.481, 8.0–18.0, 38b
Zinnia elegans	12.04 ± 0.350, 7.3–15.8, 26bc
Dahlia pinnata × *coccinea*	11.82 ± 0.320, 7.7–17.4, 35bc
Callistephus chinensis	11.26 ± 0.204, 9.5–15.0, 35c
Aster spp.	7.67 ± 0.145, 6.3–9.9, 35
Eupatorium coelestinum	3.34 ± 0.117, 1.8–5.0, 35

patula, and *Zinnia elegans*. All foraged significantly more ($P < 0.05$, FEPT) on the innermost mature disk flowers than on ray flowers when empirical data were compared to hypothetical cases in which skippers foraged at equal numbers on each of the two kinds of flowers.

Stigma Contact

All of the VFVFS of both skipper species have narrow corolla tubes with stigmas and anthers in positions that should promote proboscis contact as skippers imbibe nectar. Feeding skippers usually placed only their proboscis tips into corolla tubes, the remainders of their proboscides bending above corolla tube openings. Some skippers feeding at flowers with longer corolla tubes, such as *Tagetes erecta*, *T. patula*, and the infrequently visited *Consolida orientalis*, *Viola* ×*wittrockiana*, and *Capsicum* sp., occasionally pushed their proboscides deep into corolla tubes, possibly effecting stigma and anther contact with their "faces" and palpi.

Pollen Transport

From their VFVFS, 283 *A. campestris* carried 68.35 ± 3.250 (0–357) pollen grains, and 59 *E. clarus* carried 45.05 ± 3.760 (0–143) pollen grains. *Atalopedes campestris* carried the greatest mean amount of pollen from *Eupatorium coelestinum*, the only VFVFS that is native to the study-site region. The pollen loads that *A. campestris* carried from some species were significantly different from one another (Table 4). Regarding their VFVFS, *E. clarus* carried significantly more *Scabiosa atropurpurea* than *Zinnia elegans* pollen grains ($P < 0.05$, DMRT).

Selected examples of significant differences in numbers of grains

TABLE 3. Sequential flower visits of individual skippers. AH, *Ageratum houstonianum*; CA, *Capsicum* sp.; CC, *Callistephus chinensis*; CS, *Cosmos sulphureus*; DB, *Dianthus barbatus*; DX, *Dahlia pinnata* × *coccinea*; EC, *Eupatorium coelestinum*; IW, *Impatiens wallerana*; LS, *Lythrum salicaria*; SA, *Scabiosa atropurpurea*; TE, *Tagetes erecta*; TP, *Tagetes patula*; ZE, *Zinnia elegans*.

Skipper number	Sequence of flower visits
	Atalopedes campestris
1	SA (14 times)
2	ZE (10)
3	ZE (6), SA (2), TE (3)
4	TP (9)
5	TE (4), EC (2), TE (2), EC (1), TE (1), EC (2)
6	TP (5), DX (1), TP (6), CA (1)
7	ZE (8), CC (1), ZE (2)
8	ZE (5), SA (2), ZE (3)
9	TP (5), SA (1), TP (5)
10	TE (6), EC (4), TE (1)
11	EC (10)
12	ZE (11)
	Epargyreus clarus
1	ZE (10)
2	ZE (1), LS (3), ZE (5)
3	SA (1), DB (5), SA (3)
4	ZE (1), DB (2), ZE (6)
5	SA (10)
6	DB (8)
7	ZE (1), DB (4), ZE (5)
8	ZE (11)
9	ZE (11)
10	ZE (5), SA (1), ZE (5)
11	IW (4), ZE (2), SA (1), ZE (2)
12	SA (13)
13	ZE (10), IW (2)
14	SA (11)
15	SA (12)
16	SA (5), CS (2), SA (2)
17	SA (10)
18	ZE (5), SA (1), AH (1), SA (4)
19	ZE (4), SA (1), ZE (2), SA (2)
20	ZE (13)

carried by different skipper parts are listed in Table 5. Individual skippers carried significantly more pollen of these flowers in their facial cavities than on, or in, other structures, except for pollen of *Tagetes patula*. The most pollen any one *A. campestris* carried in its facial cavity (and in fact on, or in, any part) was 161 grains from *Eupatorium coelestinum*. For seven of their eight VFVFS, *A. campestris* carried the second largest amounts of pollen on their proboscides. *Epargyreus clarus* carried more pollen from *Scabiosa atropurpurea* and *Zinnia*

TABLE 4. Mean number of pollen grains carried by *Atalopedes campestris* and *Epargyreus clarus* from very frequently visited flower species and *Cosmos sulfureus*. Within a skipper species, means followed by the same letter are not significantly different from one another (P > 0.05, DMRT).

Flower species	Mean ± SE, range, n
Atalopedes campestris	
All very frequently visited flower species	68.35 ± 3.250, 0–357, 283
Cosmos sulphureus	135.83 ± 15.662, 11–240, 16a
Eupatorium coelestinum	116.22 ± 9.298, 21–357, 45ab
Aster cv.	91.55 ± 9.350, 0–259, 42bc
Dahlia pinnata × *coccinea*	73.50 ± 13.132, 8–168, 12c
Zinnia elegans	59.04 ± 4.042, 16–132, 48cd
Callistephus chinensis	56.75 ± 15.554, 12–132, 8cde
Tagetes patula	40.41 ± 3.755, 8–142, 35de
Scabiosa atropurpurea	37.29 ± 4.222, 7–108, 35e
Tagetes erecta	26.60 ± 3.821, 0–103, 35
Epargyreus clarus	
Both flower species	48.05 ± 3.760, 0–143, 59
Scabiosa atropurpurea	54.28 ± 6.172, 0–135, 43
Zinnia elegans	38.06 ± 4.371, 9–143, 25

elegans in their facial cavities than on, or in, any other parts. They carried significantly more *Scabiosa atropurpurea* pollen than *Zinnia elegans* pollen in their facial cavities (P < 0.001, TT). *Epargyreus clarus* from both flowers carried the second largest amounts of pollen on their proboscides.

The significant differences in Table 5 indicate that skippers generally carried more pollen anteriorly and less posteriorly. In order of decreasing amounts of pollen, *E. clarus* carried pollen in facial cavities, on proboscides, on hindlegs, on forelegs, in genital cavities, and on middle legs from *Zinnia elegans* and in facial cavities, on proboscides, forelegs, hindlegs, and middle legs and in genital cavities from *Scabiosa atropurpurea*. When mean numbers of pollen grains of two kinds of legs (or legs versus genital cavity) were compared, they were not usually significantly different from one another. In contrast, pollen loads carried in skipper facial cavities and on proboscides were significantly greater than those carried by legs and genital cavities. Pollen of VFVFS was distributed similarly on *A. campestris*.

The skippers usually carried more pollen of VFVFS on their proboscides or in their facial cavities compared to on, or in, other parts; this probably resulted from their more frequently putting their tongues rather than tips of their legs or other parts into flowers. Pollen from proboscides then builds up in facial cavities as skippers recoil their proboscides between flower visits. In cavities, pollen is likely to stick

TABLE 5. Selected examples of significant differences (P ≤ 0.05, PTT) in the pollen loads carried between two body parts of an individual skipper from very frequently visited flower species. AC, *Aster* cv.; see Table 3 for other plant abbreviations.

Compared parts	Plants with significant differences
Atalopedes campestris	
Facial cavity > proboscis	AC, ZE
Proboscis > hindleg	AC, CC, DX, EC, TE, TP, ZE
Hindleg > foreleg	AS, TE
Hindleg > middle leg	AC, EC, SA, TE, ZE
Foreleg > middle leg	EC, SA, TE, TP, ZE
Hindleg > genital cavity	AC, EC, SA, ZE
Foreleg > genital cavity	AC, EC, SA, ZE
Middle leg > genital cavity	AC, SA, ZE
Eparygreus clarus	
Facial cavity > proboscis	SA
Hindleg > foreleg	ZE
Hindleg > middle leg	ZE
Foreleg > middle leg	SA, ZE
Hindleg > genital cavity	SA, ZE
Foreleg > genital cavity	SA, ZE
Middle leg > genital cavity	ZE

to scales and other pollen already present and remain relatively undisturbed. Skipper posture and movement on asteriad heads could also account for the pollen distribution on their bodies. On these capitula, they often have their heads over innermost, polliniferous disk florets and their thoraces and abdomens over outermost (female stage) disk florets and ray florets with little or no pollen. Further, skippers are likely to have smaller pollen loads on their legs and other more exposed parts due to pollen loss during locomotory and grooming behaviors.

Some pollen was found in the genital cavity of at least one skipper collected from each of the VFVFS. This pollen was confined to the hairlike scales on females' papillae analis and males' valvae (Ehrlich, 1960). The mean number of pollen grains borne in genital cavities for all VFVFS ranged from 0.17 ± 0.171 (0–6, N = 35) grains of *Scabiosa atropurpurea* to 4.12 ± 1.880 (0–15, N = 8) grains of *Callistephus chinensis*. Females of both skipper species carried significantly more pollen of these flowers, except for *Dahlia pinnata* × *coccinea,* in their genital cavities than males (P < 0.05, TT). Of the 41 skippers that carried pollen in their genital cavities, only eight were males. The most pollen any one female skipper carried in her genital cavity was 67 pollen grains of *Tagetes patula*. The most pollen any one male skipper carried in his genital cavity was seven grains from *Tagetes erecta*. Pollen is likely to enter genital chambers when skippers touch pollen on flowers with their abdominal tips during foraging. Perhaps grooming movements also cause pollen to enter genital chambers. Since the amount of pollen that a skipper carries might increase with its age, we examined our data for possible positive correlations between age and the pollen load of VFVFS on a skipper's forelegs, middle legs, hindlegs, and proboscis, and in its facial and genital cavities. In *A. campestris*, age was positively correlated ($P < 0.05$) with the amount of pollen in facial cavities (3 flower species) and genital cavities (4), and on forelegs (1), hindlegs (1), and proboscides (5). In *E. clarus*, age was positively correlated with the amount of pollen in facial cavities (2 flower species) and on proboscides (2). Thus, pollen loads were generally not positively correlated with age, because out of a possible 48 correlations, only 13 were found for *A. campestris*, and out of a possible 12 such correlations only four were found for *E. clarus*.

In our study, the skippers visited *Zinnia elegans* more than other flowers. However, they carried more pollen from *Eupatorium coelestinum* and *Scabiosa atropurpurea* than from *Zinnia elegans*, which might not be expected (Heinrich & Raven, 1972). This finding might be due to *Zinnia elegans* having larger (55-μ-diameter) and spinier pollen than the other two species which have 35-μ-diameter pollen (Erdtman, 1966; Kapp, 1969). Pollen with a smoother exine surface adheres better to parts of Lepidoptera, such as tongues, than pollen with a spinier surface (Kislev et al., 1972). Further, pollen of smaller rather than larger diameter is generally picked up by a butterfly's proboscis during feeding and is retained when its proboscis is recoiled and not in use (Levin & Berube, 1972). Besides skipper-visitation frequency and pollen size and surface characteristics of a particular flower species, the pollen load of a skipper is likely to be affected by many other variables which have not been studied.

In conclusion, three lines of evidence suggest that the skippers were pollinators of their VFVFS. First, they were ordinarily constant to particular species during foraging bouts. Second, they transported pollen. Finally, they were likely to contact stigmas frequently with their proboscides, since they mainly visited flowers with narrow, tubular corollas. They contacted some flowers with their facial cavities and may have contacted stigmas with their pollen-bearing legs and genital cavities, as well, because they sometimes walked over stigmas.

