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ABSTRACT

The Bistonini is a relatively small, compact group of geometrid moths found in the Holarctic region. In the New World they occur in Alaska, Canada, and the United States, and there is one known record from the State of Chihuahua, Mexico. The Nearctic species are placed in six genera; four of these also occur in the Old World. A total of 22 species are represented in our fauna; *Cochisea undulata* (Arizona), *C. paula* (California), *C. unicoloris* (California), *C. recisa* (California), and *C. curva* (California) are described as new. Keys to the genera and species are given, as are illustrations of the adults, their genitalia, and maps of their distribution.

Some members of the tribe, including species of *Biston* and *Phigalia* for example, have melanic forms; these have been studied for "industrial melanism." At times some species are of economic importance as defoliators of woodlands and shade trees. Neither of these facets is covered intensively, as the present paper is intended as a revisionary study. However, I have included a number of references to these two fields of interest in order to call attention to their presence in the appropriate species.

The possible phylogeny and distribution of the tribe is discussed, with the relationships of the New and Old World faunas being covered. A number of different morphological characters are treated, with some assigned as either primitive or derived. Three characters are presented that apparently were not known for the North American Geometridae. These are the presence of hairy eyes in *Biston* and *Cochisea* and the progressive reduction and loss of both the fore tibial process and the tympanic organs in the brachypterous and wingless females.

INTRODUCTION

The Bistonini is a group of moths that are of interest from several viewpoints. The present revisionary study is a systematic one, and it points out some possible evolutionary trends within the group. The tribe is Holarctic in distribution with several genera in common to both the Old and New World, and others that are restricted to their own hemispheres; interesting zoogeographical problems arise from this situation. Some species have melanic forms, but the majority do not; the former have led the geneticists to study and breed some of them. Still other species are known to defoliate deciduous forests and orchards; these are of economic interest. Notwithstanding all the preceding points, the last revisionary study for North America was published in 1896 by Hulst; W. T. M. Forbes covered the taxa that occur in New York and neighboring states in 1948. It is the purpose of this study to define the tribe as it occurs in North America, to describe all the genera and species, with keys for their determination, and to illustrate all species and their genitalia.

This tribe is "a very distinct and universally recognized group" (W. T. M. Forbes, 1948, p. 64). Our fauna consists of six genera and 22 species; that of the Old World is probably larger, but the lack of modern comprehensive revisionary studies makes it difficult to give definite figures. Many papers have been written over the years on the Palaearctic fauna, and numerous genera, some species, many subspecies, forms, and aberrations have been described. Fortunately our area has not received this type of treatment, as relatively few genera and only six forms or aberrations have been named. In North America I recognize six genera; four of these also occur in the Palaearctic region. No attempt has been made to cite the Old World literature for these genera, with the exception of the original descriptions.

Similarly, I have not made a great effort to cite either the economic literature for those species that are known defoliators, or the citations on melanism and whatever is known about the genetics thereof; these fields are outside the scope of my taxonomic treatment for this group. It can be noted that many of the studies on melanism in Lepidoptera, including "industrial melanism," have been accomplished using *Biston betularia* (Linnaeus), a member of the Bistonini (see Kettlewell, 1973). I have, however, included a number of references to these two fields of interest in order to call attention to their presence in the appropriate species.

During the course of this study I have examined more than 7663 specimens (6966 males, 697 females) and 226 genitalic dissections (172 males, 54 females). The great majority of the latter were prepared by me; in addition, I made slide mounts of the antennae and legs of both sexes of all species when material was available. All specimens studied by me at the American Museum of Natural History have had either identification or type labels placed on their pins. The majority of specimens (4647) and slides (159) are in the collection of that institution.

All the photographs in this revision were taken by me. Whenever possible, specimens from the American Museum of Natural History were utilized; some material is from other collections and is specifically noted as such. The following abbreviations have been used:

AMNH, the American Museum of Natural History
CAS, the California Academy of Sciences
CNC, the Canadian National Collection
LAM, the Natural History Museum of Los Angeles County
USNM, the National Museum of Natural History, Smithsonian Institution

PHYLOGENY AND DISTRIBUTION

The ancestral form of the Bistonini differed basically from other Ennominae, in my opinion, by a reduction in the size and usage of the tongue, the uncus of the male genitalia having a broad apex, and by the very long apophyses posteriores in the female genitalia. These characters, plus some others that occur in both the Bistonini and in the great majority of the Ennominae, I consider to be primitive. Some of the more noticeable derived ones within the tribe include the loss of the tongue, changes in the male antennae, in the upper surface of the abdomen, and in the wings of the female. A selected list of both primitive and derived characters is given in table 1. Two of the most valuable characters in recognizing and delimiting genera are the male antennae and the scaling or spining of the upper surface of the abdomen; the latter is the same in both sexes. As there is a progression of characters within the tribe, it is assumed that they reflect a phylogenetic sequence.

The most primitive characters are pectinate male antennae, scaled abdomens, and male genitalia with the uncus having a broadly bifurcate apex. *Biston*, *Cochisea*, and *Lycia* form this primitive group of genera. I consider *Biston* to be the most primitive genus in North America, as it has the above characters. In addition, the adults fly in midsummer, another primitive character. *Cochisea* is more specialized, in that it has a strong spine at the distal end of the fore tibia, and the adults are on the wing from late summer into midwinter. Both *Biston* and *Cochisea* have females that are fully winged. *Lycia* begins to show a change in abdominal scaling, as there is a mixture of elongate hairlike scales and flattened, slender, apically bifurcate scales. The

TABLE 1
Primitive and Derived Characters in North American Bistonini

Character	Primitive Condition	Derived Condition
Male antennae	Bipectinate	Four-pectinate or ciliate
Tongue	Reduced	Vestigial or absent
Female fore tibial process	Present	Absent
Upper surface of abdomen	Scaled	Spined
Wings of female	Fully developed	Brachypterous
Male genitalia:		
uncus	Broad apex	Pointed apex
valves	Simple	With spinose area
Female genitalia:		
apophyses posteriores	Very long	Short
signum	Present	Absent

females vary from being fully winged to brachypterous. The males fly from January into the spring months.

The remaining genera have the apex of the uncus narrowed. The Old World genus *Agriopis* has pectinate male antennae, a scaled abdomen, and the females with their wings reduced to about half the length of their body.

Phigalia also has pectinate male antennae, but the dorsal surface of the abdomen is either covered with flattened, deeply bifurcate scales or with numerous spines of equal size. The abdominal spines in this tribe are derived from modified scales; the latter are present in *Lycia* and in some of the species of *Phigalia.* The females are brachypterous; all four wings are recognizable, and vary from 3 or 4 mm. in length down to minute pads. The males fly from December or January into late spring.

The last genus with pectinate male antennae is the Old World *Apocheima*. Here the abdomen is spined, with segments two and three having one row of large thick spines and a second row of small spines; the remaining segments have numerous setae.

Paleacrita has male antennae in which the segments have either one or two swellings, from which arise an elongate group of setae. The abdominal spining is basically similar to that of *Apocheima* but it is reduced to two rows per segment; segments two and three have spines that are larger and thicker than are the others. The females have greatly reduced wings, less than 1 mm. in length. The males have about the same flight period as is found in *Phigalia.*

Erannis is unique in the tribe in that its male antennae have two pairs of short, squat projections per segment, with each projection bearing numerous long setae. The abdomen is scaled. The females have wings that are reduced to minute pads about 0.5 mm. in length. The males fly from late fall into winter.

The Bistonini are Holarctic in distribution, with the most primitive types occurring in eastern Asia (W. T. M. Forbes, 1948, p. 64). It has been postulated that *Biston* and *Lycia* are of Siberian origin, becoming differentiated in the upper Pliocene (Povolny and Nosek, 1955, pp. 201, 202). There is no solid evidence for this, so far as I know, fossil or otherwise, so the preceding statement and the following ones that pertain to the origins of this tribe have to be considered hypotheses.

The North American fauna resulted from one or more invasions across the Bering land bridge by several different forms; we have four genera in common with the Old World. One of these is *Biston*, with the Holarctic species *betularia*, ranging from western Europe and England to Japan, and across North America. Kettlewell stated that *betularia* (in England) and our *cognataria* "have been separated from each other for several hundred thousand years . . ." (1973, p. 316). He believed that *betularia* and *cognataria* are distinct species; I consider our North American population to be of subspecific rank (see below).

The early invading population of *Biston* spread across the continent and south down the Rocky Mountains and the Pacific coast. One segment of the population became isolated in the arid southwestern United States and, in due course, developed into *Cochisea*, an endemic genus. The prominent spine at the end of the fore tibia presumably evolved to enable the newly emerging moth to dig itself out of the hard, arid ground, where pupation takes place. In southern California, apparently cool autumn or early winter weather is necessary to break pupal diapause and for the adults to emerge. This precedes the normal winter rains of that area, which are necessary for the leafing out of the host plants; the larvae do not emerge from their eggs until after the rains have occurred (Comstock, Henne, and Sala, "1957" [1958], p. 170).

Lycia has a similar history, although there are no species in common in the Old and New World. Two of our species (*ursaria* and *ypsilon*) are related to the Palaearctic *hirtaria*; the third (*rachelae*) to the three Old World species that have been placed in *Poecilopsis*. I consider the latter to form a species group within *Lycia*; Povolny and Nosek (1955) considered *Poecilopsis* to be a distinct genus closely allied to *Lycia*. They believed *Poecilopsis* originated in the forests of central and northern Europe, with *rachelae* getting to the New World "through the presumed continental bridge of Iceland and the present islands of the northern Atlantic" (1955, p. 202). Based on the present distribution of *rachelae*, I think that it is more likely that it came to the New

World via the Bering route; it is possible that it became established at a different time (probably later) than did the other species of *Lycia.*

Phigalia has species in both hemispheres, as does *Erannis.*

Paleacrita represents our second endemic genus. It presumably arose from the same ancestral line that produced *Apocheima*, which is more primitive than *Paleacrita*. Both genera have basically the same type of abdominal spining; that of our genus is more highly developed. The ancestral form spread across the continent, with two species developing in eastern North America and a third becoming isolated in California.

MORPHOLOGY

Two of the more recent definitions of the North American Geometridae are by W. T. M. Forbes (1948, pp. 10-12) and McGuffin (1967, pp. 5, 6; 1972, pp. 1, 2). The results of the present study show that the descriptions of the following three structures should be either included or modified from those given in the above family definitions.

One pertains to the eyes; Forbes (*op. cit.*) stated "eyes . . . never hairy." The definition that Forbes (1923, p. 21) used for this term is: "Often there are minute straight hairs arising between the facets, in which case the eye is called hairy." The adults of both *Biston* and *Cochisea* have prominent hairlike setae between the eye facets, and hence must be considered "hairy."

Another character is the process on the fore tibiae of brachypterous females; this is not mentioned by either Forbes or McGuffin. Normally, in the North American Geometridae, both males and females have a well-developed process, or epiphysis (W. T. M. Forbes, 1923, fig. 17) on this segment. The winged, flying males and females of our Bistonini have the process. There is a progression of species in this tribe from females that are winged but seldom fly, to brachypterous, and to being almost completely without wing pads. This progression, in general, is accompanied by a reduction in size and then loss of the process. *Lycia ursaria* (Walker), with the females fully winged but seldom flying, has a much smaller process than does the male; *L. rachelae* (Hulst), with brachypterous females, lacks the process altogether. The brachypterous females of *Phigalia* have the process greatly reduced or rudimentary but still present in the posteromedian depression on the tibia. The brachypterous or wingless females of *Paleacrita* and *Erannis* lack the process altogether. In other North American geometrids with wingless females the process may be absent, as in *Animomyia smithii smithii* (Pearsall) (Ennominae), minute (about 0.1 mm. long) and apical, as in *Alsophila pometaria* (Harris) (Oenochrominae), or greatly reduced (about 0.3 mm. long) and near the end of the segment, as in *Oporophtera bruceata* (Hulst) (Larentiinae).

The third structure is the paired tympanic organs found ventrally on the first segment of the abdomen. In most of our geometrids this organ is prominent and well developed, and can be used as a diagnostic structure to separate the Geometridae from all other moths except some of the Pyralidae (W. T. M. Forbes, 1948, p. 11; McGuffin, 1967, p. 5; 1972, p. 1). This structure is present in the winged males and females of our Bistonini; according to both Forbes (*op. cit.*) and McGuffin (*op. cit.*) it is also true for the wingless females. My studies show that this is not so. The tympanic organ of the females of *Phigalia* is reduced to a small, elongate sclerotized structure with a transverse hooklike process; that of *Paleacrita* to a small platelike object; and of *Erannis*, a small but elongate platelike object with a hooklike process. A survey of the wingless females found in two other groups of our North American geometrids show that the tympanic organ is apparently lost in both *Alsophila pometaria* (Harris) and *Oporophtera bruceata* (Hulst).

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SYSTEMATIC DESCRIPTIONS

The tribal characters for the Nearctic genera are summarized here to avoid needless repetition in the generic descriptions:

Adult. Head, eyes large to moderate, round or elliptical, with hairlike scales or naked; front flat, extending beyond eyes for short distance; tongue reduced, vestigial or absent; palpi small to rudimentary; antennae of male bipectinate, shortly four-pectinate with group of cilia from end of each pectination, or lengthily ciliate, of female simple or ciliate. Thorax stout or moderate, with mixture of flattened scales and hairlike scales dorsally; fore tibia unarmed or with prominent terminal spine, process well developed in male and winged females, reduced or absent in brachypterous females; hind tibia with either one or two pairs of spurs, strongly represented or reduced, not dilated and without hair pencil in male. Abdomen stout to moderate, without tufts, row of setae ventrally on third segment of male, and eight segment unmodified; tympanic organ reduced or obsolescent in brachypterous females; dorsal surface with normal scales, hairlike scales, flattened scales ending in two or more points and arising from sockets, or with spines. Forewing of males broadly triangular to elongate; with 11 or 12 veins, usually without areole, R_{1+2} stalked or free, R_1 sometimes uniting with Sc, from top of cell, R_5 from stalk before R_{3+4}; M_1 from, at or below upper angle, udc straight, mdc straight or curved, ldc angled; Cu_1 from below lower angle; fovea absent. Hind wings of males broad; frenulum strong; Sc approximate to R about middle or in basal portion of cell; R and M_1 either from before or beyond upper angle, or separate; M_3 from lower angle; cell elongate, extending beyond middle of wing; Cu_1 from one-fourth to one-third distance between angle and Cu_2. Wings of females variable, from similar to those of males, fully functional, to large but seldom used for flying or brachypterous.

Male Genitalia. Uncus either with broadly bifurcate apex, or with variously shaped single point; socius absent; gnathos prominent, well sclerotized, medially either broadly rounded or pointed; valves moderately large, either simple or with distal end bifurcate, inner surface either simple or with raised group of setae or spines; transtilla present, anteromedian margin of costa tending to become pointed or swollen and to form part of transtilla; anellus moderate to large, with more or less elongate posterior extension; cristae and furca absent; tegumen large, broad, with elongate setae from dorsal surface; saccus large to moderate; aedeagus either simple, tubelike, or somewhat irregular in shape, in length varying from shorter to longer than combined lengths of uncus, tegumen and saccus; vesica relatively small when exserted, either unarmed, with single spine of varying shape, or with elongate band of short setae.

Female Genitalia. Papillae anales elongate, slender, membranous, with apophyses attached anteriorly; apophyses posteriores varying from extremely long to moderate; sterigma inconspicuous, with or without sclerotized lamella antevaginalis; ductus bursae either an elongate membranous funnel-like tube, or a square to rectangular, heavily sclerotized structure; corpus bursae varying from elongate, symmetrical or asymmetrical, to short and simple; signum present or absent, when present variable in shape.