However, two more important lines of evidence indicate that the skippers probably functioned mainly as nectar thieves. First, they mostly foraged upon asteriads rather than upon other kinds of flowers and primarily probed innermost (male-stage) disk florets, tending not to contact female-stage florets with their more pollen-laden parts. Second and more importantly, the skippers carried pollen in loads that appear too small for efficient pollination. In the *Colias-Phlox* pollination system, Levin and Berube (1972) found that only 0.5% of the *Colias*-transported pollen, that was transferred to receptive stigmas, germinated and produced pollen tubes. In our study, 0.5% of the mean number of pollen grains from VFVFS that was carried by an entire individual skipper was always less than one grain. Making the liberal assumption that all pollen grains in the skippers are available for pollination and extrapolating from the *Colias-Phlox* system, we find that it would take an average of at least four flower visits for a skipper to deposit a pollen grain. If one considers an efficiently working capitulum to be one with many florets that can be pollinated by a single foraging insect (Burtt, 1961), capitula of the VFVFS are not efficiently working ones with regard to the skippers we studied.

The butterflies-as-nectar-thieves hypothesis is not rejected by our observations on skippers and quantification of their pollen loads. Emmel (1971) presents strong circumstantial evidence that the Ecuadorian skipper *Perichares philetes dolores* (Reakirt) is a pollinator of the orchid *Maxillaria "ontoglossom"* (which is not in Index Kewensis). However, because he does not present direct evidence that this skipper is indeed a pollinator, his data do not reject the hypothesis. A further test of the hypothesis based on an extensive literature survey will be presented in a future paper.

The hypothesis that the skippers might indirectly increase pollination and seed set of their thieved flowers remains to be tested. This increased pollination might occur because pollinators have to visit more flowers to obtain adequate resources from thief-depleted flowers compared to ones not depleted by thieves (Heinrich & Raven, 1972; Barrows, 1976). An alternative hypothesis to consider is that skippers somehow cause pollinators to forage less on patches of thieved flowers, thereby reducing pollination of these patches (McDade & Kinsman, 1980; Roubik, 1982).

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PERMANENT TRAPS FOR MONITORING BUTTERFLY MIGRATION: TESTS IN FLORIDA, 1979–84

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ABSTRACT. Three models of a flight trap made principally of hardware cloth were tested at Gainesville, Florida. All models had a 6 m long central barrier of ½ inch mesh hardware cloth. Butterflies encountering opposite sides of the barrier were trapped separately, allowing calculation of net movement up or down the Florida peninsula. The most efficient model has a barrier 3.7 m high and a two-stage trapping superstructure of ¼ inch hardware cloth. It catches 22–70% of migrant *Phoebis sennae, Agraulis vanillae,* and *Urbanus proteus.*

Migrating butterflies characteristically fly in a straight line a few meters above the ground and rise and fly over obstacles rather than deviating laterally (Williams, 1930). Beginning in 1975, I have used stationary flight traps that intercept and trap migrant butterflies at Gainesville, Florida (Walker, 1978, 1980; Walker & Riordan, 1981). My first traps were made of polyester, which ripped in strong winds and deteriorated in sunlight. They consequently required frequent repair and annual replacement. Furthermore, they lost about 90% of the migrants they intercepted.

In this paper I describe the development of a hardware-cloth trap that will work for years without repair and that promises, with specified improvements, to catch more than 70% of the migrants that encounter it.

THE TRAPS

Three models of permanent flight traps were tested. All resembled the polyester traps in having a 6 m long central barrier oriented ENE–WSW (perpendicular to the Florida peninsula) and a holding device at either end. All kept the butterflies that had encountered the barrier from the migratory direction ±90° separate from those that had encountered it from the opposite direction ±90°.

Model #1. The first trap (Fig. 1, right) was constructed during February 1979 in a pasture with scattered trees, northwest of Gainesville (NW¼, sec. 31, tp. T9S, R19E). The central barrier was of ½ inch hardware cloth attached to three pressure-treated "4×4" posts (i.e., 9 × 9 cm). The roof, also of ½ inch hardware cloth, was 1.2 m from ridge to eave and was fastened laterally and medially to treated "2×4's" (4 × 9 cm). Its ridge slanted upward from the center post (3.4 m high) to either end post (4.0 m), in imitation of a polyester trap (see fig. 1 of Walker, 1978). The roof sloped 30° toward its eaves. Migrant but-

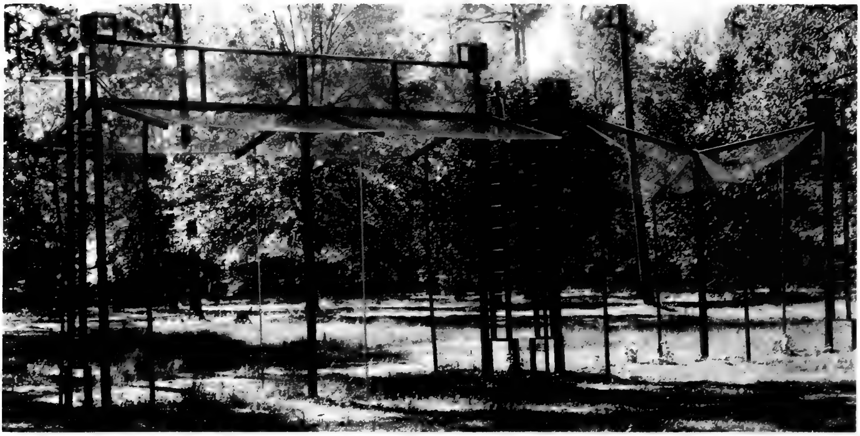

FIG. 1. Models #3 (**left**) and #1 (**right**) of a permanent flight trap for migrating butterflies.

terflies were to encounter the central barrier, be detained between the roof and the barrier, and work their way upward to the nearest end. There they were to continue upward through an 8 × 24 cm opening, through an immovable hardware cloth "valve," and into a holding cage of plywood and ¼ inch hardware cloth. Watching migrants encounter model #1, I discovered that most individuals shunned the offered openings and instead flew out and over the roof or around the end "wall" (i.e., panels of ½ inch hardware cloth that extended 1.2 m from either end of the central barrier and perpendicular to it).

Model #2. During August of 1983 I constructed a second trap immediately ENE of the first. It differed from model #1 in having a 13 cm slot along the entire upper edge of each roof panel. These slots gave access to a longitudinally partitioned 6.0 × 0.4 × 0.4 m duct of ¼ inch hardware cloth that prevented the butterflies' escaping as they worked their way to either end of the trap, through hardware cloth valves and into holding cages. The central barrier was rectilinear and 3.7 m high. The roof ridge was made straight and the roof slope was reduced to 15°—making the eaves 3.4 m high. Although model #2 caught substantially higher proportions of migrants than model #1, most migrants were hesitant to fly through the 13 cm slots and would, instead, hover under the roof and eventually escape.

Model #3. During February 1984 I greatly improved access to the longitudinal duct, thereby converting model #2 to model #3. The width of the roof slots was increased more than threefold to 45 cm and a sharply sloping upper roof of ½ inch hardware cloth was interposed between the duct and each main roof (Fig. 1, left; Fig. 2). The hard-

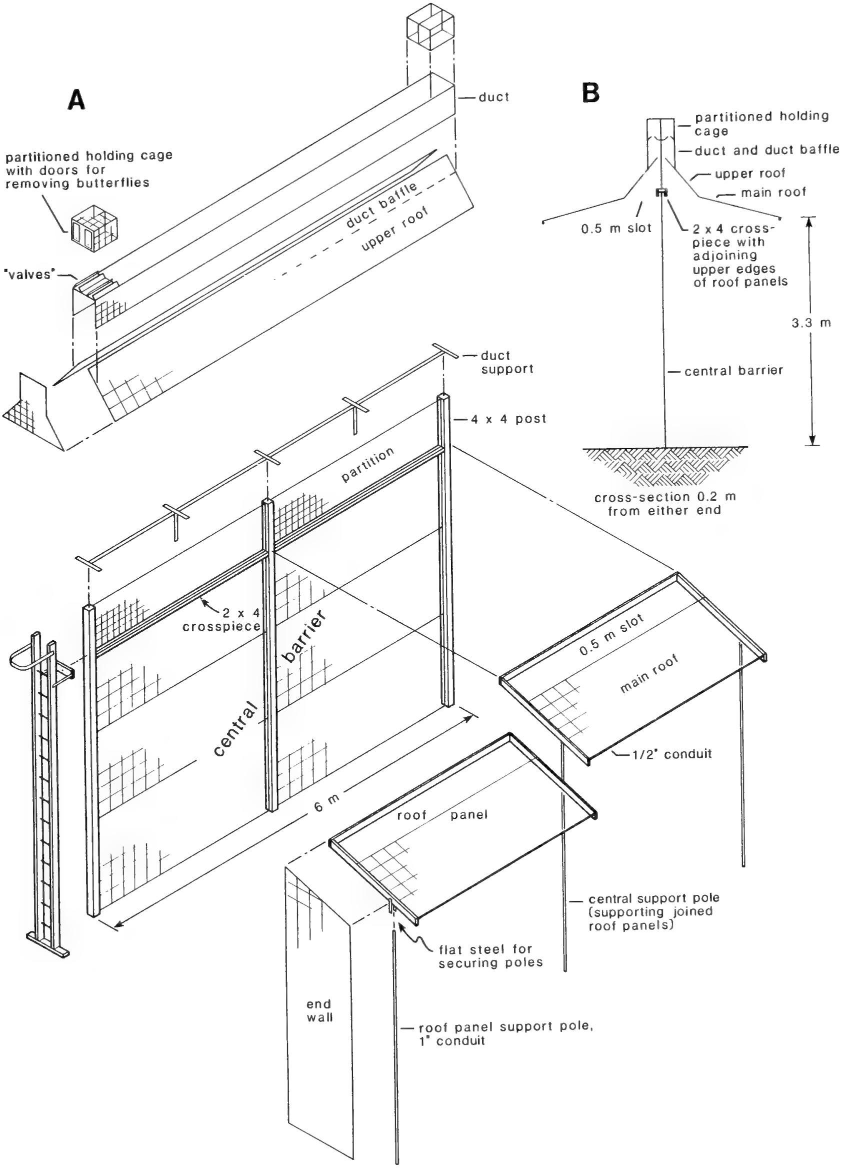

FIG. 2. Model #3 permanent flight trap: **A,** exploded diagram; **B,** cross section. (Drawings by S. A. Wineriter)

TABLE 1. Migration of four species of butterflies as revealed by 6 m, permanent flight traps at Gainesville, Florida, 1979–1984.

Trap	Net northward spring migration[a]				Net southward fall migration[b]			
Year	*P. sen.*	*A. van.*	*J. coenia*	*U. prot.*	*P. sen.*	*A. van.*	*J. coenia*	*U. prot.*
Model #1								
1979	0	1	185	0	157	22	2	13
1980	3	0	13	0	69	12	1	5
1981	2	0	44	0	263	26	6	1
1982	7	2	85	0	126	15	22	24
1983	2	0	4	0	54	7	−1	0
1984	1	1	27	0	92	10	−3	0
Model #2								
1983	—	—	—	—	86	157	21	55
Model #3								
1984	6	6	252	−1	548	326	62	531
Sum	21	10	610	−1	1395	575	110	629
Consistency[c]	96	92	96	33	91	94	72	99

[a] Number trapped on south side of barrier minus number trapped on north side of barrier (1 March to 22 May).
[b] Number trapped on north side of barrier minus number trapped on south side of barrier (1 Sep. to 30 Nov.).
[c] Percent of total trapped that were flying in the migratory direction (viz. southward in the fall, northward in spring).

ware cloth of the 50 cm upper roof extended as a baffle 25 cm into the duct, thereby impeding the escape of migrants from the duct (Fig. 2B). (Building a #3 trap is described in the appendix.)

THE CATCHES

At least seven species of butterflies migrate southward through Gainesville each fall: *Phoebis sennae* (L.), *Agraulis vanillae* (L.), *Junonia coenia* Hübner, *Urbanus proteus* (L.), *Panoquina ocola* (Edwards), *Lerema accius* (J. E. Smith), and *Eurema lisa* (Boisduval & LeConte) (Walker, 1978, 1980, 1985). Only the first four will be dealt with here, because they were captured in the largest numbers.

As reported previously (Walker, 1980), the direction of net movement of these species at Gainesville is down the peninsula in the fall and, for the first three species, toward Georgia in the spring (Table 1). Net numbers trapped flying northward in spring (1 March to 22 May) for the six years varied from −1 for *U. proteus* (viz., 1 northward, 2 southward) to 610 for *J. coenia*. Net numbers trapped flying southward in fall (1 Sep. to 30 Nov.) varied from 110 for *J. coenia* to 1395 for *P. sennae*. With the exception of *U. proteus* in spring and *P. coenia* in fall, more than 90% of migrants trapped were captured flying in the seasonally appropriate direction (Table 1).

Trapping efficiency of models #1 and 3 was studied during October 1984. During the five observation periods of 3 hours or more, model

TABLE 2. Absolute trapping efficiency of model #3 of a permanent trap for sampling migrating butterflies.

		P. sennae		*A. vanillae*		*U. proteus*	
Date (1984)	Time (EDT)	Capt./cand.[a]	%	Capt./cand.	%	Capt./cand.	%
4 Oct.	1251–1551	16/25	64	6/11	55	15/25	60
5 Oct.	0917–1217	14/17	82	3/7	43	11/23	48
5 Oct.	1306–1606	8/12	67	0/6	0	9/19	47
11 Oct.	1238–1600	12/18	67	4/13	31	3/10	30
12 Oct.	1100–1400	8/24	33	5/15	33	3/7	43
All observations		58/96	60	18/52	35	41/84	49
95% C.I.[b]			49–70		22–50		38–60

[a] Number of migrants *captured* during observation period/number of *candidate* migrants (i.e., southward flying individuals that would have flown over the 6-m, ENE–WSW line at the base of the trap's central barrier had the trap not been in place).

[b] Based on binomial distribution.

#3 caught an average of 60% of candidate *P. sennae*, 35% of *A. vanilla*, and 49% of *U. proteus* (Table 2). Model #1 caught 13% of candidate *P. sennae* (13 of 98) but 0 of 44 *A. vanillae* and 0 of 55 *U. proteus*.

Because the traps sample adjacent 6 m cross sections of migrants, it is likely that season-long differences in their catches are due principally to differences in trapping efficiency and that differences in numbers of potential captives are minor or lacking. Confirming this conjecture is the fact that numbers of *P. sennae* and *A. vanillae* observed during 15+ hours of watching were 98 and 44 for model #1 and 96 and 52 for model #3. (Numbers of *U. proteus* were more discrepant for the two traps, 55 and 84, but these butterflies are relatively small, dark, and fast, making it likely that some escaped notice—which, in turn, makes it likely that 49% overestimates the proportion of this species trapped.) Table 3 compares catches of models #2 vs. 1 during fall of 1983 and catches of models #3 vs. 1 during all of 1984.

By using the absolute trapping efficiencies in Table 2 and the relative trapping efficiencies in Table 3, the numbers of fall migrants in Table 1 were converted to estimates of total fall migration across each ENE–WSW meter (Table 4). (All traps were oriented ENE–WSW—perpendicular to the axis of the Florida peninsula.)

DISCUSSION

Further improvements. The model #3 flight trap caught far higher proportions of the migrant butterflies that encountered it than did earlier polyester or hardware cloth traps (Table 3). However, its absolute efficiency was still less than 70% (Table 2). Two easy-to-make changes promise to improve its performance substantially. The first

TABLE 3. Relative trapping efficiency of models #1, 2, and 3 of a permanent trap for migrating butterflies.

Species of migrant	Model 2 vs. 1		Model 3 vs. 1		Model 3 vs. 2
	Numbers[a]	Ratio	Numbers[b]	Ratio	Ratio[c]
P. sennae	86 vs. 54	1.6	554 vs. 93	6.0	3.7
A. vanillae	157 vs. 7	22.4	332 vs. 11	30.2	1.3
J. coenia	21 vs. −1	—	314 vs. 24	13.1	?
U. proteus	55 vs. 0	—	530 vs. 0	—	?

[a] Net numbers of migrants caught by models 2 and 1 during fall 1983.
[b] Net numbers of migrants caught by models 3 and 1 during spring and fall 1984.
[c] Calculated by using model 1 as the standard.

change concerns the fact that some migrants refused to fly upward into the longitudinal duct. The refusal of some of these migrants probably resulted from their view of the sky being partially blocked by 6 m of 2×4 that supported the duct. A less sky-blocking support (e.g., a 3 × 3 cm steel angle) should be substituted. The second change concerns the fact that most of the migrants that escaped did so by flying around the end walls. (Specifically, 67 of the 115 escapees in Table 2 left the trap within 10 seconds by flying around the end wall.) The end walls could be extended to 2.4 m making lateral escape much less likely.

Uses. Permanent flight traps can monitor butterfly migrations continually, and they can provide information about migrations so sparse that they cannot be directly observed. The data in Tables 1 and 4 (and unpublished data on other species) illustrate these uses. Permanent flight traps also provide a convenient means of collecting large numbers of live migrants for studies of morphology, physiology, sex ratios, mating status, behavior, etc.

Traps with other uses. The great improvement in efficiency of the model #3 over the model #1, which copied the design features of the original polyester trap (Walker, 1978), suggests that a much improved, portable, polyester trap might be made by copying the design features

TABLE 4. Fall migration (net no. flying southward across each ENE–WSW meter) as estimated by permanent flight traps, Gainesville, Florida, 1979–1984. (Numbers captured are in Table 1; trapping efficiencies based on Tables 2 and 3. Estimates for 1983 and 1984 are from catches of models #2 and 3, respectively.)

Species	Year					
	1979	1980	1981	1982	1983	1984
P. sennae	262	115	438	210	88	152
A. vanillae	316	173	374	216	97	155
U. proteus	—	—	—	—	—	181

of the model #3 permanent trap. Furthermore, traps half as long should catch much larger numbers of migrants than did the original 6 m polyester traps. (A similar shortening is also an option for permanent traps and would reduce costs for materials ca. 30%.)

An important limitation for all flight traps yet used to study butterfly migration is that they distinguish migratory directions only crudely. This limitation could be overcome by constructing an octagonal trap having eight identical openings leading to eight holding cages, thereby separating migratory directions at 45° intervals rather than the 180° intervals of the present traps.

The permanent traps built thus far capture migrants alive and, therefore, require daily servicing. Traps could be run at remote locations, or at near locations with reduced service time, if the holding cages were modified to kill and preserve the migrants captured. For example, dichlorvos-impregnated plastic could be used to cause the captives to drop into containers of dilute formalin.

Finally, devices could be substituted for the holding cages that would automatically mark the butterflies with fluorescent pink paint and allow them to continue their migratory flights—to be caught, perhaps, by downstream traps. (If such devices seem far-fetched, see Wolf and Stimmann, 1972.)

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APPENDIX

This appendix describes the main steps in building a model #3 permanent flight trap. It omits details that can be improvised by anyone with experience in light construction. The present model #3 was built by modifying a model #2, but the following steps describe how to build one from scratch. Materials for one trap now cost ca. $500.

1. Central supports. Lay out a 6 m line perpendicular to the migratory direction. At each end and at the center of the line set a post (e.g., an 18′ treated 4×4) so that 4.4 m extends vertically from the ground. Connect the posts at 3.7 m with treated 2×4's (to which the main roof panels will be attached).

2. Superstructure. Prepare a support for the duct by attaching 3/16″ × 1″ × 0.4 m cross pcs. of flat steel at the ends and at 1.5 m intervals along one flat surface of a 6.0 m pc. of ⅛ × 1¼ × 1¼″ steel angle. Attach the steel angle, cross pcs. up, to the tops of the main posts. Affix a 0.7 m vertical support for the steel angle midway between each pair of main posts. Install two 3.0 × 0.7 m vertical partitions of ¼ inch hardware cloth, attaching the top edges to the steel angle, the ends to the posts, and the bottom edges to the 2×4 cross pcs. Make a three-sided square duct by bending lengthwise a 6.0 × 1.2 m pc. of ¼ inch hardware cloth at 0.4 and 0.8 m. Invert the duct over the duct support and attach a 6.0 × 0.75 m pc. of ½ inch hardware cloth to each lower edge of the duct in such a fashion that the lower 50 cm of width can become upper roof and the upper 25 cm of width can become duct baffle (Fig. 2).

3. Main roof panels. Build four roof panel frames of treated wood and steel tubing, each consisting of a 2 × 4 × 1.7 m (outer rafter; make 2.5 m if end wall is to be 2.4 m), a 1 × 4 (=2 × 9 cm) × 3.0 m (upper edge), a 1 × 4 × 1.7 m (inner rafter), and a 3.0 m pc. of ½″ electrical conduit (lower edge). Cut upper ends of rafters at 75°. Attach a 1.2 × 3.0 m pc. of ½ inch hardware cloth to each roof panel with one edge riveted to the conduit, leaving a 0.5 m slot between the hardware cloth and the upper edge of the panel frame. Attach each roof panel by its upper edge to one of the 2×4 cross pcs. Support the rafters at ca. 1.2 m with poles that position the eaves at 3.3 m. (Make poles of 2 pcs. of 1″ electrical conduit joined by driving them over opposite ends of a short pc. of ¾″ galv. pipe.) Bolt together the inner rafters of adjacent roof panels. Attach the lower edge of the secondary roof to the upper edge of the main roof.

4. Central barrier and ends. Attach the central barrier of three 6.0 × 1.2 m pcs. of ½ inch hardware cloth to the main support posts. Close the ends of the duct and the secondary roof with ¼″ hardware cloth. Make the end walls by attaching 1.2 m wide pcs. of ½″ hardware cloth to the end posts, the outer rafters of the roof panels, and the roof support poles. (If the end walls are to be 2.4 m wide, install another pole 1.2 m beyond each existing end-rafter support pole.)

5. Attachments. Construct two 4.4 m ladders using treated 2×4's as side pieces and 1″ electrical conduit as rungs. Install one ladder 0.3 m away from each end post. At the top of each ladder secure a safety loop of ⅛ × 1″ aluminum (to enable one to use both hands in servicing the trap). Make hardware cloth valves by appropriately cutting 15 × 30 cm areas on each side of each end of the top of the duct. Build two partitioned holding cages that will fit over the valves at either end of the duct. Make the doors to the chambers of the holding cages so that they will stay open as butterflies are removed. Install the holding cages—and wait for migrants.