KEY TO GENERA

Based on Morphology and Color

1. Males 2
   Females 7
2. Antennae bipectinate 3
   Antennae fasciculate or with two pairs of short setose projections per segment . . . 6
3. Hind tibia with two pairs of spurs 5
   Hind tibia with terminal pair of spurs only . 4
4. Fore tibia with well-developed terminal spine . . . . . *Cochisea*
   Fore tibia without terminal spine . . . . *Lycia*
5. Abdomen with dorsal surface covered with elongate scales . . . . . *Biston*
   Abdomen with dorsal surface having each segment covered with either flattened, deeply bifurcate scales or with scales and multiple rows of spines (figs. 1, 2) . . . . . *Phigalia*
6. Abdomen with dorsal surface covered by scales; antennae with two pairs of setose projections per segment . . . . . *Erannis*
   Abdomen with dorsal surface covered by elongate spines, those on second and third segments noticeably larger than others (fig. 3); antennae fasciculate . . . . . *Paleacrita*
7. Fully winged 8
   Brachypterous or wingless 10
8. Hind tibia with two pairs of spurs . . . *Biston*
   Hind tibia with one pair of spurs 9
9. Fore tibia with well-developed terminal spine . . . . . *Cochisea*
   Fore tibia without terminal spine . . . . . *Lycia* (in part)
10. Abdomen with dorsal surface covered by elongate scales 11
    Abdomen with dorsal surface covered with either flattened, deeply bifurcate scales or with scales and multiple rows of spines. 12
11. Body black and white, smoothly scaled . . . . . *Erannis*
    Body black, with or without long, projecting white scaling . . . . . *Lycia* (in part)
12. Abdomen with dorsal surface having each segment covered with multiple rows of flattened, deeply bifurcate scales or of equal sized spines (figs. 1, 2) . . . *Phigalia*
    Abdomen with dorsal surface having each segment covered with two rows of spines, those on second and third segments noticeably larger than others (fig. 3) . . . . . *Paleacrita*

Based on Male Genitalia

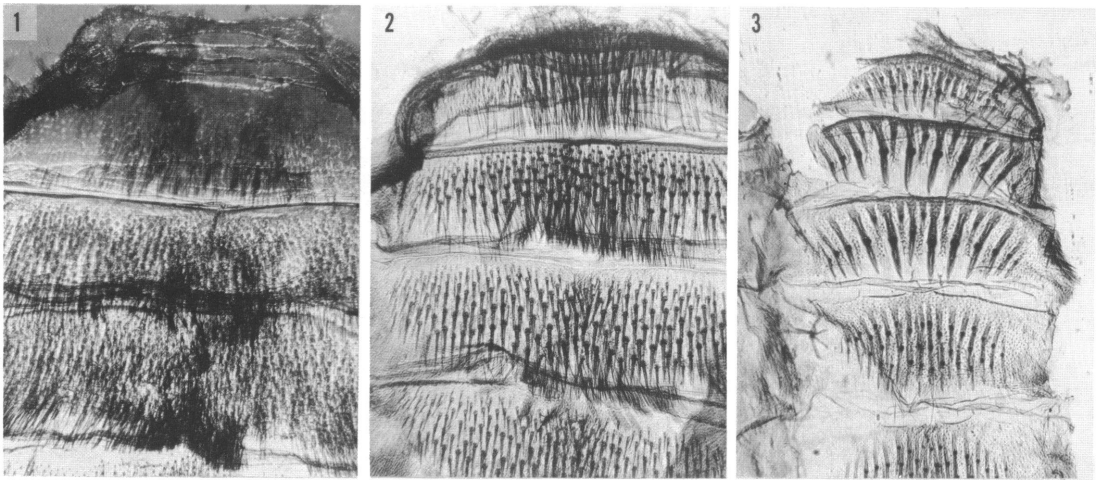
1. Uncus with apex broadly bifurcate 2
   Uncus with apex tapering to single point . . 3
2. Vesica armed with single, elongate band of setae . . . . . *Cochisea*
   Vesica armed with both band of setae and smaller, raised setose swelling. . . . *Biston*
3. Valves without median setose protuberance on inner surface . . . . . *Lycia*
   Valves with median setose protuberance on inner surface. 4
4. Each valve elongate, rounded apically; vesica unarmed or with single spine 5
   Each valve short, terminally bilobed; vesica with row of setae. . . . . *Erannis*
5. Vesica unarmed. . . . . *Paleacrita*
   Vesica with spine. . . . . *Phigalia*

Based on Female Genitalia

1. Apophyses posteriores 5.0 mm. or longer. . 2
   Apophyses posteriores shorter than 5.0 mm. 5
2. Signum present 3
   Signum absent . . . . . *Biston* (in part)
3. Signum sagittate . . . . . *Lycia*
   Signum a transverse ridge or inward-pointing thornlike process. 4
4. Signum an elongate transverse ridge about 0.6 mm. long . . . . . *Biston* (in part)
   Signum a small transverse ridge or thornlike process, 0.2 to 0.3 mm. in length . . . . . *Cochisea*
5. Signum present 6
   Signum absent, or with posterior end of corpus bursae partially sclerotized. 7
6. Lamella antevaginalis membranous, inconspicuous . . . . . *Phigalia* (in part)
   Lamella antevaginalis heavily sclerotized, broad . . . . . *Paleacrita* (in part)
7. Sterigma heavily sclerotized, with prominent lateral areas . . . . . *Erannis*
   Sterigma weakly sclerotized, without prominent lateral areas 8
8. Ductus bursae membranous, slender, at least twice as long as wide . . . . . *Paleacrita*
   Dustus bursae sclerotized, broad, with width subequal to length . . . . *Phigalia* (in part)

GENUS *BISTON* LEACH

Biston Leach, 1815, p. 134; 1832, p. 723. Packard, 1876, p. 414. Gumppenberg, 1893, p. 382.



FIGS. 1-3. Dorsal surface of anterior portion of abdomens. 1. *Phigalia titea* (Cramer) (group I of *Phigalia*). 2. *P. strigataria* (Minot) (group II of *Phigalia*). 3. *Paleacrita vernata* (Peck).

Amphidasis Treitschke, 1827, p. 229. Hulst, 1896a, p. 359 (as synonym of *Lycia*). Dyar, "1902" [1903], p. 328 (as synonym of *Lycia*). Barnes and McDunnough, 1917, p. 119. McDunnough, 1938, p. 166. Francle-mont, 1949, p. 5 (as synonym of *Biston*).

Amphidasys (emendation): Wiegmann and Ruthe, 1832, p. 428; 1848, p. 445. Guenée, 1857, p. 206. Walker, 1860b, p. 305. Gumppenberg, 1893, p. 378. Dyar, "1902" [1903], p. 328 (as synonym of *Lycia*). W. T. M. Forbes, 1948, p. 64 (as synonym of *Lycia*).

Lycia Hübner (in part): W. T. M. Forbes, 1948, p. 64.

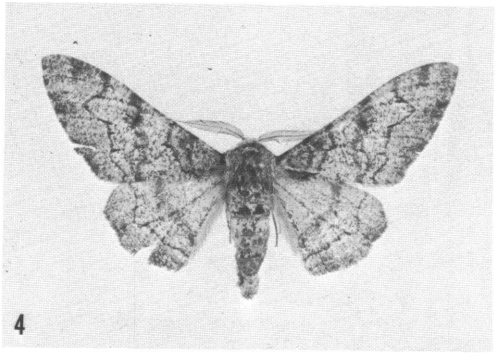
Diagnosis. The hind tibia have two pairs of spurs; the palpi are small but normal; the tongue, though present, is reduced; the wings of the female are of normal size and are used in flying; in the male genitalia the uncus has a bifurcate apex, and the valves are without a raised spinose area on their inner surface.

Adult. Head with eyes large, round, with hair-like scales between facets; tongue short; palpi small, normal; antennae of male bipectinate, of 50 to 53 segments, apex with terminal 12 to 17 segments simple, with pectinations arising medio-distally, longest pectinations with length about six times as long as basal segments, or 0.9 to 1.1 mm. in length, each pectination lengthily bicili-ate below; antennae of female simple. Thorax robust; fore tibia without terminal spine, with process of male arising basad of middle, of female well developed, arising just distad of middle of segment; hind tibia with two pairs of spurs, upper slightly smaller and thinner than lower. Abdomen stout; dorsal surface with elongate, flattened, slender apically bifurcate scales arising from sockets; tympanic organs of both sexes of about equal size.

Forewings of male elongate, triangular, outer margin only weakly curved; with 12 veins, R_{1+2} stalked or free; hind wings with Sc approximate to R along basal portion of cell, and with outer margin weakly concave between veins M_1 and M_3; vein M_1 from before upper angle. Wings of female similar to those of male, slightly larger, used for flying.

Upper surface of wings either pale gray, more or less heavily scaled with grayish black scales, median area tending to be slightly paler than basal and distal areas, with cross lines present, prominent, and with hind wings similar to forewings, or with forewings white, with broad, irregularly edged gray median area and grayish black distal area, and with hind wings unicolorous gray.

Male Genitalia. Uncus with broadly bifurcate apex; gnathos broadly enlarged and rounded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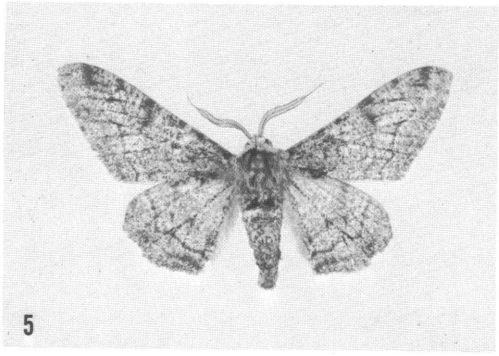
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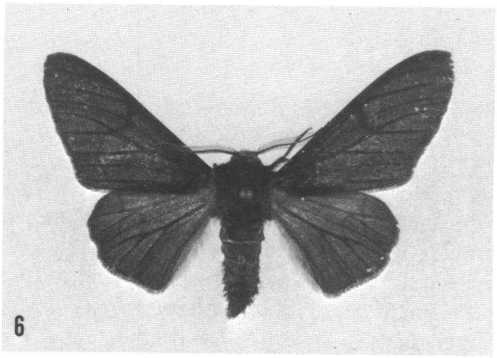
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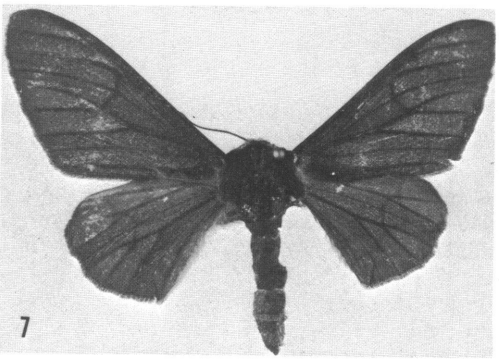
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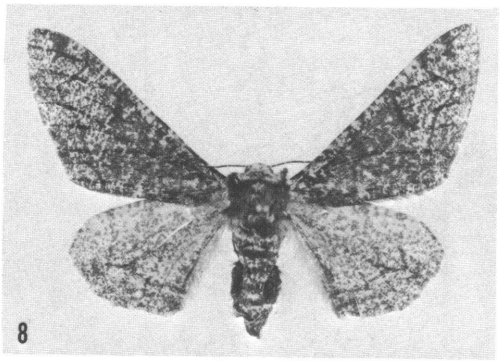
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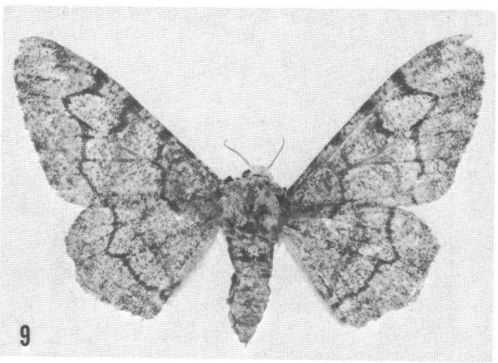
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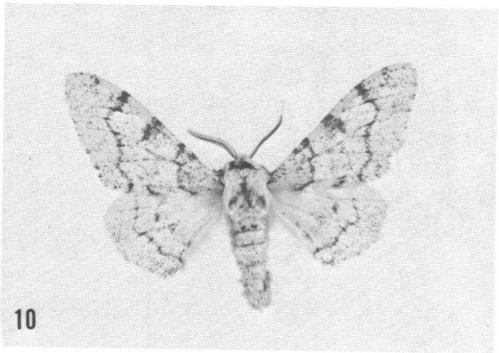
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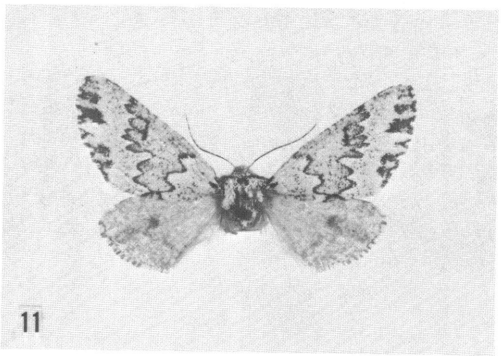
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medially; valves simple, inner surface without raised group of spines but with extensive area of setae; anellus with posterior portion conelike in outline, elongate; aedeagus simple, longer than combined lengths of uncus, tegumen, and saccus; vesica either unarmed or with elongate band of short setae, when exserted extending ventrally and slightly anteriorly, elliptical in form.

Female Genitalia. Sterigma not differentiated, without lamella antevaginalis; ductus bursae either elongate, tapering anteriorly or very short; ductus seminalis either arising dorsally from swollen portion of corpus bursae or from end of sac of corpus bursae on right side; corpus bursae elongate, varying from finely denticulate and convoluted to smoothly membranous; signum present or absent; apophyses posteriores 2.3 to 6.3 mm. in length.

Early Stages. For *cognataria*, see below.

Food Plants. Polyphagous on trees and shrubs (*cognataria*).

Type Species. For *Biston*, *Geometra prodromaria* (Denis and Schiffermüller), 1775; designated by Westwood, 1840, p. 99. *Geometra prodromaria* is a junior subjective synonym of *Phalaena strataria* Hufnagel, 1767.

For *Amphidasis*, *Geometra prodromaria* (Denis and Schiffermüller), 1775; designated by Duponchel, 1829, p. 106.

Distribution. Holarctic.

Remarks. Biston contains a number of Palaearctic species, but only two are represented in North America.

There has been a considerable amount of confusion in the past concerning the usage of *Biston*, *Amphidasis*, *Lycia*, and related genera and synonyms. Franclemont (1949) was the first to call attention to the proper usage of the names in North America.

Biston virginarius Grote (1880, p. 220) was carried in the literature as a geometrid for almost 25 years. It is now placed in the genus *Panthea* Hübner of the Noctuidae.

KEY TO SPECIES[1]
Based on Color and Maculation

1. Upper surface of wings with median area concolorous with basal and outer areas. 2
   Upper surface of wings with median area gray, sharply contrasting in color with white basal and outer areas . . . . . *multidentata*
2. Upper surface of wings dark gray or black . . . . . *betularia cognataria*
   Upper surface of wings white with black maculation. . . . . *betularia contrasta*

Based on Female Genitalia[2]

1. Signum large, prominent; apophyses posteriores 5.3 to 6.3 mm. in length . . . . . *betularia cognataria*
   Signum absent; apophyses posteriores 2.3 to 2.4 mm. in length . . . . . *multidentata*

Biston betularia (Linnaeus)

P[halaena] Geometra betularia Linnaeus, 1758, p. 521.

The species was named from Europe; a number of names have been given to this species in the Palaearctic area.

Biston betularia cognataria (Guenée), revised status
Figures 4-9, 12, 13, 16

Amphidasis cognataria Guenée, 1857, p. 208. Packard, 1876, p. 413, pl. 13, fig. 4 (adult male). Barnes and McDunnough, 1917, p. 119. Procter, 1938, p. 240; 1946, p. 279. McDunnough, 1938, p. 166. F. M. Jones and Kimball, 1943, p. 117. Jerrel and Jaques, 1944, p. 465. J. R. J. L. Jones, 1951, p. 133. Tietz, [1952], p. 139. Moore, 1955, p. 72. Brower, 1974, p. 106.

Amphidasys cognataria: Walker, 1860b, p. 307.

[1]The males of *multidentata* are unknown.

[2]The females of *betularia contrasta* have not been examined.

FIGS. 4-11. Adults of *Biston*. 4-9. *Biston betularia cognataria* (Guenée). 4. Male, Severn Bridge, Ontario, July 15, 1967 (G. E. Scott; AMNH). 5. Male, Putnam, Connecticut, July 6-9, 1961 (A. B. Klots; AMNH). 6. Melanic male, Finleyville, Pennsylvania, August 14 (H. Engel; AMNH). 7. Melanic female, Oak Station, Pennsylvania, August 16, 1922 (AMNH). 8. Female, Fort Lee district, New Jersey (H. Wormsbacher; AMNH). 9. Female, New Brunswick, New Jersey, August 17 (AMNH). 10. *B. betularia contrasta* (Barnes and Benjamin), male, Lamoille Canyon, Nevada, August 2, 1964 (W. R. Bauer and J. S. Buckett; LAM). 11. *B. multidentata* (Guedet), holotype female, Fly's Peak, Arizona, July 30, 1947 (J. A. Kusche; CAS). All ×1.2.

Anon., 1882, p. 24. Dimmock, 1885, p. 271. Gumppenberg, 1893, p. 381.

Eubyja cognataria: Goodell, 1878, p. 67. Grote, 1882, p. 49. Beutenmüller, 1890, p. 222.

Eubyia cognataria: Smith, 1891, p. 73.

Eubyia (Amphidasis) cognataria: Lugger, 1898, p. 245, fig. 191 (adult male).

Lycia cognataria: A. W. P. Cramer, 1883, p. 48. Dyar, "1902" [1903], p. 328; 1903a, p. 78; 1904, p. 911. Smith, 1903, p. 77; 1910, p. 504. Holland, 1919, p. 345, pl. 1, fig. 17 (larva), pl. 44, fig. 13 (adult male). Britton, 1920, p. 117. W. T. M. Forbes, 1928, p. 603; 1948, p. 65, fig. 24 (forewing venation) (in part).