ADDENDUM

During March 1985 the model #1 trap was razed and in its place an improved model #3 trap (i.e., a model #4 trap) was built using the directions given above—except that the main roof was made horizontal, thereby, simplifying construction and elevating the duct by 11 cm. The end walls extended 2.4 m from the central barrier. During the period 10 Apr to 29 May 1985, the net numbers of *J. coenia* trapped flying northward were 216 for the model #3 and 302 for the model #4 trap, translating into a 40% improvement in catch.

For the first time *Vanessa virginiensis* Drury was identified as a spring migrant, with 11 trapped flying northward and 2 flying southward (chi-square = 6.23; $P < 0.05$).

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ADULT NOCTUIDAE FEEDING ON APHID HONEYDEW AND A DISCUSSION OF HONEYDEW FEEDING BY ADULT LEPIDOPTERA[1]

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ABSTRACT. Adult *Aseptis characta* (Grote) and *Rhynchagrotis exertistigma* (Morrison) (Lepidoptera: Noctuidae) were observed feeding on honeydew produced by *Zyxaphis canae* (Williams) (Homoptera: Aphididae) on basin big sagebrush, *Artemisia t. tridentata* Nuttall, in south-central Idaho. The feeding behavior is described. The lack of similar reports among other Lepidoptera, excluding the Lycaenidae, is discussed. Means by which the moths could locate honeydew sources and the adaptive value of this ability in specific situations are considered.

On 22 July 1983, a male *Aseptis characta* (Grote) and a female *Rhynchagrotis exertistigma* (Morrison) (Lepidoptera: Noctuidae) were observed feeding on the honeydew of *Zyxaphis canae* (Williams) (Homoptera: Aphididae) on basin big sagebrush, *Artemisia t. tridentata* Nuttall. This observation was made in a canyon 6 miles SSW of Howe, Butte Co., Idaho. The day was moderately cool (about 22°C) and cloudy, with a light rain falling. Despite the weather, there was a moderate amount of insect activity. Numerous aphids, flies and wasps, especially Ichneumonidae, were seen on the sagebrush, *Artemisia* spp.

Each moth located an aggregation of aphids and moved its proboscis from aphid to aphid within that aggregation. Then, each probed with its proboscis and if necessary, walked a short distance to locate another group of aphids. The behavior was similar to locating composite inflorescences and probing individual florets.

Feeding on homopterous honeydew is a logical extension of the typical nectar-feeding habit of adult Lepidoptera. Both are aqueous solutions containing carbohydrates and amino acids, plus a variety of minerals, lipids, organic acids and vitamins (Hagen, 1958; Auclair, 1963; Strong, 1963; Baker, 1977; Baker & Baker, 1979). Nectars may also contain potentially toxic compounds, e.g. alkaloids and glycosides (Baker, 1977; Baker & Baker, 1979). There are no reports of such potentially toxic compounds in honeydews. Therefore, it should be possible for many adult Lepidoptera to exploit this alternative food source. However, few accounts of honeydew feeding by adult Lepidoptera could be located and all involved Lycaenidae (Bingham, 1907; Lamborn, 1914; Roepke, 1918; Farquharson, 1922; Balduf, 1939; Hin-

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ton, 1951; Gilbert, 1976; Orsak, 1977; Henning, 1983). Species in some lycanenid genera are not known to visit floral nectaries, so homopteran honeydew may be their primary source of nutrients (Cottrell, 1984).

All of the earlier reports of adult Lepidoptera feeding on homopterous honeydew involved Lycaenidae. The family includes many, taxonomically diverse species in which the larvae are predaceous on Homoptera, associated with ants in some way or both (Balduf, 1939; Clausen, 1940; Hinton, 1951; Henning, 1983). Species with homopterophagous or myrmecophilous larvae commonly oviposit near aggregations of Homoptera which serve as prey or indicators of an area where hosts are likely to be found, respectively. Therefore, it is not surprising that they have evolved the habit of exploiting honeydew as a readily available source of adult food.

There is no evidence that *A. characta* or *R. exertistigma* would be expected to locate aphid aggregations for any purpose, other than as a source of honeydew. This implies that exploiting this alternative food source should be possible for many Lepidoptera, in addition to the entomophagous Lycaenidae. The paucity of observations of this behavior in other groups could be due to Lepidoptera being less conspicuous when feeding on honeydew than when feeding on nectar. Entomophilous flowers are usually prominently displayed so that they may be more readily located by their insect pollinators (Jensen & Salisbury, 1972). Most aphid aggregations, on the other hand, are relatively inconspicuous and may be effectively concealed, thus, also concealing any visitors. However, since many Lepidoptera are relatively large and easily observed, it seems unlikely that this behavior would not have been reported more frequently, if it were common. So, it seems probable that adult Lepidoptera, other than Lycaenidae, rarely consume honeydew.

At this point two questions arise: 1) Why is honeydew feeding unusual among adult Lepidoptera, other than Lycaenidae?; and 2) Why did it occur in the situation described earlier? Possible answers for both questions will be discussed.

While adult Lepidoptera are generally regarded as nectar-feeding insects, they actually display considerable flexibility in their feeding behavior. "Puddling," in the broad sense, includes feeding at the margins of puddles, etc. and on urine, dung and carrion (Arms, Feeny & Lederhouse, 1974; Downes, 1973); it is common among adult Lepidoptera. Some Lepidoptera are also known to feed on fluid from the eyes of mammals and mammalian skin secretions, including sweat, and blood flowing from wounds (Bänziger, 1971; Buttiker, 1959, 1962, 1964). Still more specialized is behavior of the SE Asian noctuid *Calyptra eustrigata* (Hmps.), which moth uses its proboscis to pierce the skin of large mammals to obtain blood meals (Bänziger, 1971, 1975). Water and amino acids were considered to be the key nutrients acquired from these atypical food sources, but in at least some cases, the acquisition of sodium may also be of great importance (Arms, Feeny & Lederhouse, 1974). The two latter nutrients could be deficient in specific nectars, therefore, these foods could be important supplements to diets that consist largely of nectar. In this situation, it is not surprising that Lepidoptera have evolved the habit of exploiting these food sources.

Still, some adult Lepidoptera regularly consume atypical foods that would seem more suitable as substitutes for nectar, than as dietary supplements. African and Asian Sphingidae of the genus *Acherontia*, commonly enter nests of wild and domestic bees to consume stored honey (Balduf, 1939). Their probosces are recurved apically and relatively short, indicating that they may be specialized for feeding in this manner. Bänziger (1970) discusses a Malayan noctuid, *Calyptra thalictri* (Bkh.), that uses its similarly structured proboscis to pierce fruit. (This behavior is assumed to be ancestral to the skin-piercing, blood-sucking habit of *C. eustrigata*.) In these two cases, the high concentrations of sugars in the foods suggest that carbohydrates may be among the nutrients sought by the moths. The high sugar concentrations and the large volumes of food available in these situations seem to be plausible reasons for the moths evolving these unusual feeding habits. However, the possibility of some other nutrient(s) being of primary importance to the moths cannot be totally discounted.

Though few in number, these examples of highly modified feeding behaviors, which are apparently directed primarily to the acquisition of carbohydrates, are important. They make it more surprising that adult Lepidoptera do not consume homopterous honeydew more regularly. Intuitively, it would seem that there must be some factors which have tended to restrict their exploitation of this food source.

The Ditrysia, the dominant and most advanced suborder of the Lepidoptera, seem to have radiated ecologically and taxonomically, in synchrony with the Angiospermae (Common, 1970, 1975). With a coevolutionary history that extends back about 100 million years to the mid-Cretaceous (Powell, 1980), it is not surprising that these Lepidoptera have, in general, evolved the specialized ability to efficiently locate floral nectar sources using visual and olfactory cues (Brantjes, 1976).

An aggregation of aphids would certainly not present visual stimuli like those of a flower or inflorescence. Nor would there be any stimulus analogous to floral odor to guide Lepidoptera to a source of honeydew. Yet, the occurrence of Lepidoptera at sap flows on injured trees and the successful use of molasses bait traps, demonstrate that some Lepidoptera are capable of locating food sources using only olfactory cues other than floral odors. Therefore, it is possible that some Lepidoptera could locate honeydew sources, perhaps in a manner similar to that used by *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae). Adult *C. carnea* orient anemotactically to indole acetaldehyde, a breakdown product of the amino acid tryptophan which occurs in some honeydews (Hagen, Greany, Sawall & Tassan, 1976; van Emden & Hagen, 1976). So, the question remains, why is a convenient food source apparently underexploited by adult Lepidoptera?

Competition with ants and other common honeydew-feeding insects seems likely to be an important factor. Unlike floral nectar, which is often protected by morphological and chemical systems which restrict access to specific groups of visitors (Grant & Grant, 1965; Heinrich, 1970; Feinsinger, 1983), honeydew is usually exposed and freely accessible to many visitors. Therefore, the honeydew-feeding niche would be more likely to be dominated by groups like the ants, which are abundant, aggressive, effectively search plant surfaces and are less specialized in their feeding habits.

The generally ready and dependable availability of flowers during the seasons of adult Lepidoptera activity may be equally important. Aphid populations are prone to sudden, dramatic increases, e.g. pest outbreaks, and decreases, e.g. following an *Entomophthora* sp. epizootic (Hagen, 1976) or a period of extreme heat (Neuenschwander, Hagen & Smith, 1975). This less stable situation would seem poorly suited to relatively short-lived, pro-oogenic species, like most Lepidoptera (Chapman, 1982), which must rather quickly locate carbohydrate sources and deposit large numbers of already mature eggs. The influence of dependably available nectar is indirectly supported by the circumstances that existed at the time this observation was made.

In the high desert of south-central Idaho, mid-July is normally a time of transition, as the late spring flowers, e.g. desert paintbrush, *Castilleja chromosa* A. Nelson, globe mallow, *Sphaeralcea munroana* (Douglas) Spach ex Gray, and *Chaenactis douglasii* (Hooker) Hooker and Arnott, are passing and the summer flowers, e.g. rabbitbrush, *Chrysothamnus* spp. and horsebrush, *Tetradymia* spp. are coming into bloom. Sagebrush species in this area begin flowering in early fall and produce little, if any, nectar since they are anemophilous (Stebbins, 1974). However, in July 1983, an atypical, prolonged period of cool, rainy weather seemed to substantially delay the bloom of the summer flowering shrubs in this area, leading to a temporary, but acute, shortage of nectar sources.

Prolonged periods of moderately cool weather are also known to produce "aphid years." This is believed to be due to the temperature remaining above the developmental threshold of the aphid species, but below that of their predators and parasites (Neuenschwander, Hagen & Smith, 1975). This situation can lead to a rapid increase in the aphid population. An increase of this type would have increased the availability of honeydew, thus, increasing the likelihood that the moths would discover this alternate food. Since it remained cool and rainy at the time this observation was made, the weather may have severely limited the moths' abilities to search for and exploit the few nectar sources that were available. It seems likely that some combination of these factors induced the moths' atypical behavior.

So, honeydew feeding by adult Lepidoptera, other than entomophagous Lycaenidae, appears to be uncommon. If it were generally to occur only under circumstances similar to those outlined above, it would explain the scarcity of reports of this intuitively logical behavior. Still, under specific conditions, the ability to efficiently locate and consume honeydew could be important to the survival of many Lepidoptera.

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GENERAL NOTES

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NOTES ON THE PARASITISM OF *ROTHSCHILDIA* SP. PUPAE (SATURNIIDAE) IN GUANACASTE PROVINCE, COSTA RICA

Tachinid flies (Diptera) comprise a major source of pupal mortality in *Rothschildia* spp. (Saturniidae) in El Salvador (Quezada, 1967, Ann. Entomol. Soc. Amer. 60:595–599). In spite of the broad geographical distribution of *Rothschildia* in Central America (Ferguson, 1972, The moths of America north of Mexico, Bombycoidea–Saturniidae, E. W. Classey, London, 275 pp.), little has been published on similar mortality agents on pupae for other localities. In this note I report some qualitative observations on pupal mortality in *Rothschildia* sp. from lowland Guanacaste Province, Costa Rica since (1) such data for this moth genus in Costa Rica are lacking, and (2) a hymenopterous species was discovered, providing a significant difference from the El Salvador studies (Quezada, op. cit.).

Five intact cocoons of *Rothschildia* sp. were collected from one bush (1.5 m tall) in a roadside patch of deciduous forest about 5 km north of Bagaces (10°31'N, 85°15'W) along the Pan-American Highway on 2 March 1984. The cocoons were placed in a small "Zip-Loc" bag without close examination. About two months later (10 May) I noticed numerous newly emerged small wasps inside the bag. Upon closer examination I determined that a total of 67 wasps, all apparently the same species, emerged from two of the cocoons. All five cocoons were opened to determine the condition of the pupae. In one of the two cocoons from which wasps emerged, the pupa appeared mummified but with numerous, small round holes, apparently the exit sites of the wasps. The second parasitized pupa had no such holes but was broken open in the abdominal region. A single dead wasp was found at the bottom of the pupal cavity in each of these cocoons. Curiously and yet-to-be explained, a third cocoon was completely devoid of a pupa, pupal or larval exuvium, but had dried mud "caked" to the bottom of the pupal cavity. This cocoon also had a small round hole near the top (but not the emergence valve for the moth) tightly plugged with mud. This hole was about twice the diameter of the wasp emergence holes in the pupal cuticle found in one of the cocoons. A fourth cocoon contained a dead, mummified pupa, one dead wasp, and when broken apart, appeared to contain many mold spores. The fifth cocoon contained a hardened, mummified, but otherwise intact, dead pupa.

The wasps were determined to be *Spilochalcis* sp. (Hymenoptera: Chalcididae).

Although pupal parasitism in *Rothschildia* spp. in El Salvador is attributable primarily to tachinids, a low percentage of parasitism by an ichneumonid was also observed (Quezada, op. cit.). Quezada does not mention chalcids as being a pupal parasite of these silk moths in El Salvador. While the cocoons in my study were clearly *Rothschildia,* it was not possible to confirm a species determination since no viable adults were obtained. Although my sample size is terribly small, it is also interesting to note that these pupae had been collected during the pronounced dry season of the region, but the adult parasites did not appear until the end of this period.

I thank Susan S. Borkin for assistance and Dr. E. E. Grissell, Systematic Entomology Laboratory, U.S. Department of Agriculture, for determining the wasps. The wasps are deposited in the collections of the Milwaukee Public Museum.

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AN ABERRATION OF *ICARICIA ACMON LUTZI* (LYCAENIDAE)

Responding to the suggestion of F. Martin Brown, Colorado Springs, Colorado, I present a photograph of an aberrant male *Icaricia acmon lutzi* (dos Passos). This butterfly,

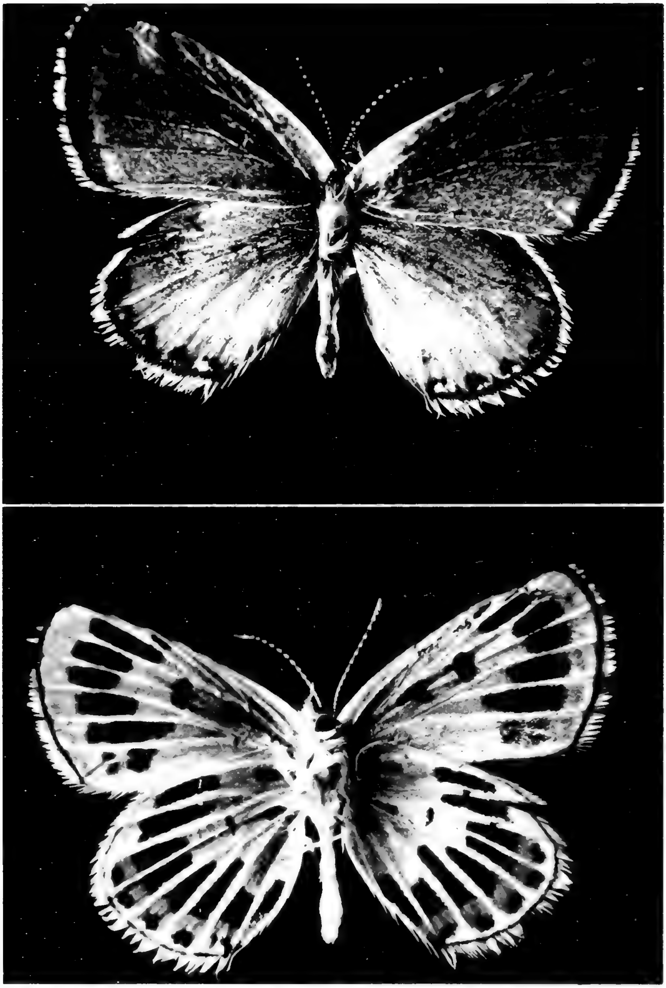

FIG. 1. Aberrant male of *Icaricia acmon lutzi*, Custer Co., Idaho: **Above**—top view; **below**—bottom view.

the only one sighted to date, was captured while it was visiting cold campfire coals on 14 July 1983, in Stanley Basin, Custer County, Idaho. Mr. Brown conveyed to me that he was unaware of any record of this aberrant form of *lutzi*.

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NATURAL HISTORY NOTES FOR *AELLOPOS CECULUS* (CRAMER) (SPHINGIDAE) IN NORTHEASTERN COSTA RICA

With the exception of one early study (Moss, 1920, Novit. Zool. 27:333–424) and one recent one (Haber & Frankie, 1983, *In* Janzen, D. H. (ed.), Costa Rican natural history, The Univ. of Chicago Press, Chicago, 816 pp.), little information has been published regarding the life cycle and associated natural history for Neotropical sphingids of the genus *Aellopos* (formerly *Sesia*). In this note I report additional information on the early stages and life cycle of *A. ceculus* (Cramer) (Fig. 1) at one locality in northeastern Costa Rica, including observations on oviposition, larval food plant, and caterpillar behavior. Previously, a description of the fifth instar larva and a larval food plant record had been reported by Moss (op. cit.) in Brazil.

The locality is "Finca La Tigra," near La Virgen (10°23'N, 84°07'W; 220 m elev.), Heredia Province and Sarapiqui District, Costa Rica. Information on this sphingid was generated by observing caterpillars in captivity and one instance of repeated oviposition attempts by one female in the wild. One fourth instar larva was reared in February 1984 to adulthood, and a second individual was reared from egg to adult in August–September 1984. Rearing was done by confining a caterpillar in a large, tightly closed, clear plastic bag containing fresh cuttings of the food plant.

On 4 August 1984 and 1600 h, a female *A. ceculus* alighted a total of five times on the very long (approx. 1.0 m) meristem of the rubiaceous vine-like shrub *Sabicea billosa* R. & S. Immediately prior to this time, I observed the same moth meander through dense pockets of secondary-growth vines on the opposite side of the roadcut from this individual of *S. billosa*. The moth fluttered and hovered in this vine patch for several minutes before darting across the gravelly dirt road to oviposit on *S. billosa*. Although the moth momentarily alighted at several places on the long meristem, including unfurling leaflets, close examination of the vine following the departure of the moth revealed only a single egg carefully positioned on the dorsal surface of a tiny leaflet near the very tip of the meristemal growth (Fig. 2). Even though freshly opened flowers were present on the older portions of this vine and on adjacent individuals of *S. billosa, A. ceculus* did not pause to feed. Careful examination of both meristems and older leaves and flowers on three *S. billosa* vines in the same area revealed no additional eggs or sphingid caterpillars. All three vines possessed very clear evidence of recent "explosive" growth of meristems, easily recognizable by the reddish tinge of these tissues.

The white 1.1 mm dia. spherical egg (Fig. 2) bears no external ridges or other sculpturing and hatches in five days. The first instar larva immediately devours the egg shell; the larva is 6 mm long × 1.2 mm thick, and pale, translucent green with a 1.1 mm long terminal black caudal "horn." About four days later, the caterpillar molts to the second instar; it is about 14 mm long at this time. Although very similar in overall appearance to the first instar, the caterpillar's body cuticle assumes a reflective luster and with faint evidence of a medial, dorsal pink band running the length (Fig. 2). Throughout all instars, the head capsule remains pale green in color but with a stripe pattern becoming evident by the third instar larval stage. The trunk region of both the first and second instars is dark green and covered sparsely with fine setae. The caudal horn in both instars stands

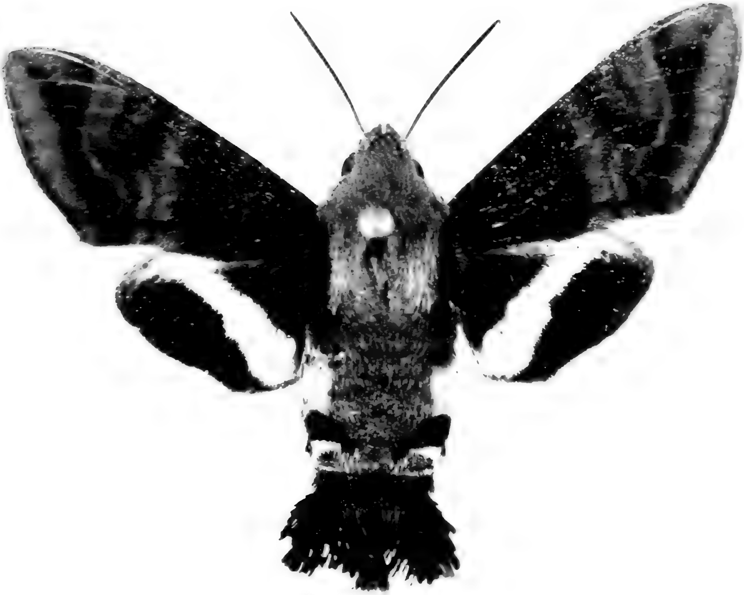

FIG. 1. Adult female *Aellopos ceculus* (Cramer), dorsal view, reared from the egg stage in this study. This specimen is deposited, along with the pupal shell, in the collections of the Milwaukee Public Museum.

almost perpendicular to the main axis of the body. The second instar lasts about five days and grows to 25 mm long.