Biston cognataria: Franclemont, 1949, p. 5. Ferguson, 1954, p. 317. Owen, 1962, p. 696. Prentice, 1963, p. 468, fig. 295 (distribution in Canada). McFarland, "1966" [1968], p. 16. Sugden, 1968, p. 27. Covell, 1970, p. 178. Scudder, 1972, p. 46. Heitzman, "1973" [1974], p. 176.

Amphidasis betularia cognataria: Staudinger and Rebel, 1901, p. 337 (in part).

Amphidasis cognataria form *swettaria* Barnes and McDunnough, 1917, p. 246, pl. 26, fig. 6 (holotype male).

Amphidasis cognataria aberration *swettaria*: McDunnough, 1938, p. 166.

Amphidasis cognataria melanic *swettaria*: Brower, 1974, p. 106.

Lycia cognataria aberration *swettaria*: W. T. M. Forbes, 1948, p. 65.

Amphidasis cognataria fortitaria Barnes and McDunnough, 1917, p. 246, pl. 26, fig. 2 (paratype male). McDunnough, 1938, p. 166. NEW SYNONYM.

Lycia cognataria fortitaria: W. T. M. Forbes, 1948, p. 65.

Lycia cognataria var. *mesle* W. T. M. Forbes, 1928, p. 603. NEW SYNONYM.

Diagnosis. This population has the upper surface of all wings darker than that of nominate *betularia*; it can be distinguished from all other North American Bistonini by its color and maculation.

Male. Head with vertex gray, having apices of scales broadly grayish white; front brownish black; palpi blackish brown. Thorax above brownish black, with some gray scales, collar with apices of scales broadly grayish white, becoming black distally; below gray or grayish brown; legs gray or grayish brown, tarsi tending to be brown, with ends of segments broadly grayish white. Abdomen above with mixture of pale gray, dark gray, and brownish black scales, tending to have dark band posteriorly on segments, below gray or grayish brown, with scattered dark scales.

Upper Surface of Wings: Forewings grayish white, heavily and evenly covered with gray, grayish black, and black scales, producing finely speckled appearance, with median area tending to be slightly paler than basal and distal areas; cross lines black, prominent; t. a. line arising on costa one-third distance from base, going at right angle from costa to cubital vein, angled or curved basad to anal vein, then inwardly oblique to inner margin one-fourth distance from base; t. a. line more or less broadly geminate basally, with inner line tending to be somewhat indistinct; median line marked on costa by large dark patch, varying from complete but rather nebulous, to absent; discal dot present, usually incorporated in, or near, median line; t. p. line arising on costa three-fourths distance from base, curving outward to vein M_2, concave basally to vein Cu_2, with short outward bulge below that vein, then paralleling outer margin to anal vein, thence outwardly angled to inner margin six-sevenths distance from base; s. t. line variable in intensity, obsolescent or well defined, with dark patch extending below costa near apex; terminal line absent but with intravenular spots; fringe concolorous with wing. Hind wings concolorous with forewings; intradiscal line absent; discal spot present, sometimes reduced; median line present, complete, tending to become geminate in center of wing, outer portion incorporating discal dot; extradiscal line prominent, complete, with outward angle near middle of cell M_1, then more or less concave to cell Cu_2, and concave again to anal margin; terminal line absent, and intravenular spots weakly represented when present.

Under Surface of Wings: All wings similar to upper surface but with less dark scaling.

Length of Forewing: 20 to 28 mm.

Female. Similar to male but tending to have wings, above and below, more evenly colored, tending to be more brownish gray.

Length of Forewing: 25 to 30 mm.

Male Genitalia. Anellus 1.5 to 1.6 mm. in length; vesica with elongate band of short setae

posteriorly and with second, much shorter setal patch anteriorly.

Female Genitalia. Sterigma not differentiated, without lamella antevaginalis; ductus bursae elongate, tapering anteriorly, weakly sclerotized, with longitudinal striations; ductus seminalis arising dorsally from swollen portion of corpus bursae; corpus bursae with posterior end enlarged, weakly sclerotized, finely denticulate, and with irregular surface on left side, narrowed medially, swollen anteriorly; signum large, prominent, in form of transverse indented ridge 0.6 mm. long; apophyses posteriores very long, 5.3 to 6.3 mm. in length.

Early Stages. The life history is well known. A few of the references to the early stages are Packard (1876, p. 413), Goodell (1878, p. 67), A. W. P. Cramer (1883, p. 48), Dimmock (1885, p. 271), Dyar (1903a, p. 78), Holland (1919, p. 345, pl. 1, fig. 17 (larva)), W. T. M. Forbes (1948, p. 65), and Sugden (1968, p. 27). Additional references are listed in Tietz (1972, p. 200).

Food Plants. Polyphagous on many deciduous trees and shrubs, with some records from *Larix* (Pinaceae); the larvae are often found on *Salix*, *Populus* (Salicaceae), *Betula*, and *Alnus* (Betulaceae). More than 50 different hosts have been recorded. Food plant lists are given by Beutenmüller (1890, p. 222; 13 listed), J. R. J. L. Jones (1951, p. 133; more than 20), Tietz ([1952], p. 139; 39 listed), Prentice (1963, p. 468; 15 listed), Sugden (1968, p. 27; 6 listed), and Tietz (1972, p. 200; 41 listed) among other authors.

Types. Guenée described *cognataria* from a single female. The holotype is in the collection of the National Museum of Natural History.

The holotype, male, of "swettaria" Barnes and McDunnough, is in the same collection.

Barnes and McDunnough described *fortitaria* from a type series of five males and one female. The lectotype is hereby designated and labeled as the male specimen bearing their "type ♂" label; it is also in the National Museum of Natural History.

Forbes's entire description reads "Glendale, black var. *mesle*." The type is not in the Cornell University collection (Franclemont, in letter), and may not have ever been labeled. Its location is unknown.

Type Localities. New York (specimen label), with the original description stating "Amérique septentrionale" (*cognataria*); New Brighton, Beaver County, Pennsylvania ("swettaria"); Glenwood Springs, Garfield County, Colorado (*fortitaria*); Glendale, Queens County, New York ("mesle").

Distribution. Transcontinental. In Canada, *cognataria* extends from Newfoundland to British Columbia (Prentice, 1963, fig. 295), extending almost as far as latitude 60° N in the west. In the United States, it extends south in the mountains as far as Tennessee and North Carolina in the east; it is found across the northern states, and extends south in the Rocky Mountains to Arizona and New Mexico, and in the Pacific Coast states as far as central California (see fig. 12). It is also known from the Sierra Madre Occidental in Chihuahua, Mexico.

Several authors (including Staudinger and Rebel, 1901; Prout, 1915; W. T. M. Forbes, 1948; Scudder, 1972, among others) have stated that *cognataria* occurs in eastern Asia and Japan; this is not so, as this subspecies is restricted to North America.

Flight Period. June and July in the north; in more southern latitudes the flight period is longer. In New York and New Jersey adults have been caught from April into September; in southern Arizona, from March into October; and in coastal Oregon, from April into August.

Remarks. One thousand two hundred eighty-six specimens (1144 males, 142 females) and 21 genitalic dissections (15 males, six females) have been studied. I have examined the holotypes and lectotype of *cognataria*, *fortitaria*, and "swettaria."

I have placed two names in the synonymy of *cognataria*. One is *fortitaria* Barnes and McDunnough; as the type series from Glenwood Springs, Colorado, does not consistently differ from series of *cognataria* from eastern North America, the name is placed in the synonymy. Forbes's "mesle" represents the melanic form of *cognataria*, and it is the same as "swettaria" that was described 11 years earlier.

Fresh specimens tend to have the cross lines and dark scaling black or slightly brownish black; the color fades to dark brown with age.

This population has melanic individuals (form

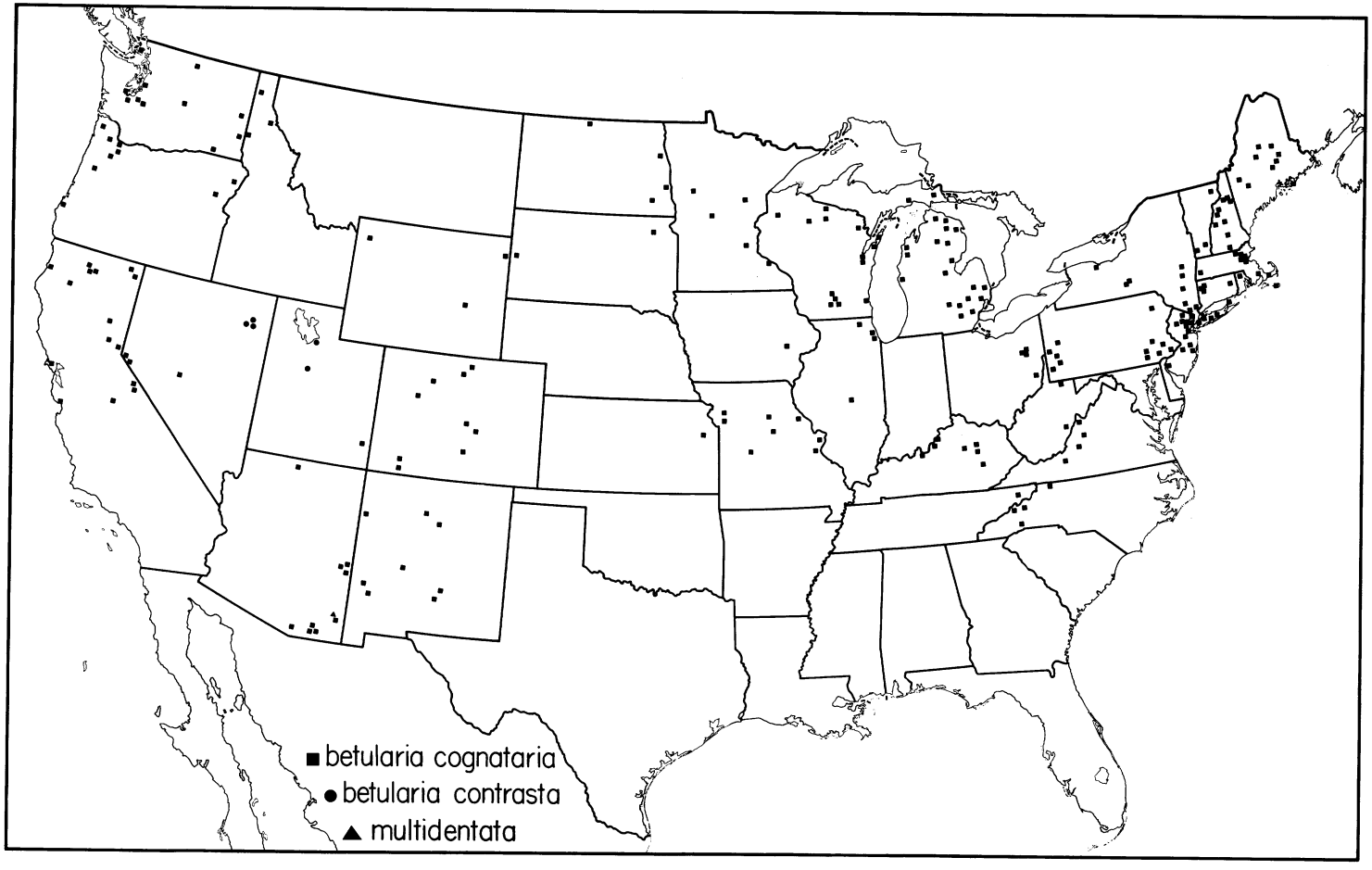


FIG. 12. Distribution of *Biston* in the United States.

"swettaria" and its synonym "mesle"). For many years they were only known from a rather restricted area in the eastern United States. The melanic form is now more widespread in northeastern North America (Owen, 1962, p. 696), and has been reported on Vancouver Island, British Columbia (Scudder, 1972).

Kettlewell has done hybridization experiments using British *betularia* (Linnaeus) and Canadian *cognataria*; this was carried on for four generations. The resulting progeny were highly fertile and there was no gross disturbance of the sex ratio. Kettlewell claimed that the two are distinct species, differing as follows: "*cognataria* is somewhat darker than . . . *betularia*; it hatches earlier in the summer and over a much shorter period; and the larvae feed at a great speed and most have pupated by the end of August. Quick feeding and early hatching are no doubt essential for avoiding the sudden onset of Canadian winters. By contrast, imagines of British *betularia* hatch from May to August and larvae can be found till October." (Kettlewell, 1965, p. 1295; 1973, pp. 84, 111, 316).

I place a different interpretation on Kettlewell's data. The somewhat darker color of *cognataria* I consider to be a subspecific character. Kettlewell's own breeding experiments show that *betularia* and *cognataria* freely interbreed, that there is no apparent reproductive isolation between the two, and that the isolating mechanisms that are present between full species have not been developed. Kettlewell admitted that the earlier emergence and the shorter feeding period for his Canadian *cognataria* are climatically induced; specimens of this population are at least double brooded in more southern localities and would not necessarily have these habits. Morphologically, the several species of *Biston* I have examined are quite distinct in the structure of the male antennae, the genitalia of both sexes and, in some cases, the number of hind tibial spurs; *betularia* and *cognataria* are apparently indistinguishable in all these characters. The basic color, maculation, and tendency to commonly produce melanic individuals are apparently identical, or nearly so, in *betularia* and *cognataria*; no other species of *Biston* can be confused with them in these characteristics. In my opinion, all the evidence indicates that these two populations are parts of a single biological species. Consequently, I am placing *cognataria* as a peripherally isolated subspecies of *betularia*.

Biston betularia contrasta
(Barnes and Benjamin),
new combination and revised status
Figures 10, 12

Amphidasis cognataria contrasta Barnes and Benjamin, 1923, p. 12. McDunnough, 1938, p. 166.

Lycia cognataria contrasta: W. T. M. Forbes, 1948, p. 65 (placed as synonym of *fortitaria*).

Diagnosis. Specimens occurring in the Great Salt Lake Desert area of northwestern Utah and in northeastern Nevada are markedly paler in color, and have reduced maculation, as compared with *cognataria*.

Male. Similar to *cognataria*, differing mainly as follows: scaling on head, thorax, and abdomen whiter; upper and under surfaces of wings white, with grayish brown, brown and black scales; maculation tending to be reduced.

Length of Forewing: 20 to 24 mm.

Female. Similar to male but tending to have wings more evenly colored.

Length of Forewing: 26 to 30 mm.

Male Genitalia. Similar to those of *cognataria*.

Female Genitalia. Not examined.

Early Stages. Unknown.

Food Plants. Unknown.

Type. Holotype, male, in the National Museum of Natural History. *Contrasta* was described from a single male.

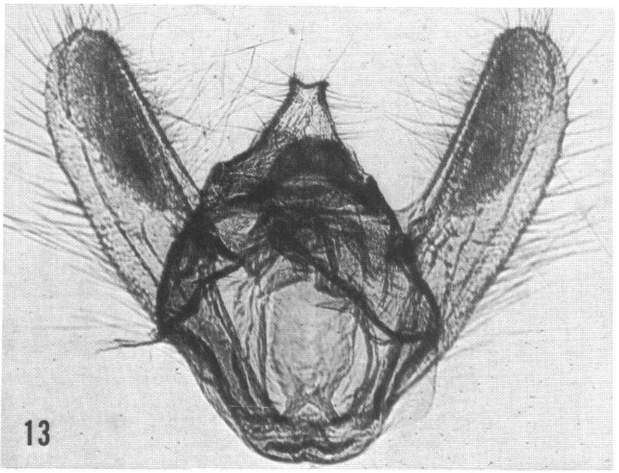
Type Locality. Eureka, Juab County, Utah.

Distribution. The Great Salt Lake Desert area of northwestern Utah and in northeastern Nevada (the Ruby Mountains in Elko County). See figure 12.

Flight Period. July, August, and September.

Remarks. Twelve specimens (nine males, three females) and one genitalic dissection have been studied, including the holotype.