The third instar larva (Fig. 2) assumes the basic color pattern and overall appearance which is retained until pupation. The third instar attains a maximum body length of 31 mm in about six days. The caudal horn is 5 mm long, deflected posteriorly, and reddish. The spiracles are also ringed in red. The broad dorso-medial band running lengthwise is faintly edged in white. This composite band begins on the second thoracic segment but becomes very pronounced on the abdominal segments. Laterally the trunk region is marked with a series of seven composite, oblique bands, reddish anteriorly and white posteriorly. These bands appear "white" even though they are actually composites of two colors (Fig. 2). Laterally, each of these composite oblique bands crosses three adjacent body segments and fuses into the dorso-medial line on the third segment (i.e., posteriormost) in such a triplet. Adjacent oblique bands overlap considerably in the segments bearing them (Fig. 2). All abdominal segments bear multiple vertical rows of pronounced white studs, readily seen with a 10× hand lens; these markings are also present on the thoracic segments, but they are less pronounced. The fourth and fifth instars are virtually identical in color patterns to the third instar. By the time of pupation, the caterpillar is 51 mm long; the overall duration of the caterpillar stage is 28 days.

A greenish prepupal stage lasts about three days, and the dark brown pupa measures 31 mm long × 9 mm laterally through the wing pad (thoracic) area. In the rearing study, the pupa was formed in the folds of dampened paper towels at the bottom of the plastic

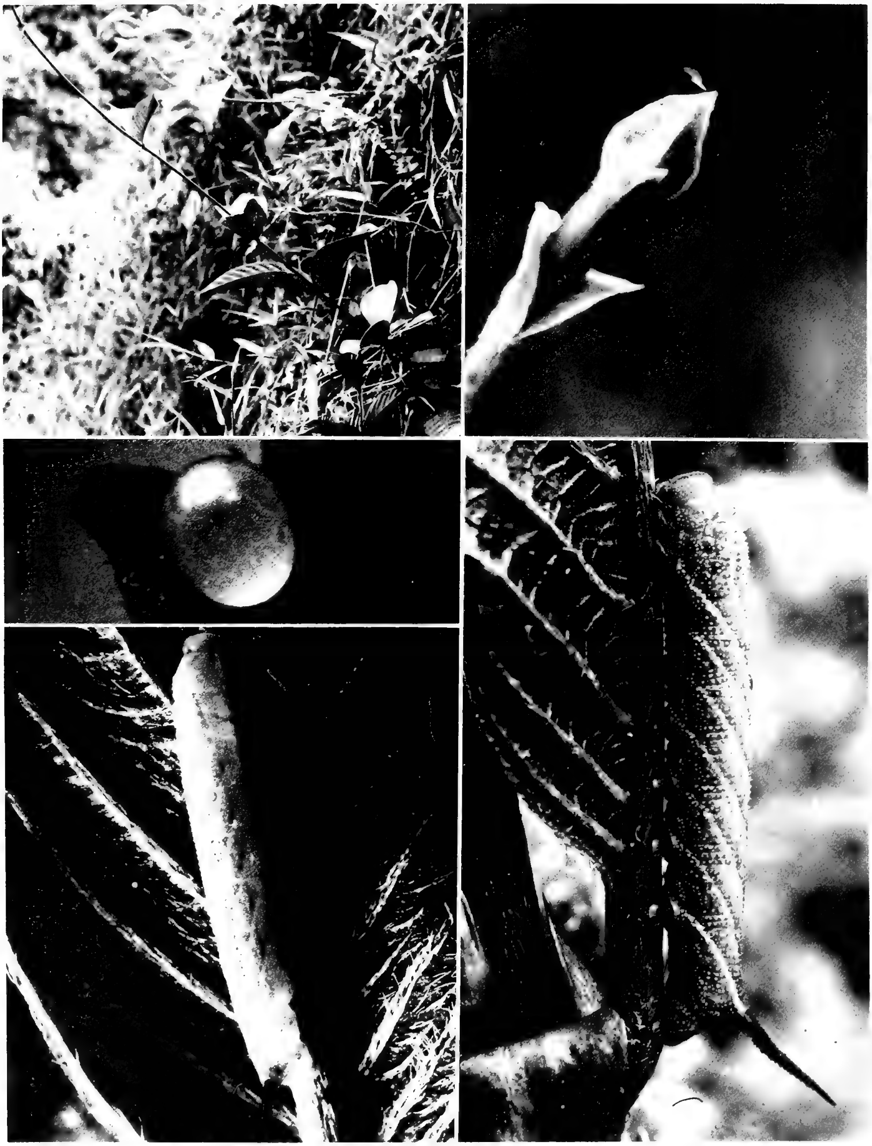

FIG. 2. Larval food plant, oviposition, and early stages for *Aellopos ceculus* at "Finca La Tigra," near La Virgen, Sarapiqui District, Costa Rica. Top two photographs: the larval food plant, *Sabicea billosa* R. & S. (Rubiaceae) showing the long meristem and terminal leaflet used as an oviposition site (left), and position of the egg on the dorsal surface of an unfurling meristemal leaflet (right). Left column below these photographs: close-up view of the egg, and second instar larva (dorsal view) and resting on ventral midrib of meristemal leaf; third instar larva, lateral view, showing pattern of markings and studded rugosity of the cuticle (right); also resting on a midrib of a food plant leaf.

bag containing the food plant. When handled, the pupa quickly responds with violent movements of the abdominal segments. The pupa stage lasted 22 days for my sample of N = 1 individual reared from egg to adult. A pupa obtained in February 1984 from a caterpillar discovered in the fourth instar lasted 17 days. The individual *A. ceculus* obtained from the complete rearing (Fig. 1) was a female. This individual has a wingspread of 39 mm and a body length of 25 mm. A detailed description of the adult for this species (under *Sesia*) is given in Seitz (1924, Macrolepidoptera of the World, vol. 6, A. Kernan, Stuttgart, 501 pp.).

Following the devouring of the egg shell, the first instar larva positions itself along the midrib of the ventral surface of a reddish meristemal leaf. The caterpillar throughout all five instars perches on the midrib of a leaf and appears very cryptic in this manner. Until the latter half of the third instar, the caterpillar feeds exclusively on reddish, soft meristemal leaf tissues and not on the greener, mature leaves of *S. billosa*. Feeding appears to occur in both day and night.

This sphingid is generously distributed geographically from Mexico to southern Brazil (Seitz, op. cit.). Moss (op. cit.) reported two different Rubiaceae as larval food plants in Brazil, including *Sabicea*. Moss reported that different color morphs of the caterpillar are associated with the two different food plants, and the description for the *Sabicea*-associated form matches that reported here for the Costa Rican population. One interesting difference, however, is that Moss reported *Sabicea*-associated caterpillars to possess chestnut-red lateral stripes, while my individual clearly had more whitish stripes. Haber and Frankie (op. cit.) also note that the caterpillars of *A. titans* Cramer are dimorphic in color. Larval descriptions and food plants for other species of *Aellopos* are summarized in Hodges (1971, The moths of America north of Mexico, Fasc. 21, Classey, London, 158 pp.). But, Hodges (op. cit.) also reports that descriptions of early stages and associated natural history data are poorly known for some species. In Costa Rica, *A. ceculus* has previously been reported for a different, lower-elevation locality in the Sarapiqui District, "Finca La Selva," about 25 km from "Finca La Tigra," and it is one of five species of the genus known to occur in Costa Rica (Haber, 1983, *In* Janzen, D. H., op. cit.). Interestingly, *A. ceculus* is the only member of the genus reported from the Sarapiqui District (Haber, op. cit.).

Oviposition behavior in the late afternoon hours may be part of a more general diurnal pattern of adult activity in this sphingid in which activities are concentrated near dusk (e.g., Haber and Frankie, op. cit.). Although *Aellopos* adults may feed on the flowers of their larval food plants (Haber and Frankie, op. cit.), this behavior was not observed in my very brief study, even though flowers were present on the *S. billosa* vines examined. And while most sphingids, including *Aellopos,* presumably place their eggs on the undersides of leaves on the larval food plant (e.g., Haber & Frankie, op. cit.), this was not the case for *A. ceculus* in the present study, albeit a very limited sample. *Aellopos ceculus* gravid females in search of egg-placement sites, as well as other sphingids in the Neotropical Region, may opportunistically exploit meristemal tissues of larval food plants proliferating at certain times of the year. These tissues may serve as highly suitable oviposition sites in that newly hatched caterpillars are placed in close spatial proximity to soft, digestible plant tissues under these conditions. Since there is little evidence indicating that Neotropical sphingid adults or their caterpillars are unpalatable as a consequence of larval food plant selectivity (Haber & Frankie, op. cit.), observed oviposition preference by *A. ceculus,* and perhaps other sphingids, for seasonally available meristemal tissues may indicate a facultative form of natural selection permitting these herbivorous organisms to exploit the most energetically cost-efficient food plant tissues.

Susan Borkin and Joan Jass discovered the *A. ceculus* caterpillar in February 1984, and they shared their observations with me. Luis Diego Gomez of the Herbarium, National Museum of Costa Rica, identified the larval food plant based upon the examination of extensive vegetative material as well as flowers. Mel Scherbarth photographed the adult moth illustrated in this note.

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MISDIRECTED MONARCH MATING BEHAVIOR (DANAIDAE: *DANAUS PLEXIPPUS*) OR *NOBLESSE OBLIGE*?

T. E. Pliske (1975, Ann. Entomol. Soc. Amer. 68:143–151) has described the aggressiveness of the male *Danaus plexippus* (Linn.) as it employs its "take-down" maneuver to drive the female to the ground during its courtship routine. J. W. Tilden (1979 ('81), J. Res. Lepid. 18:2) has depicted the male's sometimes faulty discrimination resulting in male attempting to mate with male. That this indiscriminate activity can become even more misdirected is evidenced by the following observation.

In April 1982, while photographing butterflies nectaring at a *Pittosporum* tree on Ossabaw Island, Chatham County, Georgia, I noted two *D. plexippus*, the first a worn and decrepit female and the other a fairly fresh and active male, neither of which showed any interest in the other.

As I watched, the cruising male suddenly stooped like a falcon, struck a nectaring *Vanessa virginiensis* (Drury), sex undetermined, from its blossom, and pinned it to the pavement below (Fig. 1). In the brief moment available for photographing the event, I did not observe any actual attempt to copulate. The *virginiensis* then struggled free, and both butterflies flew off.

One should perhaps resist the temptation to anthropomorphize regarding the monarch and the painted lady.

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FIG. 1. *V. virginiensis*, grasped by the legs of a male *D. plexippus* and pinned to the ground.

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A NEW FOOD PLANT RECORD FOR *ATALOPEDES CAMPESTRIS* (BOISDUVAL) (HESPERIIDAE)

Atalopedes campestris (Boisduval) is a common skipper found in the new world from Canada to Ecuador and northern Brazil (Evans, 1955, A catalogue of the American Hesperiidae, the British Museum, London). Host plant records for the larval stages of *A. campestris* include several grass species: 1) Bermudagrass, *Cynodon dactylon* (L.) Pers. (Klots, 1951, Field guide to the butterflies, Houghton-Mifflin, Co.; Warren & Roberts, 1956, J. Kans. Entomol. Soc. 29:139–41; Harris, 1972, Butterflies of Georgia, Univ. Oklahoma Press); 2) St. Augustinegrass, *Stenotaphrum secundatum* (Walter) Kuntze (Howe, 1975, Butterflies of North America, Doubleday & Company, Inc.); 3) large crabgrass, *Digitaria sanguinalis* (L.) Scop.; and 4) saltgrass, *Distichlis spicata* (L.) Greene (Tietz, 1972, An index to the described life histories, early stages, and hosts of Macrolepidoptera of the continental United States and Canada, Allyn Mus. Entomol., Sarasota, FL).

Several "tent" structures typical to grass and sedge feeding Hesperiinae were observed on biotypes of Cogongrass, *Imperata cylindrica* (L.) Beauv. on 28 September 1984 at Stoneville, MS. Two larvae and one pupa were found, and from these, two male and one female *A. campestris* adults emerged on 5 and 10 October. Additional larvae and "tents" were observed on *I. cylindrica* biotypes collected from Alabama, Mississippi (Patterson, 1980, Proc. So. Weed Sci. Soc. 33:251) and Iraq (Al-Juboory & Hassaway, 1980, Weed Sci. 28:324–26).

These observations not only establish a new host plant record for *A. campestris* but indicate that this skipper should be evaluated for its potential as a biological control agent against *I. cylindrica*. Biological controls are certainly needed for this weedy native of Indo-Malaysia. It is an aggressive, rhizomatous perennial weed, ranking as the world's seventh worst weed (Holm et al., 1977, The World's worst weeds, The University Press of Hawaii). Since its introduction between 1910 and 1920 (Patterson, 1980, Weed Sci. 28:735–740), it has become a pernicious weed of non-cultivated areas in the southeastern United States.

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SPECIMENS OF *CALLOPHRYS RUBI* L. (LYCAENIDAE) FROM FIJI— TRANSPLANTED COLONY OR ONE-TIME OCCURRENCE?

While studying specimens of worldwide *Callophrys*-related taxa in the British Museum (Natural History) in 1983, I located two specimens of *C. rubi* L. in unincorporated material of the Adams Bequest, which bore labels indicating capture in Fiji in 1904. Given the oddity of these data on specimens of a butterfly generally distributed from the British Isles eastward through Soviet Asia (Higgins & Riley, 1970, A field guide to the butterflies of Britain and Europe, Houghton-Mifflin Co., Boston; Johnson, 1986, A revision of the Callophryina of the world with phylogenetic and biogeographic analyses, Bull. Am. Mus. Nat. Hist., in press), the specimens were photographed (Fig. 1). Robinson (1975, Macrolepidoptera of Fiji and Rotuma, Classey, London) does not list *C. rubi* from

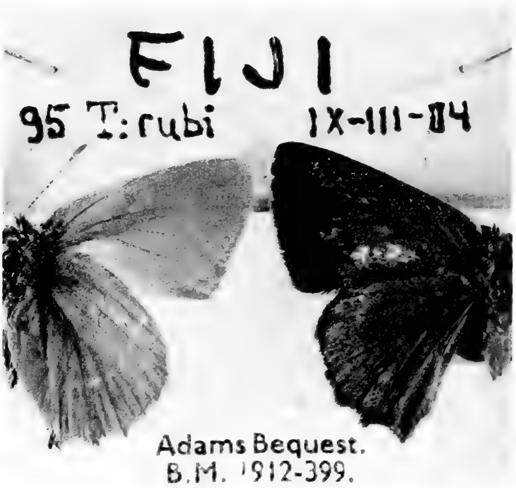

FIG. 1. Photograph of two male specimens of *C. rubi* and data recording their capture in Fiji. Specimens are in British Museum (Natural History).

Fiji. He records 45 species of butterflies for the island, of which four are cited as endemic. It was, therefore, important to ascertain the possible validity of the above-mentioned specimens and their associated data. Two factors are relevant to this consideration—the overall veracity of data in Adams Bequest material and the availability of suitable larval foodplants in Fiji to support *C. rubi*. Regarding the former, I have examined Adams Bequest material from some 18 genera of Lycaenidae in the British Museum. Although some data are limited to only regional or country citation, I have never found an instance suggesting erroneous data. On the contrary, when Adams Bequest material has provided examples of species poorly represented in international collections, such material has always had data compatible with the known distributions of such species. Further, the *C. rubi* specimens noted above were found with other Fiji material, including the lycaenids *Zizina otis mangoensis* (Butler) and *Strymon bazochii gundlachianus* (Bates), both listed by Robinson from Fiji. Regarding the question of suitable larval foodplant availability, Dr. Herbert Wagner (University of Michigan, Ann Arbor) has informed me that of the foodplants of *C. rubi* listed by Tutt (1907–1908, British Lepidoptera, Swan Sonnenschein & Company, London [p. 109]) the following are known to have been transplanted to Fiji and, consequently, occur there in varying distributions: *Rubus idaeus* (Richter), *R. frangula* (Glitz), *Rumex* spp., *Medicago lupulina* Linnaeus, *Lotus corniculatus* Linnaeus, *Trifolium* spp., *Genista tinctoria* Linnaeus, *Cytisus spinosus* (Linnaeus), and *Amygdalus* spp. The above categories of taxa represent some 25% of the larval foodplants listed by Tutt. Considering the above, it seems reasonable to accept the two British Museum specimens of *C. rubi* from Fiji as probably valid records. They have been curated by me into the overall collection of *C. rubi* at that museum with a special label citing this present note. It remains to be resolved whether this occurrence represents a possible transplanted colony of *C. rubi* in Fiji or simply a one-time occurrence due to accidental transplantation. Robinson (loc. cit.) cites human factors as having massive influence upon the fauna and flora of Fiji. He also records some butterflies of Fiji as known only from original types or (as in the case of *Nacaduba dyopa* (Herrich-Schaffer)) as having representation by a large series from one time with few, if any, subsequent captures recorded. Considering the above and the availability of Robinson's general faunal work, the publication of these data concerning *C. rubi* specimens from Fiji has seemed advisable.

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ECOLOGICAL OBSERVATIONS ON *APODEMIA PHYCIODOIDES* BARNES & BENJAMIN (RIODINIDAE)

In their paper on the rediscovery of *Apodemia phyciodoides* Barnes & Benjamin, Holland and Forbes (1981, J. Lepid. Soc. 35:226–232) indicated that the ecological associations of *phyciodoides* were imperfectly known and required further study. In late July 1984, I was joined by three other members of the Arizona Entomological Society on a trip to southeastern Sonora, Mexico. This trip was part of an on-going study of the Lepidoptera of Sonora by several members of the Arizona group. Observations made during this trip on *phyciodoides* may further clarify its habitat preferences and relationships with other riodinids.

Our group consisted of Jim Brock, John Palting, Steve Prchal and myself. The eight day collecting trip was spent along Highway 16, southeast of Hermosillo, terminating at Yecora, near the Chihuahua state line. The collecting area covered was primarily in the Sierra Madre Occidental and its outer foothills and was about 125 airmiles south of the area collected by Holland and Forbes. Four biotic communities (or life zones) were sampled, from San Jose de Pimas to Yecora. Using terminology from Brown (ed., 1982, Desert plants 4:1–342, Biotic communities of the American southwest—United States and Mexico), these communities were: Sinaloan Thornscrub, Sinaloan Deciduous Forest, Madrean Evergreen Woodland, and Petran Montane Conifer Forest. *A. phyciodoides* was found to be relatively common along the dirt road between Santa Rosa and Yecora, from four to 10 miles east of Santa Rosa. All of these sites fall in the Madrean evergreen woodland community, a *Quercus-Juniperus-Pinus* habitat. The lowest collecting site, four miles east of Santa Rosa, is near the transition into the Sinaloan deciduous forest, which is indicated by a *Ficus-Ceiba-Celtis* habitat. The upper collecting site, 10 miles east of Santa Rosa, is near the plateau region of the Petran montane conifer forest, dominated by *Pinus* species. The *Quercus* dominated habitat in which *phyciodoides* was found consisted of a rugged canyon-ridge (barranca) geography. Despite fairly extensive collecting, *phyciodoides* was not observed in either of the two adjoining biotic communities. Other "indicator" butterfly species that were most prevalent in the Madrean evergreen woodland were: *Thessalia theona* ssp. (Menetries), *Thessalia cyneas* (Godman & Salvin), an unknown *Piruna* species, and *Cyllopsis pyracmon nabokovi* L. Miller. The presence of *phyciodoides* and *cyneas* together, both of which previously were found in the Chiricahua Mountains of Arizona and both of which have not been found there recently, is intriguing.

On 29 July 1984, while travelling up toward Yecora, both sexes of *phyciodoides* were observed in mid-afternoon at wet places along the dirt road. On 30 July, Brock and I hiked about four miles down the road in late morning, starting from the upper collecting site. The entire length of the hike was in the *Quercus* woodland habitat. Males of *phyciodoides* were observed patrolling along, and landing in, the dirt road. Both sexes were also observed at moisture and nectar. A total of about 25 specimens were collected in the two days. Extensive collecting in the Sinaloan deciduous forest (one to three miles east of Santa Rosa) on 29 July yielded no specimens of *phyciodoides*. The conifer forest plateau above the *Quercus* zone was also sampled without any observations of *phyciodoides.* The results of this sampling would indicate that the species is associated with the *Quercus* dominated Madrean evergreen woodland biotic community. According to Brown (1982, ibid.), this community also dominates much of the region collected by Holland and Forbes, as well as the Chiricahua Mts. of Cochise Co., Arizona—the type locality for *phyciodoides.*

Holland and Forbes also expressed interest in the relationship between *phyciodoides* and other riodinids, especially *Apodemia palmeri* (Edwards) and *A. hepburni* (Godman & Salvin). While our limited observations cannot answer the questions in this subject, they may provide a better understanding of the Riodinidae associations by biotic community. In addition, a potential pattern becomes apparent in the associations between *phyciodoides, palmeri,* and *hepburni.*

No riodinid species were observed in the sampling of the Petran montane conifer forest. Within the Madrean evergreen woodland, we found *phyciodoides, Apodemia hypoglauca* (Godman & Salvin), *Emesis ares* (Edwards), *Baeotis zonata* (Felder), *Lasaia maria* Clench, and *Calephelis arizonensis* McAlpine. Only *phyciodoides* and *arizonensis* were common in this area, the other species were represented by less than half a dozen specimens each. In the Sinaloan deciduous forest, and lower into its transition with the Sinaloan thornscrub (16 miles east of Tecoripa to three miles east of Santa Rosa), six species were recorded: *hepburni, hypoglauca, arizonensis, maria, Emesis poeas,* and *zonata.* In this zone, only *maria* and *hepburni* were common. *A. hypoglauca* was not observed here on the late July 1984 trip but was taken on 26 August 1984 by Doug Mullins within the same zone (near Tepoca, highway 16). A stop along the river at San Jose de Pimas in the lower Sinaloan thornscrub (transitioning to Sonoran desert-scrub) resulted in three different species: *palmeri, Apodemia mormo mejicanus* (Behr), and *Calephelis nemesis* (Edwards). *A. palmeri* was common while the other species were present in lower numbers.

In summation, these observations do not answer the problems presented by Holland and Forbes, but they do provide further clarification of the biotic associations of *phyciodoides* and its relationship with *palmeri* and *hepburni.* In southeastern Sonora, *phyciodoides* appears to be closely associated with the *Quercus* dominated Madrean evergreen woodland, a habitat which dominates middle and upper mountain regions into southeastern Arizona. Categorizing riodinid species by biotic community in this region gives the perception that the three *Apodemia* species mentioned above are each associated with different habitats, and perhaps "replace" each other as the biotic communities are transversed.

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POPULATION OUTBREAK OF PANDORA MOTHS (*COLORADIA PANDORA* BLAKE) IN THE MAMMOTH LAKES AREA, CALIFORNIA

Pandora moths (*Coloradia pandora* Blake), which are fairly widespread over the northern pine forests of the west, periodically exhibit an unusual increase in population as described by Brown (1984, J. Lepid. Soc. 38(1):65) and Ferguson (1971, Moths of America north of Mexico, Fasc. 20.2a, E. W. Classey Ltd., London). During a field trip in 1982, shortly after the described outbreak of adults on the Kiabab Plateau of Arizona, such an outbreak was witnessed in the Mammoth Lakes area (el. 7000 ft.) of California. On the night of 30 August 1982, many hundreds of adults were observed flying and at rest on a motel in the town of Mammoth. Activity began at about 2000 h and continued for at least several hours.