The moths of this population are poorly represented in collections. Specimens are usually scarce in Utah; extensive collecting by me in that state during parts of four summers produced only two male and one female *cognataria*, and none of *contrasta*.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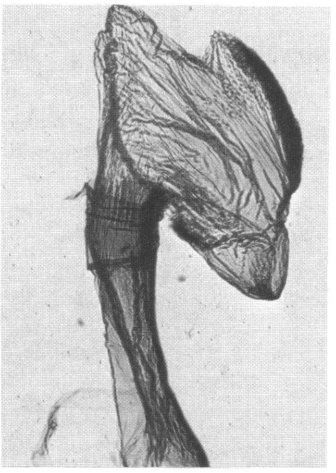

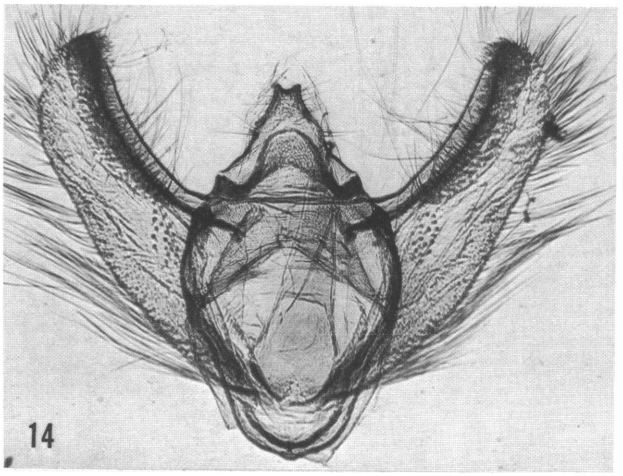
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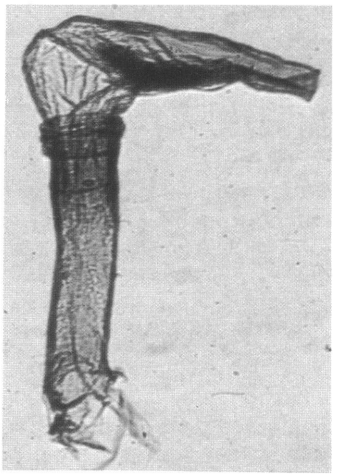

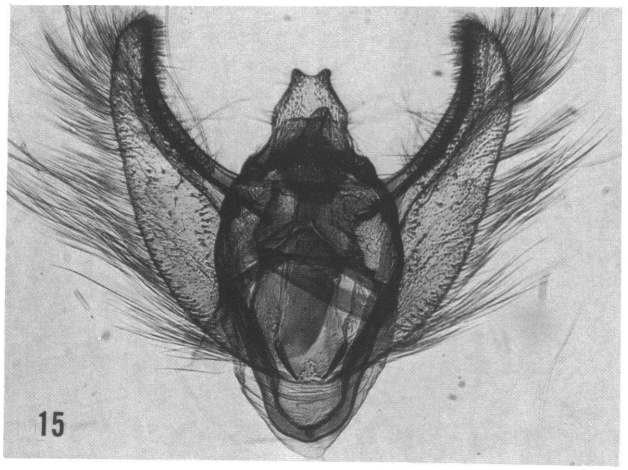
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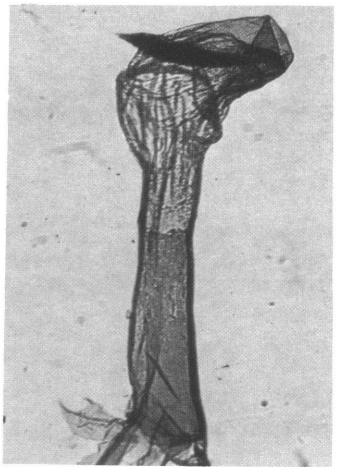


Biston multidentata (Guedet), new combination
Figures 11, 12, 17

Amphidasis multidentata Guedet, 1941, p. 191.

Diagnosis. This species can be recognized by the color and pattern of the forewings; the latter are white with a broad, gray median area with irregular margins, and with a grayish black terminal area. It also differs from *betularia* by having vein R_1 free, and by lacking a signum in the female genitalia.

Male. Unknown.

Female. Head with vertex of white or grayish white flattened scales and brown hairlike scales; front white or grayish white, becoming blackish brown laterally and ventrally; palpi brown on outer surface, whitish on inner. Thorax above with blackish brown hairlike scales and with white flattened scales primarily on collar and patagia, prominent posterior tuft blackish brown, posterolateral areas grayish brown; below grayish brown; legs dark grayish brown, tibiae and tarsi blackish brown with white bands. Abdomen above gray, with scattered dark gray, dark brown, and pale gray scales, the last tending to be at ends of segments; below grayish white, with scattered dark brown scales.

Upper Surface of Wings: Forewings white, with scattered grayish brown and blackish brown scales on both sides of dark median area; basal line black, incomplete; t. a. line black or blackish brown, arising on costa one-fourth distance from base, strongly and evenly waved, meeting inner margin beyond middle; median area appearing gray, with variable amount of white scaling, occupying entire area between cross lines, including elongate, narrow, discal dash 2 mm. in length; t. p. line arising on costa three-fourths distance from base, strongly outwardly bowed in cells, converging posteriorly toward t. a. line; terminal area broadly blackish brown, interrupted in cell M_3 and along veins; fringe checkered white and blackish brown. Hind wings pale grayish white, heavily and evenly covered with grayish brown scales; without maculation except for faint trace of extradiscal line and nebulous, dark discal spot; fringe checkered white and blackish brown.

Under Surface of Wings: Forewings white, with maculation of upper surface weakly repeated; hind wings white, evenly covered with dark brown scales and having dark brown discal spot.

Length of Forewing: 17.0 to 18.5 mm.

Male Genitalia. Unknown.

Female Genitalia. Ductus bursae short, 0.2 to 0.3 mm. in length, slightly tapering anteriorly, smoothly sclerotized; ductus seminalis arising from end of sac of corpus bursae on right side; corpus bursae membranous, with angled, elongate sac on right side, main portion very long and slender, up to 6 mm. in length; signum absent; apophyses posteriores 2.3 to 2.4 mm. in length.

Early Stages. Unknown.

Food Plant. Unknown.

Type. Holotype, female, CAS 5206. The genitalia of the type are on slide FHR 17395.

Type Locality. Fly's Peak (given as Fly Peak in the original description), Chiricahua Mountains, Cochise County, Arizona, elevation 9000-9300 feet.

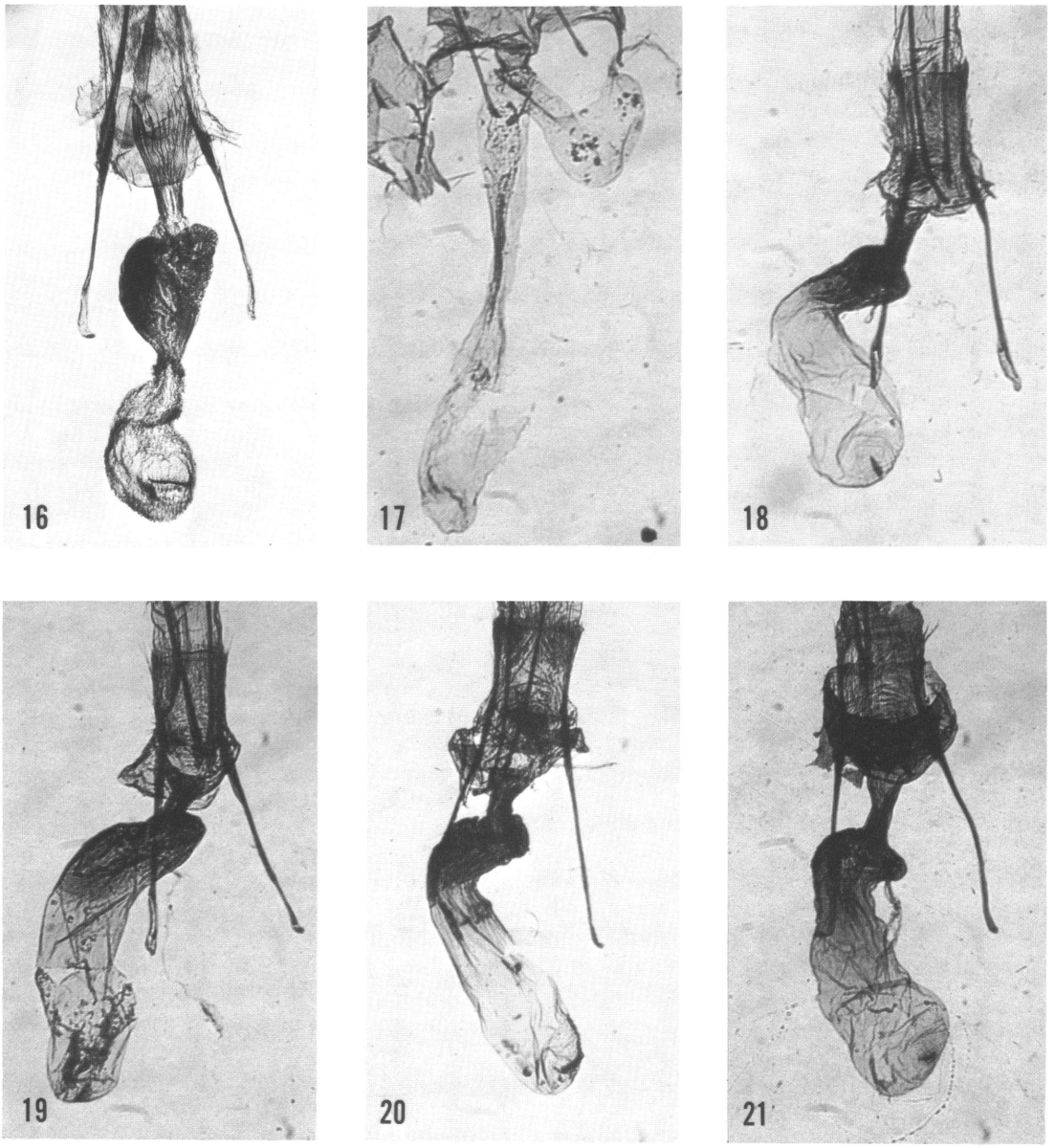
Distribution. This species is known only from the type locality (see fig. 12).

Flight Period. Mid-June to late July.

Remarks. Three specimens and two genitalic dissections have been studied, including the holotype and one paratype. The three females that made up the type series were caught July 30, 1927. The only other specimen known to me was taken in Fly's Peak Canyon, June 17, 1974 (R. F. Sternitzky); it is from my collection, and is in the American Museum of Natural History.

The generic placement of *multidentata* will not be definite until males can be studied. The females differ rather markedly from *betularia* in venation, pattern, and genitalia. The hairlike scales between the facets of the eyes are much more inconspicuous in the present species than in our other species of *Biston* and *Cochisea*.

FIGS. 13-15. Male genitalia. 13. *Biston betularia cognataria* (Guenée), 4 miles W of Oregon City, Oregon, June 26, 1973 (S. G. Jewett, Jr.; AMNH). 14. *Cochisea rigidaria* Barnes and McDunnough, Southwestern Research Station of the American Museum of Natural History, Arizona, November 3, 1960 (C. and M. Cazier; AMNH). 15. *C. paula*, new species, holotype, Bathtub Spring, California, October 7-8, 1972 (J. P. and K. E. Donahue; LAM).



FIGS. 16-21. Female genitalia. 16. *Biston betularia cognataria* (Guenée), Groton, Massachusetts, June 24 (AMNH). 17. *B. multidentata* (Guedet), holotype, Fly's Peak, Arizona, July 30, 1927 (J. A. Kusche; CAS). 18. *Cochisea rigidaria* Barnes and McDunnough, Southwestern Research Station of the American Museum of Natural History, Arizona, October 12, 1960 (C. and M. Cazier; AMNH). 19. *C. barnesi* Cassino and Swett, High Rolls, New Mexico, August (USNM). 20. *C. paula*, new species, paratype, Keystone Canyon, California, emerged October 4, 1947 (C. I. Smith; AMNH). 21. *C. sonomensis* McDunnough, Anderson Springs, California, October 24, 1947 (W. R. Bauer; AMNH).

GENUS *COCHISEA* BARNES AND McDUNNOUGH

Cochisea Barnes and McDunnough, 1916, p. 29; 1917, p. 119. McDunnough, 1938, p. 166.

Diagnosis. Specimens of this genus may be distinguished from the Nearctic species of *Biston* by the absence of the tongue, by the presence of a strong terminal spine on the fore tibia, and by the single pair of spurs on the hind tibia. The male antennae are pectinate to the end of the structure.

Adult. Similar to the Nearctic species of *Biston*, differing mainly as follows: tongue absent; antennae of 44 to 61 segments, pectinations extending to end, longest ones 1.0 to 1.3 mm. in length; fore tibia with strong terminal spine, and with process arising basad of middle of segment in both sexes; hind tibia with one pair of spurs; dorsal surface of abdomen with flattened scales rounded or truncate apically; upper surface of wings less heavily irrorate with dark scales.

Male Genitalia. Similar to those of the Nearctic species of *Biston*, differing mainly as follows: gnathos with median enlargement more finely denticulate; anellus with posterior portion more slender, tending to be slightly longer, apically with small ventral ridge, anellus 1.5 to 2.6 mm. in length; aedeagus varying from equal to, to longer than, combined lengths of uncus, tegumen, and saccus; vesica with single elongate band of short setae, when exserted extending at approximate right angle to aedeagus in form of simple tube.

Female Genitalia. Similar to those of the Nearctic species of *Biston*, differing mainly as follows: corpus bursae with a symmetrical posterior end, either projecting on right side as swollen sac and extending on left side at angle, then curving anteriorly, or with small, curved, tubelike process posteriorly, posterior end finely denticulate and ridged, anterior end not noticeably swollen; signum much smaller, 0.2 to 0.4 mm. long, in form of transverse ridge.

Early Stages. Described for *sinuaria* and *recisa* (as *sonomensis*); see below.

Food Plants. Various shrubs and trees, including members of the Fagaceae, Rosaceae, Anacardiaceae, Ericaeae (*sinuaria*), Pinaceae, and the Cupressaceae (*sonomensis* and *recisa*).

Type Species. Cochisea rigidaria Barnes and McDunnough, 1916; by original designation.

Distribution. Southwestern United States and California.

Remarks. Nine species are included in this genus, with five being described as new in the present paper.

This genus is most closely related to *Biston*, having in common such characters as eyes with hairlike scales between the facets, and females that have fully developed wings that can be used for flying.

The ancestral form of *Cochisea* probably became isolated in the arid southwestern United States, and the group evolved there. Two characters that developed were the thick terminal spine on the fore tibia, and the fall and early winter flight period; both are presumably correlated with the rainfall in the arid area. This genus probably evolved from a *Biston*-like ancestor that normally flew in midsummer. Three species of *Cochisea* are found in Arizona and New Mexico today; *barnesi* and *undulata* fly in July and August, with *rigidaria* being on the wing from late August into October. One species (*paula*) is geographically isolated in the desert mountains of eastern San Bernardino County, California; it probably has about the same flight period as *rigidaria*. Three species (*unicoloris*, *recisa*, and *curva*) are found in the mountains of southern California; all three fly in the San Jacinto Mountains of Riverside County, with one (*unicoloris*) being endemic there. *Cochisea unicoloris* flies in early and mid-September; the other two are on the wing in late September and October. Both *recisa* and *curva* have been confused with *sonomensis*; the latter species occurs only in central and northern California, and it is on the wing in September and October. The most distinct species (*sinuaria*) extends from Arizona into central California; it has been caught from late August into December. In my opinion, the occurrence of *sonomensis* and *sinuaria* in central California represents a relatively recent northward extension of the range in this genus.

Within the genus, the species tend to be quite homogenous in color, pattern, and genitalia, with one exception. The exception is *sinuaria*; it is larger than the other species, both as the adult

and in the genitalia, has a distinctive pattern and color, and is the most highly evolved species. Difficulties may be encountered identifying the other species; this can be accomplished, in some cases, only by a careful study of the genitalia. Some species are known to occur in two basic color forms, a contrasting and a unicolorous one. This is most clearly defined in *sonomensis*; it occurs, to a lesser extent, in *recisa*. The contrastingly colored form is usually the commoner of the two; however, in southern California, one species (*unicoloris*) is known only from the unicolorous phase.