At a rest stop located five miles north of Mammoth on route 395 at the same approximate altitude, several thousand adults were seen the next day (31 August 1982). On the ground of the north side of the rest stop building were many hundreds of bodies and fragments of bodies, indicating probable predation. This evidence consisted of disassociated heads and wings covering a large area.

Activity at the motel resumed the night of the 31st, and several females were captured. Each of these laid up to a hundred blue-green spherical eggs, which were not kept through hatching.

The area around Mammoth is covered almost exclusively with lodgepole pine (*Pinus contorta*), and this forest, one of the largest in California, extends past the rest stop mentioned above.

As a collector's note, the rest stop described above has proven to be an excellent collecting spot, when open, which depends on enough water being available to make it usable. Many specimens can be taken there, including large Saturnidae, as the building is lit at night. Also, less than two miles north of the Rest Stop, route 395 crosses Deadman's Creek, an excellent collection area for butterflies.

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PUDDLING BY SINGLE MALE AND FEMALE TIGER SWALLOWTAILS, *PAPILIO GLAUCUS* L. (PAPILIONIDAE)

The eastern tiger swallowtail, *Papilio glaucus* L., is noted for puddling in large groups on damp soil. These conspicuous aggregations are apparently all male; no female has ever been reported in them. This agrees with the general case in the Lepidoptera. In both butterflies and moths, puddling is a far more common behavior in males than in females (Downes, 1973, J. Lepid. Soc. 27(2):89–99; Adler, 1982, J. Lepid. Soc. 36(3):161–173).

Puddling is apparently associated with the acquisition of sodium ions and amino acids from the substrate (Arms et al., 1974, Science 185:372–374). Adler and Pearson (1982, Can. J. Zool. 60:322–325) have shown that the sodium budgets of males and females of the cabbage butterfly, *Pieris rapae* L., are significantly different, with males having a higher need for sodium than females. This greater need for sodium by males may reflect the more active role of the male in reproduction, both in terms of greater flight activity (Downes, op. cit.) and in the production of nutrient rich spermatophores (Adler & Pearson, op. cit.). This in turn may explain the preponderance of males at puddling aggregations.

We have eight observations of fresh male *P. glaucus* puddling singly over the course of several summers near Ithaca, Tompkins Co., N.Y. and near Cooperstown, Otsego Co., N.Y. These may represent cases where the individual is the first to find an area of rich resources and thus may form the core of a puddling aggregation later on. Males in this species are attracted to conspecific decoys (Arms et al., op. cit.). This may be a consequence of their mate-locating behavior, which apparently involves searching for mates at a wide variety of sites (Berger, pers. comm.). Patrolling males may key onto a puddling individual in the hopes that it is a female and remain at the puddling site if it is rich in needed nutrients. Alternatively, single puddling males may be at sites with lower concentrations of the needed resources.

We have observed five cases of puddling by female *P. glaucus* at a study site near Cooperstown, Otsego Co., N.Y. In all five cases, the females were puddling singly. The first observation was at 1050 h on 22 June 1983 (day 16 of the brood). A fresh female was captured while puddling on damp soil in a vegetable garden, where she had been settled for about two minutes.

Three observations all occurred on 13 June 1984 (day 10 of the brood). At 1045 h, a fairly worn female was disturbed while puddling on damp soil at the edge of a road. She flew to the end of a nearby cornfield where she puddled in two different locations for a total duration of about five minutes. This female was subsequently captured while nectar-feeding. At 1230 h, a fresh female flew slowly along a different road edge. She landed once, probed at the soil, then continued down the road. Finally, at 1620 h, a slightly worn female was seen taking off and landing several times along the road edge, probing the soil at least once.

The fifth observation was at 1627 h on 2 June 1985 (day 17 of the brood). A very worn female was observed taking off and landing at several different spots on the soil of the vegetable garden and was subsequently captured after she had been puddling for about three minutes.

Papilio glaucus is a highly vagile, wide-ranging species. Both sexes show very low recapture rates in mark-recapture studies (Lederhouse, 1982, Ecol. Entomol. 7:379–383). Females of this species may well have greater relative nutrient requirements than females of more sedentary species. Puddling females may represent those cases where their requirements cannot be met from larval feeding, nectar, or the contributions of a male's spermatophore.

However, we have observed both males and females puddling singly in two related species, the black swallowtail, *Papilio polyxenes* F., and the zebra swallowtail, *Eurytides marcellus* (Cramer). The black swallowtail is not a wide-ranging species and differs considerably from the tiger swallowtail in its habitat preference and reproductive strategy (Lederhouse, 1983, Oecologia 59:307–311). That males puddle singly in this species may again be influenced by their territorial mating system, which involves male defense of lek sites (Lederhouse, 1982, Behav. Ecol. Sociobiol. 10:109–118). The observations of females puddling in these species may suggest that puddling in female Lepidoptera is more common than is widely believed.

One possible reason why female Lepidoptera are not often seen puddling in groups may be to avoid harassment by males at these sites. We have often observed the investigation of and attempted copulation with puddling individuals by new arrivals at aggregations of puddling *P. glaucus* males. A female in this situation would have to compromise between efficient puddling and exercising her reproductive choice.

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FLOWER VISITATION RECORDS FOR SNOUT BUTTERFLIES (LIBYTHEIDAE)

In the course of a general survey of libytheid butterflies (Shields, Tokurana, in press), flower visitation records were noted for *Libytheana bachmanii* Kirtland (most) and *Libythea celtis* Fuessly, gleaned from published sources and correspondence. These records are arranged here according to the classification of A. Takhtajan (1969, Flowering plants:

Origin and dispersal, Smithsonian Institution Press, Washington, D.C., 310 pp.), from primitive to advanced:

Clematis vitalba (Ranunculaceae)
Boussingaultia leptostachya (Basselaceae)
Eriogonum sp. (Polygonaceae)
Erica cinerea (Ericaceae)
Tilia sp. (Tiliaceae)
Croton sp. (Euphorbiaceae)
Rubus sp. (Rosaceae)
Prunus caroliniana (Rosaceae)
Eysenhardtia amorphoides (Leguminosae)
Melilotus albus (Leguminosae)
Philadelphus coronarius (Saxifragaceae)
Cornus sp. (Cornaceae)
Ligustrum vulgare (Oleaceae)
Baccharis sarothroides (Compositae)
Senecio douglasii (Compositae)
Chrysothamnus sp. (Compositae)
Cirsium sp. (Compositae)
Mentha sp. (Labiatae)
Sorghum sp. (Gramineae)

It is instructive to compare this list with flower visitation records for *Asterocampa* by Neck (1983, J. Lepid. Soc. 37:269–274), another nymphalid genus that utilizes *Celtis* (Celtidaceae) for larval foodplants. The only overlap in nectar feeding for both was Leguminosae and Saxifragaceae. However, *Asterocampa* adults were also reported on the fruit of *Rubus* and *Prunus* (Rosaceae), two genera that appear in the flower visits for libytheids. These facts may take on phylogenetic significance, since *Libythea celtis* uses both *Celtis australis* L. and *Prunus* as larval foodplants (Vladimir B. Polacek, *in litt.*); and Rosaceae, Leguminosae, and Saxifragaceae are closely related. A preliminary survey of flower visitation records for butterflies appears in Shields (1972, Pan-Pac. Entomol. 48:189–203).

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MALE DETERMINED MATING DURATION IN BUTTERFLIES?

When considering what factors influence the mating duration in butterflies, it is important to know to what extent it can be influenced by each sex respectively. Sims (1979, Am. Midl. Nat. 102:36–50) suggested, in analogy with results by Leopold, Terranova and Swilley (1971, J. Exp. Zool. 176:353–360) on *Musca domestica*, that mating duration probably is controlled by the female. This may be true in the sense that the female can inform the male when she is ready to terminate the copulation. However, in butterflies it is more likely that the male ultimately determines mating duration. If there should exist a conflict between the male and the female about when to terminate the copulation, the construction of the male genitalia suggests that the male alone determines copula duration. This inference is supported by two incidental observations I have made.

The first concerns a pair of *Coenonympha pamphilus* (Satyridae), where the female was killed during copulation. On 26 August 1982 in Timmernabben, Sweden, I released a virgin female to a male. After mating for 1 h 39 min a crab spider (Thomisidae) attacked and grabbed the female. After 4 h 51 min I left them while they were still in copula but put a cage over them. When I returned half an hour later the copulation was over; the male was flying in the cage while the female was still held by the spider among the vegetation.

The other observation concerns a pair of *Pararge aegeria* (Satyridae) kept in a cage in the laboratory, where the male for unknown reasons died during copulation. They were found in copula on 5 February 1985 at 1100 h. It was still dark in the cage, and the pair must have been mating since 1840 h the day before when the light was switched off automatically. At 1340 h the light was turned on. At 1700 h the female was found flying in the cage with the male hanging from the tip of her abdomen. Upon inspection he was found to be dead. On 8 February the female was still alive and attached to the dead male. On 15 February the female was found dead, still in copula with the male.

Although not proven, it seems plausible that the copulation is ultimately terminated by the male. Further observations and experiments would be interesting.

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SATYRIUM AURETORUM AURETORUM (BOISDUVAL): A NEW SPECIES FOR OREGON (LYCAENIDAE)

The senior author received a number of butterflies from the junior author among which were three female *Satyrium auretorum auretorum* (Boisduval) with the following data: OREGON: Lake Co.; 2 miles south of Lakeview, 1 June 1981, *leg.* Ray Albright. Dornfeld (1980, The butterflies of Oregon, Timber Press, Forest Grove, OR) does not report the species for the state. The species has been expected there; it was taken towards the border in Siskiyou Co., California (Klamath River, near I-5, *fide* S. O. Mattoon). This new location also brings the species to within 20 miles of the Nevada border, another state where it is unrecorded.

We thank S. O. Mattoon for providing the northern California record.

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(New names in **boldface**)

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NOTICE TO CONTRIBUTORS

Contributions to the *Journal* may deal with any aspect of the collection and study of Lepidoptera. Contributors should prepare manuscripts according to the following instructions.

Abstract: A brief abstract should precede the text of all articles.

Text: Manuscripts should be submitted in *triplicate*, and must be typewritten, *entirely double-spaced*, employing wide margins, on one side only of white, 8½ × 11 inch paper. Titles should be explicit and descriptive of the article's content, including the family name of the subject, but must be kept as short as possible. The first mention of a plant or animal in the text should include the *full scientific name*, with *authors* of zoological names. Insect measurements should be given in *metric units*; times should be given in terms of the *24-hour clock* (e.g. 0930, not 9:30 AM). Underline only where *italics* are intended. References to footnotes should be numbered consecutively, and the footnotes typed on a separate sheet.

Literature Cited: References in the text of articles should be given as, Sheppard (1959) or (Sheppard 1959, 1961a, 1961b) and all must be listed alphabetically under the heading LITERATURE CITED, in the following format:

SHEPPARD, P. M. 1959. Natural selection and heredity. 2nd. ed. Hutchinson, London. 209 pp.

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

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