KEY TO SPECIES

Based on Color, Maculation, and Distribution

1. Forewings above with t. p. line tending to be straight, paralleling outer margin below vein M_2 2
   Forewings above with t. p. line angulate. . . . 3
2. Forewings with t. a. and t. p. lines parallel, usually without median line; females with forewings tending to be a uniform dark gray, deeper in color than males . . *rigidaria*
   Forewings with t. a. line angled toward t. p. line in middle of wing, and having median line; females with forewings as in males . . . . . *barnesi*
3. Forewings with t. p. line broadly concave on anal vein . . . . . *sinuaria*
   Forewings with t. p. line straight crossing anal vein 4
4. Upper surface of all wings an even gray; southern California . . . . . *unicoloris*
   Upper surface of forewings gray or brown, with paler median area; hind wings paler than forewings; California and Arizona . . 5
5. Forewings with t. p. line weakly angulate in lower half of wing; eastern San Bernardino County, California. . . . . *paula*
   Forewings with t. p. line strongly angulate; California and Arizona 6
6. Discal spot of forewing tending to be large, round; Arizona . . . . . *undulata*
   Discal spot of forewing tending to be small, obsolescent or absent; California 7
7. Central and northern California . . *sonomensis*
   Southern California . . . . . *recisa*, *curva*

Based on Male Genitalia

1. Anellus 2.6 mm. long and very slender, 0.3 mm. wide near base; aedeagus longer than combined lengths of uncus, tegumen, and saccus, being 3.4 to 3.5 mm. in length. . . . . *sinuaria*
   Anellus 1.5 to 1.8 mm. long, wider, being 0.4 to 0.5 mm. across near base; aedeagus subequal to combined lengths of uncus, tegumen, and saccus, being 2.2 to 2.4 mm. in length 2
2. Anellus with apex curved ventrally 4
   Anellus with apex flat, not curved 3
3. Anellus with apex not having median ridge. . . . . *sonomensis*
   Anellus with apex having median ridge . . . . . *recisa*
4. Anellus 1.5 to 1.6 mm. in length, and with apical median ridge 0.1 to 0.2 mm. in length 5
   Anellus 1.6 to 1.8 mm. in length, and with apical median ridge 0.2 to 0.3 mm. in length 6
5. Uncus with base 0.5 to 0.7 mm. wide . . . . . *paula*
   Uncus with base 0.8 to 0.9 mm. wide . . . . . *rigidaria*
6. Uncus with base 0.6 to 0.7 mm. wide . . . . . *undulata*
   Uncus with base 0.7 to 0.8 mm. wide 7
7. Anellus with apex very slender and curled ventrally. . . . . *curva*
   Anellus with apex broad and weakly curved ventrally 8
8. Uncus with sides biconcave . . . . . *barnesi*
   Uncus with sides straight. . . . . *unicoloris*

Based on Female Genitalia[1]

1. Apophyses posteriores 6.9 mm. in length or longer . . . . . *sinuaria*
   Apophyses posteriores 6.5 mm. in length or shorter 2
2. Apophyses posteriores 5.0 mm. in length or shorter 3
   Apophyses posteriores 5.5 to 6.5 mm. in length 4
3. Ductus bursae with posterior end symmetrical, evenly increasing in width; corpus bursae with posterior end finely to coarsely corneous . . . . . *rigidaria*
   Ductus bursae with posterior end asymmetrical, with left side sharply broadened; corpus bursae with posterior end scarcely modified . . . . . *barnesi*
4. Ductus bursae 1.0 to 1.1 mm. in length . . . . .

[1]The females of *undulata* and *unicoloris* are unknown.

. . . . . *sonomensis*

Ductus bursae 0.6 to 0.7 mm. in length 5

5. Apophyses posteriores 5.5 to 5.7 mm. in length; posterior end of corpus bursae weakly and flatly corneous 6

Apophyses posteriores 5.7 to 6.5 mm. in length; posterior end of corpus bursae with numerous slender, high corneous ridges . . . . . *recisa*

6. Corpus bursae broadly enlarged posteriorly on left side, with structure strongly angled . . . . . *curva*

Corpus bursae only moderately swollen on left side, with structure curved. . . . . *paula*

Cochisea rigidaria Barnes and McDunnough
Figures 14, 18, 22, 23, 76

Cochisea rigidaria Barnes and McDunnough, 1916, p. 29, pl. 2, figs. 2 (lectotype male), 3 ("type ♀"); 1917, p. 119. McDunnough, 1938, p. 166.

Diagnosis. This species has unicolorous gray forewings that have straight, parallel t. a. and t. p. lines, and lack a median shade line.

Male. Head with vertex having mixed white and dark brown scales, antennal bases and area between them white; front with upper median portion white, laterally and ventrally brown to brownish black; palpi grayish brown. Thorax above grayish brown, posteriorly blackish brown with narrow white median scale patch, collar grayish white with narrow black terminal border, patagia with faint, dark transverse band distally; below brownish black or grayish black anteriorly, becoming gray posteriorly; legs pale gray on inner surface, gray to grayish brown on outer surface, with variable amount of darker scaling. Abdomen above pale gray, with scattered brown and grayish black scales, and with posterior margin of each segment narrowly black; below gray.

Upper Surface of Wings: Forewings pale gray to gray, with variable number of evenly scattered dark gray, brown, and brownish black scales; cross lines dull black, prominent; t. a. line present as small spot on costa about three-tenths distance from base, extending straight or weakly curved from cubital vein to near base of wing, paralleling costa, and having faint, broad, pale grayish brown shade band basally; discal dot and median line absent in most specimens; t. p. line arising about 2 mm. basad of apex of wing, inwardly curved into cell R_5, absent or reduced to vein M_2, then extending straight or with slight basal curve posteriorly to meet inner margin about three-fifths distance from base; s. t. line pale gray, shaded basally by darker scales, present as basal shading at and below costa, obsolescent, then paralleling t. p. line; terminal line grayish black, slender, sometimes partially obsolescent; fringe concolorous with wing. Hind wings whitish gray, with scattered dark grayish brown and blackish brown scales, tending to become more numerous distally; intradiscal line absent; discal dot obsolescent; median line very weakly represented posteriad of discal dot; extradiscal line more or less complete, sometimes obsolescent or absent anteriorly, paralleling outer margin; s. t. line represented by dark basal shading in lower portion of wing; terminal line blackish brown; fringe concolorous with wing.

Under Surface of Wings: Forewings pale gray with variable number of scattered dark grayish brown scales, and with cross lines of upper surface weakly indicated; hind wings whitish gray, with some scattered dark grayish brown scales, with small discal dot and extradiscal line partially represented; terminal line present on all wings, darker and more prominent than on upper surface.

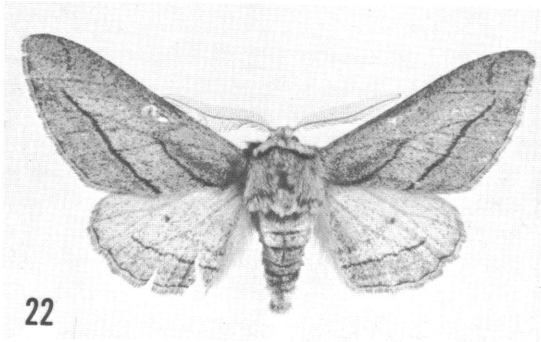
Length of Forewing: 17 to 20 mm.

Female. Upper and under surfaces of all wings darker gray than male, with cross lines of forewings above tending to be thinner.

Length of Forewing: 19 to 21 mm.

Male Genitalia. Uncus with lateral margins weakly convex medially, apex with widely separated points; gnathos with median enlargement tapering to broadly rounded apex; valves with end of each costa well defined, and with narrow band of setae extending from apex to basad of middle of valve; anellus 0.5 mm. wide near base, anteriorly rounded and having median incision, tapering posteriorly, 1.5 mm. long, apex curved ventrally and having short, median longitudinal ridge; aedeagus 2.2 mm. in length; vesica extending at right angle to aedeagus when exserted, and having elongate, narrow band of thickly set short setae 0.7 mm. in length.

Female Genitalia. Ductus bursae about twice as long as wide, 0.70 to 0.75 mm. in length,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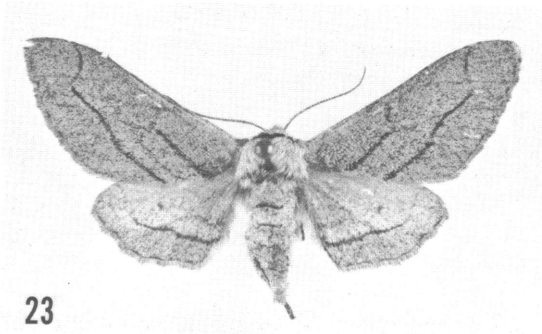
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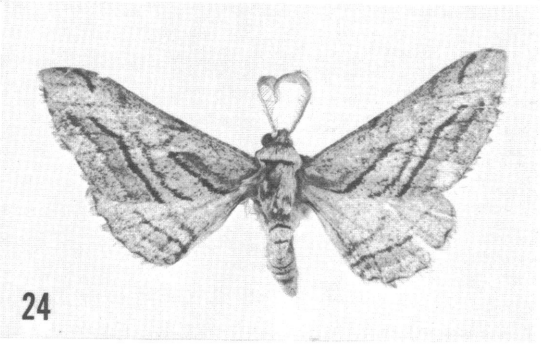
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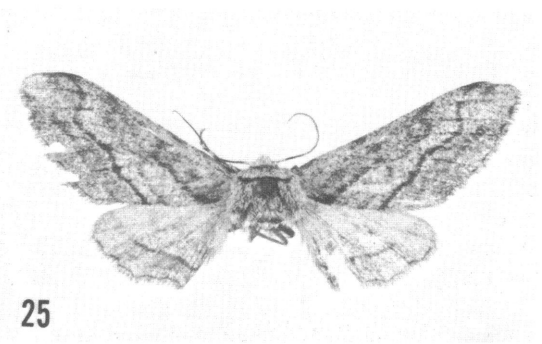
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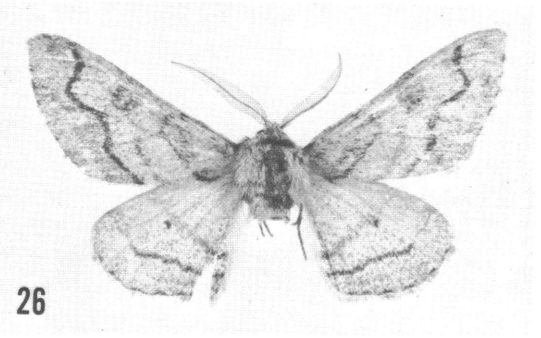
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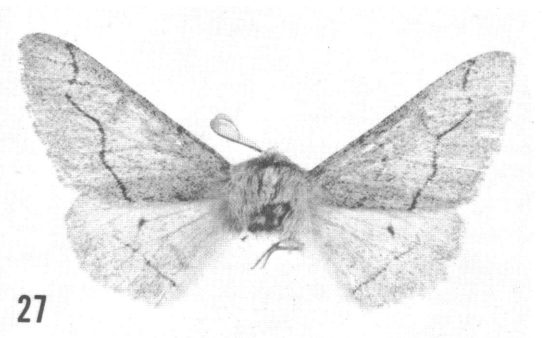
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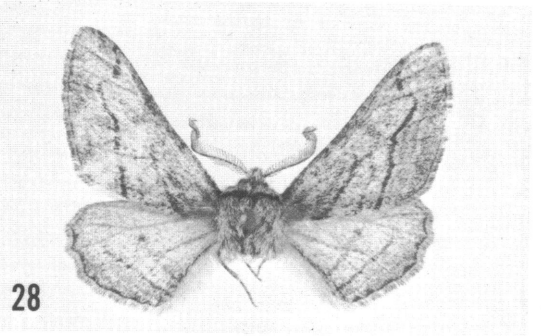
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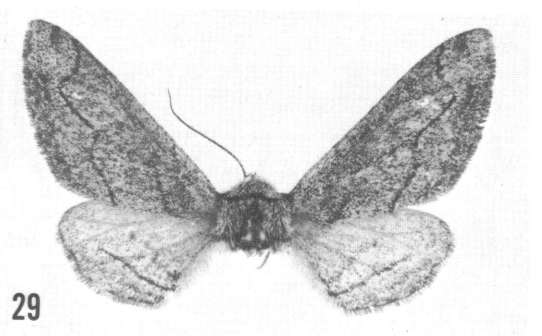
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weakly swollen posteriorly, with sclerotized longitudinal striations; ductus seminalis arising ventrally posteriad of end of ductus bursae; corpus bursae curved or L-shaped, posterior end with numerous, small, corneous swellings, extending to right of junction of ductus bursae for short distance, anterior portion longer and larger than posterior end, membranous; signum at anterior end of corpus bursae; apophyses posteriores 4.8 to 5.2 mm. in length.

Early Stages. Unknown.

Food Plant. Unknown.

Types. Barnes and McDunnough described *rigidaria* from a series of 12 male and eight female syntypes. I hereby designate, and have labeled, as the lectotype their specimen bearing the "type ♂" label; it is in the collection of the National Museum of Natural History with its genitalia on slide HWC 269.

Type Locality. Paradise, Cochise County, Arizona.

Distribution. Arizona, New Mexico, and Utah (see fig. 76). In Arizona *rigidaria* is known from the Chiricahua Mountains, Cochise County, and in the mountains south and west of the Mogollon Rim in Gila and Yavapai counties; one specimen has been examined from Mohave County but without further details. In New Mexico the single known specimen is from the Pinos Altos Mountains in Grant County. There is also one moth known to me from Utah; it is from the Ibanpah Mountains in Juab County.

Flight Period. From late August into November.

Remarks. One hundred twenty-eight specimens (108 males, 20 females) and eight genitalic dissections (six males, two females) have been studied, including the lectotype and its genitalia.

There is some variation in color for the upper surface of the forewings in the males. The hue ranges from a unicolorous gray, varying from pale to medium, to having the median area more or less paler than the basal and outer areas. Within Arizona, specimens from the Chiricahua Mountains average slightly darker than those from Gila County; those from Yavapai County are slightly grayer.

There is also variation in the cross lines on the forewings. Most specimens are without the median line; the population in the Chiricahua Mountains (20 males examined) are in this category. Others may or may not have the median line; in 43 males from Yavapai County only four have it weakly represented, whereas in 27 males from Gila County 16 lack the line and nine have it variably represented. Nearly all males examined have the t. a. and t. p. lines 2.5 to 3.0 mm. apart; one specimen has only about 1.0 mm. between them.

Cochisea barnesi Cassino and Swett
Figures 19, 24, 25, 76

Cochisea barnesi Cassino and Swett, 1922b, p. 176. McDunnough, 1938, p. 166.

Diagnosis. This species can be distinguished from *rigidaria* by its more contrastingly colored forewings, by the tendency of the t. a. line to be more completely represented and to be angled toward the t. p. line in the middle of the wing, and by the presence of a median line.

Male. Head, thorax, and abdomen similar to those of *rigidaria*, with thorax and abdomen above tending to be slightly paler.

Upper Surface of Wings: Forewings with median area whitish gray, remainder of wing pale gray, entire wing more or less heavily and evenly covered with grayish brown and blackish brown scales; cross lines black, prominent; t. a. line arising on costa one-third distance from base, outwardly angled below veins Sc and above Cu, increasing in width and angled away from t. p. line distally, meeting inner margin near base; dis-

FIGS. 22-29. Adults of *Cochisea.* 22, 23. *C. rigidaria* Barnes and McDunnough. 22. Male, 5 miles N of Prescott, Arizona, October 4, 1973 (L. M. Martin; AMNH). 23. Female, same data, October 4, 1973 (AMNH). 24, 25. *C. barnesi* Cassino and Swett. 24. Male, High Rolls, New Mexico, September (AMNH). 25. Female, same data, August (USNM). 26. *C. undulata*, new species, holotype male, Prescott, Arizona, July, 1947 (D. L. Bauer; LAM). 27. *C. unicoloris*, new species, holotype male, Idyllwild, California, September 17, 1960 (R. H. Leuschner; AMNH). 28, 29. *C. paula*, new species. 28. Holotype male, Bathtub Spring, California, October 7-8, 1972 (J. P. and K. E. Donahue; LAM). 29. Allotype female, same data (LAM). All × 1.5.

cal dot absent; median line tending to be complete, fainter than other cross lines; t. p. line arising about 2.5 mm. basad of apex of wing, inwardly curved to vein R_5, with dot on vein M_1, then complete, slightly sinuous with basal bend on base of vein Cu_2, meeting inner margin about two-thirds distance from base; s. t. line as in *rigidaria* but more broadly shaded basally; terminal line brownish black, more or less interrupted by veins; fringe concolorous with wing. Hind wings with outer margin more scalloped than in *rigidaria*; slightly paler than forewing, with scattered grayish brown and blackish brown scales, tending to become more numerous distally, but not so concentrated as in *rigidaria*; intradiscal line absent; discal dot obsolescent; median line present; extradiscal line more or less complete, tending to be obsolescent anteriorly, posteriorly slightly curving toward anal angle; s. t. line rather weakly represented by dark basal shading in lower portion of wing; terminal line blackish brown.

Under Surface of Wings: Similar to that of *rigidaria*, some specimens with faint discal dash on forewings.

Length of Forewing: 17 to 18 mm.

Female. Similar to male.

Length of Forewing: 20 mm.

Male Genitalia. Similar to those of *rigidaria*, differing mainly as follows: uncus with deeper constriction near base, with apical portion wider; gnathos with median enlargement having parallel sides, then apically rounded; valves with each base slightly wider; anellus with anterior end having median slit, entire structure longer, 1.8 mm. in length, and having longer apical ridge; aedeagus 2.4 mm. long.

Female Genitalia. Similar to those of *rigidaria*, differing mainly as follows: ductus bursae with parallel sides anteriorly, posterior end abruptly swollen to twice width of anterior portion, extending more to left side than to right; corpus bursae curved, posterior end with fewer and less prominent corneous swellings; apophyses posteriores longer, 5.3 mm. in length.

Early Stages. Unknown.

Food Plant. Unknown.

Types. Holotype, male, MCZ 16858. The allotype female has not been located.

Type Locality. High Rolls, Otero County, New Mexico.

Distribution. This species is known only from the mountains of Otero County, New Mexico, and from western Juab County, Utah (see fig. 76).

Flight Period. July and August.

Remarks. Forty-five specimens (44 males, one female) and three genitalic dissections (two males, one female) have been studied, including the holotype.

This species is quite similar in color, maculation, and genitalia to *rigidaria*. At present, with a single exception, it is known only from the specimens of the type series and others caught about the same time. Additional, and fresher, examples are needed to ascertain the variability of *barnesi*.

Cochisea undulata, new species
Figures 26, 100

Diagnosis. This Arizona species can be distinguished from the preceding ones by the more sinuate t. p. line and by the larger discal spot of the forewings.

Male. Head similar to that of *rigidaria* but with grayer scaling and narrower front. Thorax similar to that of *rigidaria*, but more unicolorous grayish white above, collar and thorax concolorous, with reduced blackish brown bands, and slightly darker below; process of fore tibia longer, 2.1 mm. in length (1.6 to 1.8 mm. in *rigidaria*). Abdomen similar to that of *rigidaria*.

Upper Surface of Wings: Similar to those of *rigidaria*, differing mainly as follows: t. a. line less obliquely angled, and with basal curve along inner margin; median area wider, about 4.0 mm. in width; large, round discal spot present, continued posteriorly as diffuse median line; t. p. line more sinuate, with strong outcurve opposite discal spot and with outward angle on vein Cu_2. Hind wings with small, distinct discal spot slightly distad of median line; extradiscal line more irregular in course, and with angle opposite discal spot.

Under Surface of Wings: Similar to that of *rigidaria*, with pattern of upper surface repeated.

Length of Forewing: 18 to 19 (holotype) mm.

Female. Unknown.

Male Genitalia. Similar to those of *rigidaria*, differing mainly as follows: uncus with broader, blunter apex, apical points varying from scarcely raised to prominent, 0.15 mm. apart; gnathos

with median enlargement more rectangular; anellus with more slender, curved apex having longer (0.2 mm.) median ridge.

Female Genitalia. Unknown.

Early Stages. Unknown.

Food Plant. Unknown.

Types. Holotype, male, and paratype, male, Prescott, Yavapai County, Arizona, July, 1947 (D. L. Bauer). The genitalia of the holotype are mounted on slide FHR 17438.

The holotype is in the collection of the Natural History Museum of Los Angeles County; the paratype in that of the American Museum of Natural History.

Distribution. This species is known only from the type locality (see fig. 100).

Flight Period. July.

Remarks. Two specimens (both males) and two genitalic dissections have been studied.

Etymology. The specific name is from the Latin *undulatus*, wavy, in reference to the course of the t. p. line.

Cochisea paula, new species
Figures 15, 20, 28, 29, 110

Diagnosis. This species can be recognized by the moderately angled t. p. line of the forewings, being straighter than that of *undulata* but more curved than in *rigidaria*, and by the genitalia (see keys).

Male. Head, thorax, and abdomen similar to those of *undulata*, differing mainly as follows: head with more white scaling on antennal bases and ventrad thereto; front tending to have longer scaling; thorax above with more prominent black terminal border.

Upper Surface of Wings: Similar to that of *undulata*, differing mainly as follows: basal and subterminal areas slightly browner; cross lines closer together, with median area 1.5 to 2.5 mm. wide at narrowest point (4.0 to 4.5 mm. in *undulata*); t. a. line tending to be more angulate anteriorly, and without basal curve on posterior margin of wing; discal spot absent; t. p. line less angulate; s. t. line varying from obsolescent to clearly defined. Hind wings with extradiscal line thinner, absent anteriorly.

Under Surface of Wings: Similar to that of *undulata*, differing mainly as follows: wings paler, with maculation more weakly represented.

Length of Forewing: 13 (reared specimen) to 17 mm.; holotype, 17 mm.

Female. Upper and under surfaces of all wings darker gray than in male, with median area of forewing above not differentiated; t. p. line tending to be slightly more angulate; hind wings with more black scaling.

Length of Forewing: 21 to 22 (allotype) mm.

Male Genitalia. Similar to those of *undulata*, differing mainly as follows: uncus with strongly biconcave lateral margins; gnathos with median enlargment broader, apically truncate; valves more tapering, with each apical region narrower; anellus shorter, 1.5 to 1.6 mm. in length (1.7 to 1.8 mm. in *undulata*).

Female Genitalia. Similar to those of *rigidaria*, differing mainly as follows: ductus bursae shorter, 0.6 mm. in length; corpus bursae with posterior end more coarsely corneous, medially less angulate, curved; signum transverse, larger, 0.3 to 0.4 mm. long; apophyses posteriores longer, 5.5 to 5.7 mm. in length.

Early Stages. Not recorded.

Food Plant. Not recorded. This species has been reared, but the specimens are not labeled as to the host plant.

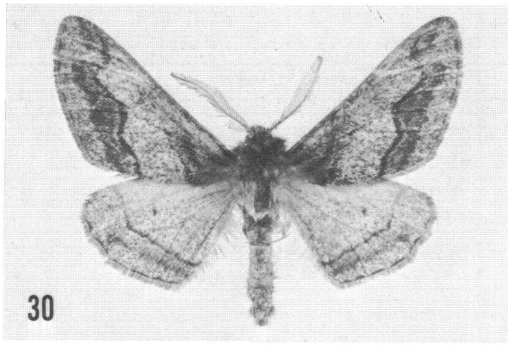
Types. Holotype, male, and allotype, female, Bathtub Spring, elevation 5800 feet, Mid Hills, 7 miles ESE of Cima, San Bernardino County, California, October 7-8, 1972 (J. P. and K. E. Donahue). The genitalia of the holotype are mounted on slide FHR 17542, and of the allotype on 17523. Paratypes: Keystone Canyon, New York Mountains, San Bernardino County, California, emerged October 4, 1947, emerged August 21, 1948, emerged September 1, 1948 (C. I. Smith), two males and one female.

The holotype and allotype are in the collection of the Natural History Museum of Los Angeles County; paratypes are in the collections of the American Museum of Natural History and of the California Insect Survey.

Distribution. The desert mountains of eastern San Bernardino County, California (see fig. 110).

Flight Period. October. Reared specimens have emerged from mid-August into October.

Remarks. Five specimens (three males, two females) and four genitalic dissections (two males, two females) have been studied.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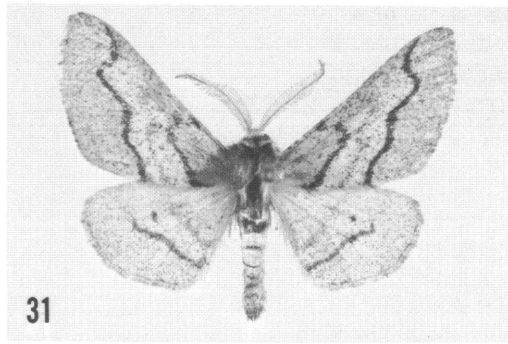
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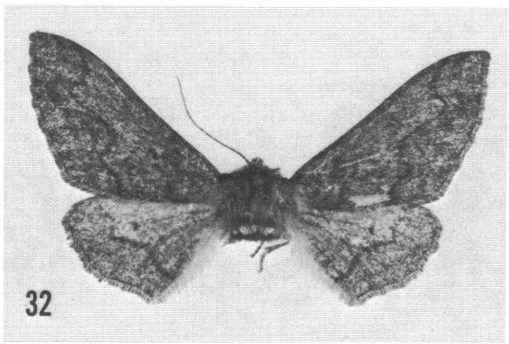
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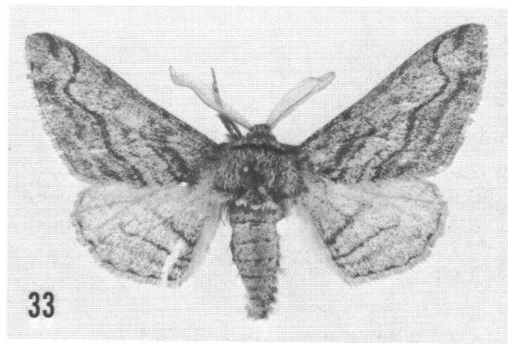
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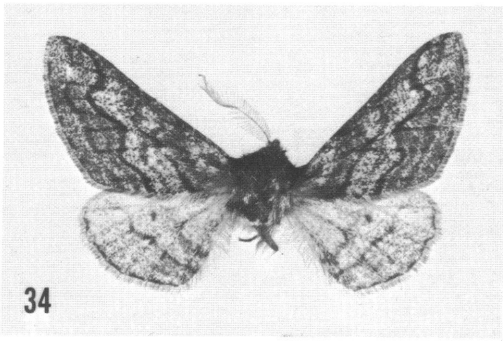
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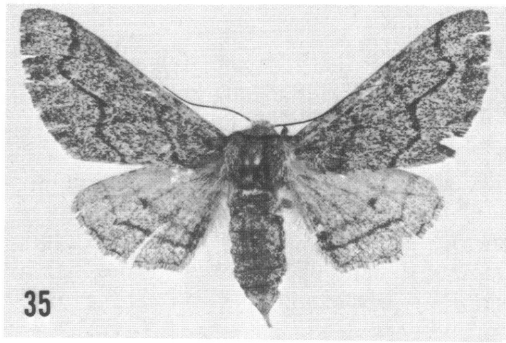
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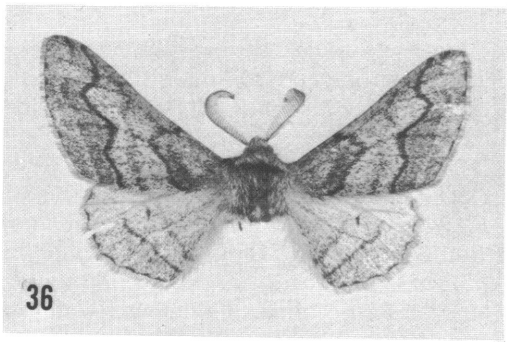
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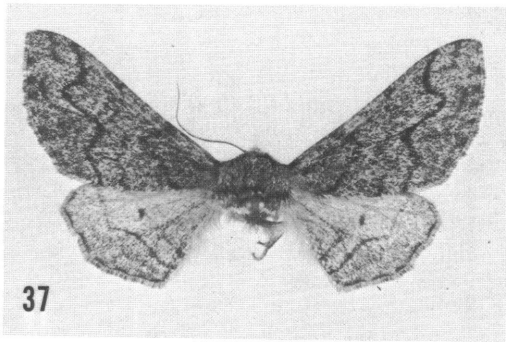
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This is one of the smaller species of the genus, even discounting the two apparently dwarfed males that were reared.

Etymology. The specific name is from the Latin *paulus*, little, in relation to the size of the species.

Cochisea unicoloris, new species
Figures 27, 110

Diagnosis. The upper surface of the wings is a uniform pale gray, paler in color than that of *rigidaria*; the t. p. line is more sinuate in this species than in the one from Arizona.

Male. Head with vertex pale grayish white; front pale grayish white, narrowly grayish brown along lateral margins; palpi dark grayish brown, becoming paler ventrally. Thorax above grayish white, posterior margin narrowly white with small dark grayish brown median scale patch, collar concolorous with thorax but with narrow dark terminal border; below grayish black anteriorly, becoming pale gray posteriorly; legs pale gray, with variable number of brown and brownish black scales. Abdomen above grayish white, with scattered dark brownish gray scales; below gray.

Upper Surface of Wings: Forewings unicolorous pale gray, with variable number of uniformly distributed gray and grayish black scales; t. a. line obsolescent to absent, when present represented on costa by small dark spot one-fourth distance from base, and by small spot on cubital vein, in cubital cell, and at inner margin one-fourth distance from base; discal spot weakly indicated; median line absent; t. p. line black, slender, arising about 4 mm. basad of apex of wing, concave to vein M_1, partially or wholly absent in cell M_1, then S-shaped from vein M_2 to inner margin, meeting the latter two-thirds distance from base; s. t. and terminal lines absent; fringe concolorous with wing. Hind wings slightly paler than forewings, unicolorous, with scattered, evenly distributed grayish black scales; intradiscal line absent; discal dot present, small; median line weakly represented in lower portion of wing; extradiscal line slender, extending from cell M_1 in straight line to anal angle; s. t. and terminal lines absent; fringe concolorous with wing.

Under Surface of Wings: Forewings pale gray, with variable number of scattered grayish black scales, and with large discal spot and t. p. line weakly indicated; hind wings whitish gray, with scattered grayish black scales, and with pattern of upper surface weakly repeated; terminal line absent on all wings.

Length of Forewing: 20 to 22 mm.; holotype, 22 mm.

Female. Unknown.

Male Genitalia. Similar to those of *recisa*, differing mainly as follows: total length of uncus, tegumen, and saccus 2.40 to 2.45 mm.; uncus with straight sides, apical points more rounded, weakly projecting ventrally; gnathos with median enlargement narrower, slightly more tapering; each valve with distal portion of costa slightly wider, with more definite demarkation at end of valve; anellus broader, with larger anteromedian indentation, apical portion with longer median ridge, being 0.20 to 0.25 mm. in length.

Female Genitalia. Unknown.

Early Stages. Unknown.

Food Plant. Unknown.

Types. Holotype, male, Idyllwild, elevation 6000 feet, Riverside County, California, September 17, 1960 (R. H. Leuschner); from the Leuschner collection. The genitalia of the holotype are mounted on slide FHR 17284. Paratypes: same data as holotype, 10 males; Idyllwild, elevation 5300 feet, Riverside County, California, September 8, 9, 10, 1964 (T. C. Emmel), five males.

FIGS. 30-37. Adults of *Cochisea*. 30-32. *C. sonomensis* McDunnough. 30, 31. Males, Spring Mountain, California, October 13, 1939 (E. C. Johnston; AMNH). 32. Female, Anderson Springs, California, October 4, 1947 (W. R. Bauer; AMNH). 33-35. *C. recisa*, new species. 33. Holotype male, S of Gorman, California, October 22, 1946 (C. Henne; LAM). 34. Paratype male, Westgard Pass, California, September 17, 1938 (G. Willett; LAM). 35. Paratype female, 2-1/2 miles SSW of Valyermo, California, October 5, 1964 (N. McFarland; AMNH). 36, 37. *C. curva*, new species. 36. Holotype male, Pinyon Crest, California, October 19, 1968 (R. H. Leuschner; AMNH). 37. Allotype female, same data (AMNH). All ×1.6.

The holotype is in the collection of the American Museum of Natural History; paratypes are in the collections of that institution, of the Natural History Museum of Los Angeles County, and of R. H. Leuschner.

Distribution. This species is known only from the type locality in the San Jacinto Mountains of southern California (see fig. 110).

Flight Period. September.

Remarks. Sixteen specimens (all males) and two genitalic dissections have been studied.

This species is known only in the unicolorous form; no specimens with contrasting maculation have been found. It is tempting to place this as a unicolorous color form of either *recisa* or *curva*, both of which occur in the San Jacinto Mountains. The present species flies a month earlier than either of the other two species; it is slightly larger; and consistent differences are to be found in the male genitalia. Therefore I am giving it specific rank.

Etymology. The specific name is from the Latin *unus*, one, and *coloris*, color, in reference to the hue of the upper surface of the wings.

Cochisea sonomensis McDunnough
Figures 21, 30-32, 100

Cochisea sonomensis McDunnough, 1941, p. 75.
Cochisea sonomensis form *abrunnea* McDunnough, 1941, p. 75.

Diagnosis. This species can be recognized by the prominent, angulate t. p. line on the upper surface of the forewings; it occurs in central and northern California.

Male. Head with vertex varying from pale gray to dark grayish brown, antennae with each basal segment and surrounding area white or whitish gray; front varying from gray to grayish brown dorsally and medially, becoming blackish brown laterally and ventrally; palpi pale brown to dark brown, becoming blackish brown dorsally and distally. Thorax above pale to dark grayish brown, posteriorly narrowly white or grayish white with small brownish black median patch, collar paler gray than thorax and having narrow, brownish black terminal border, patagia with faint, dark transverse band distally; below grayish black or brownish black anteriorly, becoming gray or pale brownish gray posteriorly; legs gray with variable amount of brown scaling. Abdomen above gray or brownish gray, with scattered brownish black scales, posterior margin of each segment narrowly black; below gray.

Upper Surface of Wings: Forewings pale gray to gray, with variable number of dark gray, grayish brown and blackish brown scales, median area usually paler than basal and distal areas, last two varying from an even gray to partially or entirely blackish brown; cross lines black, prominent in most specimens; t. a. line varying from complete to partly or almost entirely obsolescent, when present arising on costa one-fourth distance from base, outwardly sharply biangulate in cell, becoming thicker at or just above cubital vein, then weakly sinuous to inner margin about one-fourth distance from base, and often with broad, brown or grayish brown basal shade band; discal dot either weakly represented, large and rounded, or absent; median line obsolescent or absent; t. p. line arising on costa about 3 mm. from apex of wing, basally concave, with prominent outward bend on or near vein M_2, concave again, with outward bend in cell Cu_2, then weakly concave to meet inner margin two-thirds distance from base; subterminal area gray to blackish brown; s. t. line obsolescent or absent, often indicated by change in color from subterminal to usually paler terminal area; terminal line absent to weakly represented; fringe concolorous with wing. Hind wings similar in color to forewings but paler; intradiscal line absent; discal dot small; median line absent or weakly represented posteriad of discal dot; extradiscal line either complete or obsolescent anteriorly, with prominent outward angle in middle of cell M_{1+2}; s. t. line absent or indicated by dark basal shade band in lower portion of wing; terminal line usually present, narrow, dark; fringe concolorous with wing.

Under Surface of Wings: All wings pale gray, with variable number of gray and grayish brown scales; pattern of upper surface repeated, but fainter; discal spot of forewing tending to be more strongly represented.

Length of Forewing: 17 to 21 mm.

Female. Similar to male but darker gray; upper surface of forewings unicolorous dark gray to dark brownish gray, of hind wings paler gray; under surface darker than that of male.

Length of Forewing: 19 to 21 mm.

Male Genitalia. Similar to those of *rigidaria*, differing mainly as follows: total length of uncus, tegumen, and saccus 2.2 to 2.4 mm.; uncus with sides tending to be flatter; gnathos with broader median enlargement; anellus 0.45 to 0.50 mm. wide anteriorly, with small median incision, entire structure 1.6 to 1.7 mm. in length, apex not curved ventrally and without small ridge; aedeagus 2.2 to 2.3 mm. in length; vesica with shorter band of setae, 0.7 to 0.9 mm. in length.

Female Genitalia. Similar to those of *rigidaria*, differing mainly as follows: ductus bursae longer, 1.0 to 1.1 mm. in length, slightly narrower, longitudinal striations more weakly represented; corpus bursae less angulate, posterior portion slightly larger, tending to be longer and broader on right side of ductus bursae, elongate anterior portion tending to have more longitudinal striations at and anteriad of curve; apophyses posteriores longer, 5.7 to 6.4 mm. in length.

Early Stages. Undescribed. The larvae and pupae published by Comstock, Henne, and Sala ("1957" [1958], p. 169) as *sonomensis* are those of *recisa*, described below.

Food Plants. Pinus sp. (at Hayfork, Trinity County, California); this record is from a female in the California Insect Survey collection. See also under Remarks.

Types. For *sonomensis*, holotype male, CNC 5177; for form "abrunnea," also CNC.

Type Locality. Spring Mountain, Sonoma County, California (*sonomensis* and "abrunnea"). Spring Mountain is also in Napa County, as it is on the county line.

Distribution. Central and northern California, ranging from Santa Clara to Trinity counties (see fig. 100).

Flight Period. September and October.

Remarks. One hundred forty-three specimens (135 males, eight females) and nine genitalic dissections (six males, three females) have been studied.

This species occurs with two major color forms in the male. One has dark shading basad of the t. a. line and distad of the t. p. line; the other ("abrunnea") tends to have these shade bands reduced or absent, with the forewing being more unicolorous as a result. The ratio of these two forms apparently varies geographically. From Lake and Napa counties, I have examined 52 contrastingly colored males and 44 "abrunnea"; from Trinity County, 3 contrasting and 30 "abrunnea." Series of specimens are needed from additional localities for study.

The females also show variability in the color and course of the cross lines on the forewings above. Some specimens are a smooth, even gray; others are darker, with more and coarser black scaling. The t. p. line varies from being evenly curved to angulate.

There is a single female in the California Insect Survey collection that was reared from *Cupressus sargentii* Jepson at Cedar Mountain, Alameda County, California; this is the type locality of that plant. This specimen is dwarfed (length of forewing, 14 mm.), badly rubbed, and apparently without cross lines on the forewings. The genitalia, mounted on slide FHR 17529, are similar to those of *sonomensis* but the corpus bursae is not swollen posteriorly. This structure is straight, slightly enlarging anteriorly and to the right side. The apophyses posteriores of this dwarfed female are 3.4 mm. in length. This specimen is being placed doubtfully as *sonomensis*, pending receipt of more and better material.

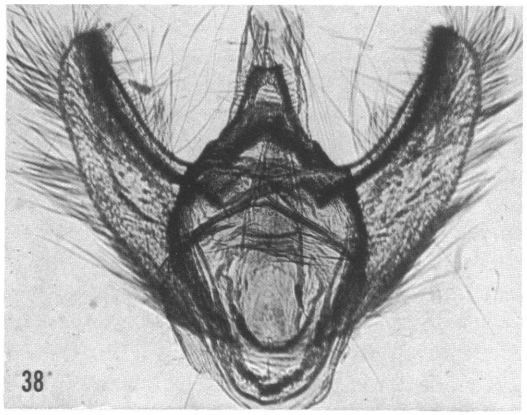
Cochisea recisa, new species
Figures 33-35, 38, 41, 100

Cochisea sonomensis (misidentification): Comstock, Henne, and Sala, "1957" [1958], p. 169, pls. 41 (mature larvae), 42 (pupae).

Diagnosis. This species is very similar to *sonomensis*, differing by the upper surface of the forewings of the males tending to be slightly darker gray, having more black scaling, and by the more angulate t. p. line. There are differences in the genitalia; see keys. The present species occurs in eastern and southern California, and western Nevada.

Male. Head, thorax, and abdomen similar to those of *sonomensis*, differing mainly as follows: front tending to have more pale gray scales, and appearing slightly longer and narrower; thorax and abdomen above with more pale gray scaling.

Upper Surface of Wings: Similar to that of *sonomensis*, differing mainly as follows: forewings slightly paler gray, with black scaling tending to be somewhat more obvious; shade bands basad of t. a. and distad of t. p. lines grayish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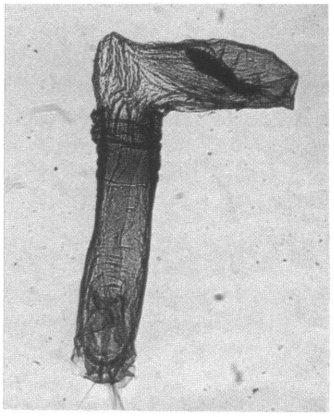

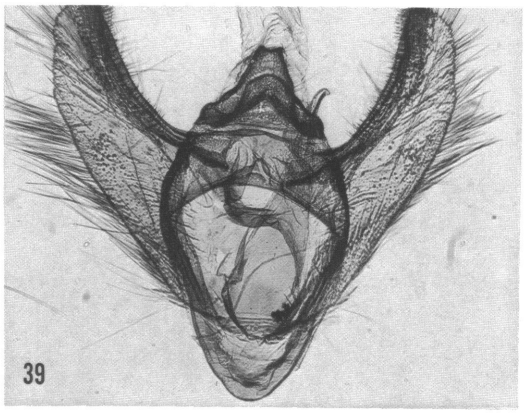
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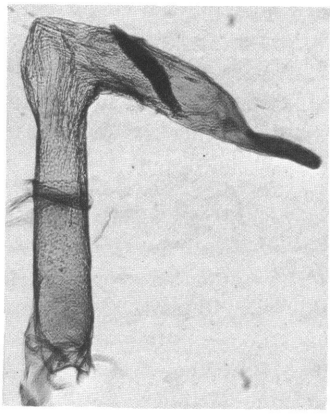

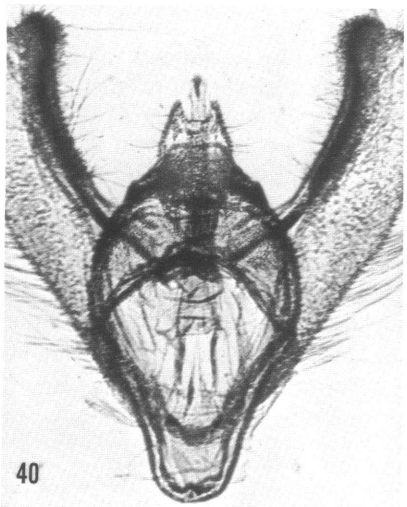
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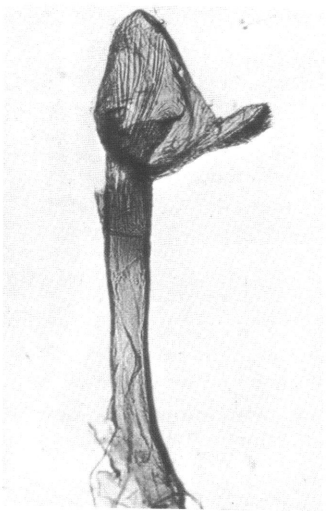


black, with less brown scaling; t. p. line tending to be more angulate; terminal area darker in some specimens, tending to be concolorous with subterminal area and separated by distinct whitish gray s. t. line. Hind wings with fewer brown scales; intradiscal line tending to be more strongly represented; extradiscal line tending to be slightly more angulate.

Under Surface of Wings: Similar to those of *sonomensis*, differing mainly as follows: paler, more whitish, with less dark scaling; veins in outer portion of wings tending to be weakly dark scaled; terminal line more strongly represented.

Length of Forewing: 18 to 21 mm.; holotype, 19 mm.

Female. Similar to those of *sonomensis*, differing mainly as follows: body varying from paler to darker gray; upper surface of all wings tending to have minutely speckled appearance; t. p. line more angulate; hind wings slightly paler. Under surface paler, but darker than male.

Length of Forewing: 19 to 21 mm.; allotype, 20 mm.

Male Genitalia. Similar to those of *sonomensis*, differing mainly as follows: shorter, with total length of uncus, tegumen, and saccus 2.00 to 2.25 mm.; uncus with more evenly tapered sides, apical points tending to be sharper and to curve outwardly; gnathos with median enlargement longer; each valve with apex narrower; anellus with small anteromedian indentation, apex not curved ventrally but with short median ridge; aedeagus 2.3 to 2.4 mm. in length; vesica with shorter band of shorter setae, length of band 0.6 to 0.8 mm.

Female Genitalia. Similar to those of *sonomensis*, differing mainly as follows: ductus bursae shorter, 0.6 to 0.7 mm. in length, tending to have fewer but more sclerotized longitudinal striations; corpus bursae with more rounded posterior end covered by diagonal, slender corneous ridges, median area more gently curved; apophyses posteriores 5.7 to 6.5 mm. in length.

Early Stages. The mature larva and pupa have been described, under the name *Cochisea sonomensis*, by Comstock, Henne, and Sala ("1957" [1958], pp. 169, 175, pls. 41 [mature larvae, lateral and dorsal aspects], 42 [pupae, ventral and dorsal aspects]). The eggs were laid in late October and hatched in from two to four weeks. The larvae were dimorphic in color, one form being predominantly gray with light brown markings, the other, more common, form being green with dull white spotting. The green form was much more common than the gray, and its color is highly protective when resting on the piñon pine needles. The parent female, from which these eggs were obtained, is the allotype of this species.

Food Plant. Pinus monophylla Torrey and Fremont (Comstock, Henne, and Sala, "1957" [1958], pp. 169, 175).

Types. Holotype, male, south of Gorman, Ridge Route, Los Angeles County, California, October 22, 1946 (C. Henne); allotype, female, same data, October 24, 1946. The genitalia of the allotype are mounted on slide FHR 17525. Paratypes: *California*: *Los Angeles County*: same data as types (and reared from eggs of allotype), ex Pinus cembroides, emerged April 17, 1947 (C. Henne), one male; Gorman, Ridge Route, elevation 4000 feet, October 12, 1962 (R. H. Leuschner), one female; Caswells to Gorman, Ridge Route, October 22, 1946 (C. I. Smith), four males, larva on *Pinus monophylla*, emerged March 25, 1948 (C. I. Smith), one male, one female; Frazier Mountain Park, emerged September 18, 1947 (P. Adams), two females; Frazier, elevation 5000 feet, October 20, 1964 (R. H. Leuschner), one male; Angeles Crest Highway, elevation 3000 feet, September 21, 1958, one male; Buckhorn Flats, elevation 6400 feet, Angeles Crest Highway, September 14, 1957 (R. H. Leuschner), two males; 7 miles south of Palmdale, September 26, 1956, October 6, 1956 (D. L. Mays), one male, two females; 2.5 miles SSW of Velyermo, elevation 4800 feet, September 20, 1964, October 2, 5, 6, 15, 19, 1964 (N. McFarland), 11 males, five females. *Kern County*: near Gorman, Ridge Route, elevation 4000 feet, October 19, 24, 1946, three males, emerged March

FIGS. 38-40. Male genitalia of *Cochisea*. 38. *C. recisa*, new species, paratype, Pinyon Crest, California, October 19, 1968 (R. H. Leuschner; AMNH). 39. *C. curva*, new species, holotype, Pinyon Crest, California, October 19, 1968 (R. H. Leuschner; AMNH). 40. *C. sinuaria* Barnes and McDunnough, The Geysers, California, October 11, 1939 (E. C. Johnston; AMNH).

17, 19, 1947, one male, one female; Lebec, September 3, 1944 (F. Sala), one male. *San Bernardino County*: Upper Santa Ana River, September 16, 1946, September 19, 1947 (G. H. and J. L. Sperry), two males. *Riverside County*: Pinyon Crest, elevation 4200 feet, October 20, 1963, November 6, 1965, October 13, 14, 1967, September 28, 1968, October 19, 1968 (R. H. Leuschner), 19 males, three females. *Tulare County*: Smoky Valley, elevation 6300 feet, September 28, 1946 (C. Henne), one male. *Inyo County*: Westgard Pass, September 17, 1938 (G. Willett), one male. *Mono County*: Topaz Lake, September 27, 1954 (M. L. Walton), two males; Tom's Place, elevation 7200 feet, September 3, 1961, September 2, 1967, August 31, 1968 (R. H. Leuschner), three males. *Nevada*: *Esmeralda County*: Mt. Magruder, September 19, 1939 (G. Willett), one female.

The holotype and allotype are in the collection of the Natural History Museum of Los Angeles County; paratypes are in the collections of that institution, of the American Museum of Natural History, of the California Insect Survey, and of R. H. Leuschner.

Distribution. The drier hills and lower mountains of southern and eastern California, and adjacent southwestern Nevada (see fig. 100). This appears to correspond to the Southern Cordilleran Biotic Province (Schick, 1965). The moths have been caught between 3000 and 6400 feet in southern California; at the known northern extremity of their range, in Mono County, they occur at 7200 feet.

Flight Period. Late August, September, October, and early November.

Remarks. Seventy-one specimens (55 males, 16 females) and 12 genitalic dissections (seven males, five females) have been studied.

This species is rather variable in color even though nearly all specimens are the contrastingly colored form, with very few examples of the almost unicolorous form being known. Examples from Mono and Inyo counties, and from the lower elevations of eastern Los Angeles County (Valyermo) tend to be more contrastingly marked than moths from higher elevations in southern California.

Etymology. The specific name is from the Latin *recisus*, shortened, in relation to the ductus bursae.

Cochisea curva, new species
Figures 36, 37, 39, 42, 110

Diagnosis. Superficially this species is almost indistinguishable from *recisa*; determination should be made by using the genitalia. The male structures have the apex of the anellus more slender, curved, and with a longer median ridge; the female corpus bursae is more angulate, and the posterior end is much more coarsely rugose.

Male. Head, thorax, and abdomen similar to those of *recisa.*

Upper Surface of Wings: Similar to that of *recisa*, differing mainly as follows: bands basad of t. a. and distad of t. p. lines tending to be slightly paler and slightly grayer; s. t. line tending to be more sharply defined, straight, grayish white, shaded basally by slender dark brown stripe; terminal area paler than subterminal area. Hind wings tending to be slightly more grayish brown.

Under Surface of Wings: Similar to that of *recisa.*

Length of Forewing: 18 to 20 mm.; holotype, 19 mm.

Female. Similar to those of *recisa*, with s. t. line of forewing above tending to be slightly better defined.

Length of Forewing: 19 to 21 (allotype) mm.

Male Genitalia. Similar to those of *recisa*, differing mainly as follows: longer, with total length of uncus, tegumen, and saccus 2.30 to 2.45 mm.; uncus with apical points curving ventrally; gnathos with median enlargement smaller; anellus tending to be narrower and longer, 1.6 to 1.8 mm. in length, with slender apex curving ventrally and having longer (0.2 to 0.3 mm.) median ridge.

Female Genitalia. Similar to those of *recisa*, differing mainly as follows: corpus bursae more angulate, extending more to left side, with posterior end only very coarsely rugose; signum smaller, tending to be more or less rectangular; apophyses posteriores 5.5 to 6.3 mm. in length.

Early Stages. Unknown.

Food Plant. Unknown.

Types. Holotype, male, and allotype, female, Pinyon Crest, elevation 4200 feet, Riverside County, California, October 19, 1968 (R. H. Leuschner); both specimens from the Leuschner collection. The genitalia of the holotype are mounted on slide FHR 17454, and those of the allotype on 17519. Paratypes: same data as holotype, October 1, 1966, October 13, 14, 1967, two males, one female; Glen Ivy, [Riverside County], California, October 7, 1937 (D. Bulgrin), one male; Singing Springs, Los Angeles County, California, October 4, 1949 (C. Hill), one male.

The holotype and allotype are in the collection of the American Museum of Natural History; paratypes are in the collections of that institution and of R. H. Leuschner.

Distribution. The mountains of southern California, in Riverside and Los Angeles counties (see fig. 110).

Flight Period. Late September and October.

Remarks. Seven specimens (five males, two females) and six genitalic dissections (four males, two females) have been studied.

Some specimens of this species have a more sinuate t. a. line than is found in *recisa*, but this does not hold for all examples. The only certain way to determine this species is by studying the genitalia.

Etymology. The specific name is from the Latin *curvus*, curved, in relation to the shape of both the apex of the anellus and the corpus bursae.

Cochisea sinuaria Barnes and McDunnough
Figures 40, 43, 47, 48, 55

Cochisea sinuaria Barnes and McDunnough, 1916, p. 30, pl. 2, fig. 1 (holotype male); 1917, p. 119. Comstock, Henne, and Sala, "1957" [1958], p. 169, pls. 38 (egg), 39 (larva), 40A (larval head), B (larva), C-E (pupa). McDunnough, 1938, p. 166.

Diagnosis. This is the largest species in the genus. The upper surface of the wings is the palest in color, and the t. p. line the most sinuous, of any species.

Male. Head with vertex having mixture of white and brownish black scales, antennal bases white; front white dorsally, becoming brownish black laterally and ventrally; palpi brownish black. Thorax above white, with some grayish brown scales, posteriorly with mixed white and grayish brown scales, with blackish brown median scales patch, collar with black or brownish black terminal border, patagia with dark grayish brown diagonal band; below grayish brown anteriorly, becoming grayish white posteriorly; legs grayish white, with variable amount of brown and grayish brown scaling. Abdomen above with mixture of white, gray, and grayish brown scales, posterior margins of segments narrowly black and grayish black; below with mixture of pale gray and grayish brown scales.

Upper Surface of Wings: Forewings pale grayish white, with variable number of scattered grayish brown and blackish brown scales, basal and median areas tending to be paler than distal portion of wing; cross lines dull black; t. a. line obsolescent or weakly represented anteriorly, arising on costa as small spot about one-fourth distance from base, broadly outcurved in cell, with sharp basal tooth on cubital vein, outwardly curved in cubital cell, then sharply angled basad, meeting inner margin one-fifth distance from base, and tending to have broad basal gray shade band in lower part of wing; discal spot elongate, gray, usually weakly represented; median line obsolescent, appearing on costa and above inner margin in some specimens; t. p. line prominent, arising 4.5 to 5.0 mm. basad of apex of wing, angled or curved inwardly to cell R_5, reduced or obsolescent while swinging outward to vein M_2, then prominent, with somewhat irregularly curved basal arc to cell Cu_2, then sharply concave over anal vein to meet inner margin three-fourths distance from base; s. t. line pale gray, shaded basally by broad grayish brown area extending to t. p. line, absent or reduced in part or all of cells R_5 and M_1; terminal line brownish black, broadly interrupted by veins; fringe concolorous with wing. Hind wings slightly paler than forewings, with distal area tending to be darkened; intradiscal line absent; discal spot present, usually prominent; median line absent or represented on anal margin; extradiscal line prominent, weakly represented anteriorly, with outward angle in middle of cell M_{1+2}, basally

concave between all veins; s. t. line, terminal line, and fringe similar to those of forewings.

Under Surface of Wings: All wings silky white or pale grayish white, with a few scattered grayish brown scales; maculation of upper surface weakly repeated, except for larger, more prominent discal spots, and for absence of s. t. lines.

Length of Forewing: 18 to 25 mm.

Female. Upper and under surfaces of all wings a more or less even gray.

Length of Forewing: 24 to 28 mm.

Male Genitalia. Similar to those of *rigidaria*, differing mainly as follows: more elongate, with tegumen and especially saccus more attenuate; uncus with markedly wider apex, apical points more deeply divided; gnathos with median enlargement tending to have shallow median indention; valves much more elongate, with curving, concave costa; anellus narrower, 0.3 mm. wide at base, without median incision, and very long and slender, 2.5 to 2.6 mm. in length, apex not curved ventrally, with short median ridge; aedeagus longer than combined lengths of uncus, tegumen, and saccus, 3.4 to 3.5 mm. in length, very slender; vesica, when exserted, extending anteriorly, then at angle to aedeagus, with band of setae elongate and slender.

Female Genitalia. Ductus bursae only slightly shorter than corpus bursae, rounded and weakly sclerotized in sterigmal area, slightly tapered anteriorly, having sclerotized, longitudinal striations; ductus seminalis arising dorsally from corpus bursae near junction of tubelike process; corpus bursae with small, elliptical area having corneous swellings at end of ductus bursae, then sharply narrowed, with tubelike process coming off left side of elliptical area, curving to right to join main portion of corpus bursae, elongate, straight, extending for short distance posteriad of junction of tubelike process, with longitudinal striations posteriorly; signum thornlike, jutting into corpus bursae on left side near anterior end; apophyses posteriores 6.7 to 8.1 mm. in length.

Early Stages. The egg, larvae, and pupa have been described and illustrated by Comstock, Henne, and Sala, "1957" [1958], p. 170, pls. 38 (egg), 39 (larva), 40A (larval head), B (larva), C-E (pupae). The larvae emerge from the eggs in 40 to 60 days, the eggs having been laid singly or in small clusters within crevices of the bark of the food plant. The five larval instars are correlated in length with the weather and the winter rains in southern California. The mature larva is russet-brown with a scattering of grayish white dots, or with olive-green laterally. Pupation occurs underground.

Food Plants. Various species of *Quercus* (Fagaceae), *Adenostoma*, *Cercocarpus* (Rosaceae), *Rhus* (Anacardiaceae), and *Arctostaphylus* (Ericaceae) (Comstock, Henne, and Sala, "1957" [1958], p. 169).

Type. Holotype, male, in National Museum of Natural History.

Type Locality. Paradise, Cochise County, Arizona.

Distribution. Arizona; southern and central California, ranging from San Diego County north to Lake, Napa, and Sonoma counties along the coast, and inland from Madera to Placer counties in the foothills of the Sierra Nevada. (See fig. 55.)

Flight Period. Late August, September, October, November, and December.

Remarks. Two hundred ninety-eight specimens (265 males, 33 females) and five genitalic dissections (three males, two females) have been studied, including the holotype.

This species shows relatively little variation in color and pattern within each sex; the males do not have both a light and a dark form.

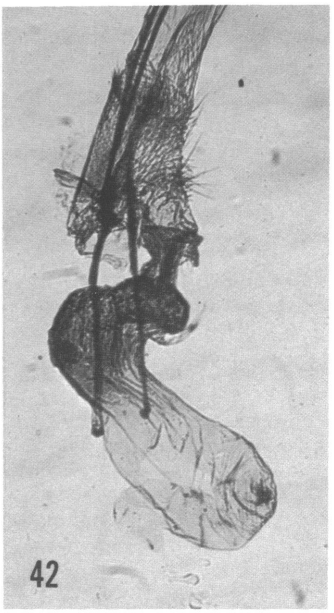
GENUS *LYCIA* HÜBNER

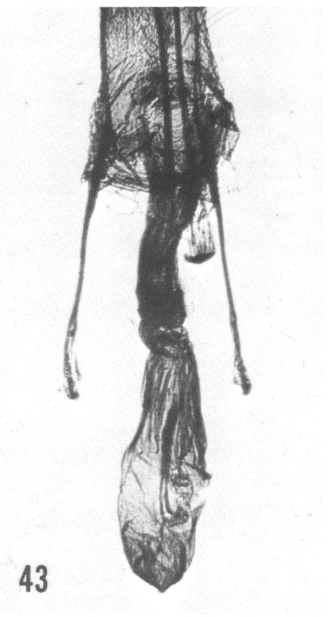
Lycia Hübner, [1825], p. 319. Hulst, 1896a, p. 359. Dyar, "1902" [1903], p. 328. Barnes and McDunnough, 1917, p. 118. McDunnough, 1938, p. 166. W. T. M. Forbes, 1948, p. 64 (in part). Franclemont, 1949, p. 5.

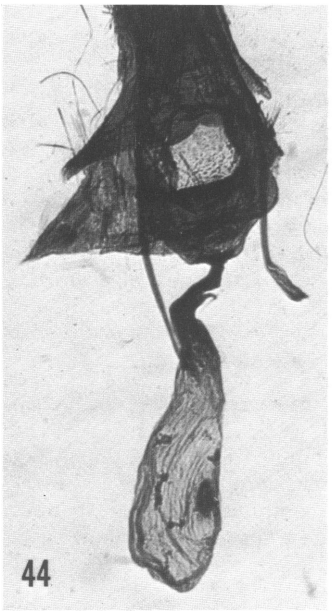
Poecilopsis Harrison, 1913, p. 344. Barnes and McDunnough, 1917, p. 119. McDunnough, 1938, p. 166. W. T. M. Forbes, 1948, p. 64 (synonym of *Lycia*).

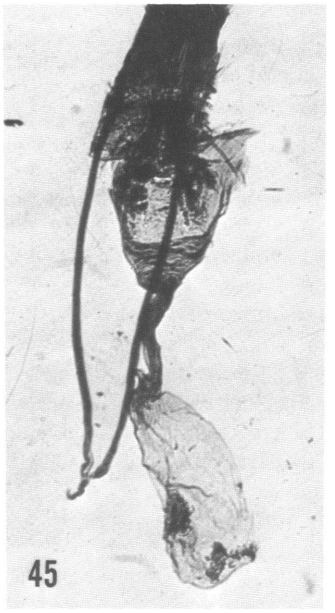
Diagnosis. The hind tibia have one pair of spurs; the fore tibia of the female may or may not have a process; the eyes are naked; the tongue is absent; the wings of the female vary from being fully developed to brachypterous; the male genitalia have the uncus tapering to a single point; and the female genitalia have a well-defined sterigma and a larger signum.

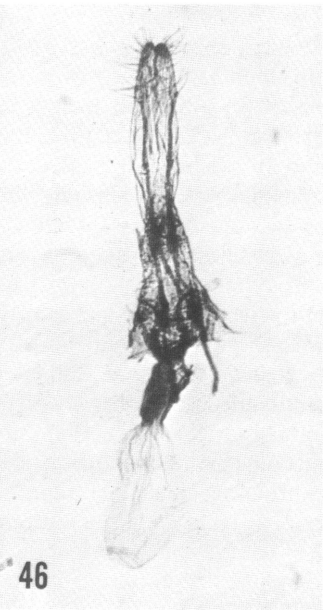
Adult. Similar to the Nearctic species of *Biston*, differing mainly as follows: eyes naked, elliptical, reduced in size, each being narrower than











FIGS. 41-46. Female genitalia. 41. *Cochisea recisa*, new species, paratype, 7 miles S of Palmdale, California, September 29, 1956 (D. L. Mays; LAM). 42. *C. curva*, new species, allotype, Pinyon Crest, California, October 19, 1968 (R. H. Leuschner; AMNH). 43. *C. sinuaria* Barnes and McDunnough, Santa Monica Mountains, California, November 7, 1956 (N. McFarland; AMNH). 44. *Lycia ursaria* (Walker), Swansea, Massachusetts, April 22, 1933 (AMNH). 45. *L. rachelae* (Hulst), Medicine Hat, Alberta, April 23, 1903 (AMNH). 46. *Erannis tiliaria tiliaria* (Harris), Tabor, New Jersey, November 19, 1933 (G. H. H. Tate; AMNH).

front; tongue absent; palpi small; antennae of male bipectinate, of 37 to 56 segments, apex with terminal four to 14 segments simple, with longest pectinations 1.0 to 1.6 mm. in length; antennae of female simple, thickly scaled. Fore tibia of male with process arising basad of middle and extending beyond end of segment, of female reduced to short spurlike process or absent; hind tibia with one pair of spurs. Abdomen medium to stout; dorsal surface with mixture of elongate hairlike and flattened, slender, apically bifurcate scales; tympanic organs of female varying in size from about equal to those of male to being reduced.

Forewings of male varying from elongate to broadly triangular; white, gray, or brown, with more or less well-defined cross lines. Wings of females varying from fully developed but not used for flying (W. T. M. Forbes, 1948, p. 65), and having same color and type of maculation as male, to being brachypterous.

Male Genitalia. Similar to those of the Nearctic species of *Biston*, differing mainly as follows: uncus tapering to single point; gnathos broader, more ringlike, with smaller median enlargement; valves narrower, tending to be of same width for nearly all their length, longer, without extensive area of setae, each costa with base cuplike or saclike, and these connected to form transtilla; anellus smaller, with shorter posterior projection, 1.2 to 1.4 mm. in length; aedeagus narrowed anteriorly, posteriorly with lateral margins sclerotized, shorter than combined lengths of uncus, tegumen, and saccus; vesica unarmed or with short sclerotized band and spines.

Female Genitalia. Similar to those of the Nearctic species of *Biston*, differing mainly as follows: sterigma large, flat, smoothly sclerotized, rectangular; ductus bursae short, triangular, then continuing as slender tube; corpus bursae elongate, weakly enlarged anteriorly; signum large, 0.3 to 0.5 mm. in length, elongate, sagittate; apophyses posteriores very long, 8.5 to 12.3 mm. in length.

Early Stages. See under the species descriptions below.

Food Plants. Polyphagous on deciduous trees and shrubs.

Type Species. For *Lycia*, [*Phalaena*] *hirtaria* Clerck, 1759; designated by Hulst, 1896a, p. 359. This species was cited by Hübner in the original description as *hirtaria* Linnaeus, an incorrect authorship, and by Hulst as *hirtarius* Clerck, an incorrect subsequent spelling.

For *Poecilopsis*, *pomonaria* Hübner, [1796-1799]; by original designation.

Distribution. Holarctic.

Remarks. Lycia contains a number of Palaearctic species; three are present in North America.

KEY TO SPECIES

Based on Morphology and Color

1. Males 2
   Females 5
2. Wings white with black maculation, translucent . . . . . *rachelae*
   Wings gray or brown, densely scaled 3
3. Wings unicolorous gray, with maculation weakly represented or obsolescent . *ursaria*
   Wings grayish brown or brown, with distinct cross lines, and with median area of forewing paler than basal and subterminal areas 4
4. Forewings with basal and subterminal areas grayish brown to blackish brown . . . . . *ypsilon ypsilon*
   Forewings with basal and subterminal areas brown . . . . . *ypsilon carlotta*
5. Wings fully developed . . . . . *ursaria*
   Wings brachypterous 6
6. Body densely covered with elongate hairlike scales, and with some red scaling . *rachelae*
   Body smoothly scaled, without red scaling . . . . . *ypsilon*

Based on Male Genitalia

1. Vesica with row of spines . . . . . *rachelae*
   Vesica unarmed 2
2. Larger, with combined lengths of uncus, tegumen, and saccus about 3.2 mm. . . . *ursaria*
   Smaller, with combined lengths of uncus, tegumen, and saccus about 2.5 mm. . . . . *ypsilon*

Based on Female Genitalia[1]

1. Apophyses posteriores 11.0 to 12.3 mm. in length; posterior end of ductus bursae as wide or wider than smoothly sclerotized sterigmal area . . . . . *ursaria*

[1]The female genitalia of *ypsilon* are unknown.

Apophyses posteriores 8.5 mm. in length; posterior end of ductus bursae narrower than smoothly sclerotized sterigmal area . . . . . *rachelae*

Lycia ursaria (Walker)
Figures 44, 49, 50, 55, 56

Biston ursaria Walker, 1860a, p. 261; 1860b, p. 304. Bowles, 1876, p. 7. Packard, 1876, p. 414, pl. 11, fig. 7 (adult male). Anon., 1882, p. 24. Gumppenberg, 1893, p. 388. Barnes and McDunnough, 1916, p. 36. Covell, 1970, p. 178.

Biston ursarius: Grote, 1882, p. 49. Bruce, 1887, p. 49. Beutenmüller, 1890, p. 222. Smith, 1891, p. 73.

Lycia ursaria: Hulst, 1896a, p. 359. Dyar, "1902" [1903], p. 328. Smith, 1903, p. 77; 1910, p. 504. Barnes and McDunnough, 1917, p. 118. Britton, 1920, p. 117. W. T. M. Forbes, 1928, p. 603; 1948, p. 65, fig. 25 (venation of forewing). Procter, 1938, p. 240; 1946, p. 278. McDunnough, 1938, p. 166. Jerrel and Jaques, 1944, p. 465. J. R. J. L. Jones, 1951, p. 132. Tietz, [1952], p. 139. Ferguson, 1954, p. 317. Moore, 1955, p. 72. Prentice, 1963, p. 466, fig. 293 (distribution in Canada). Sugden, 1968, p. 27. Heitzman, "1973" [1974], p. 176. Brower, 1974, p. 106.

Diagnosis. This is the largest North American species, and is the only one to have females with fully developed wings.

Male. Head with vertex having mixture of pale gray and grayish brown scales; front brown, with some gray scaling, tending to become brownish black laterally and ventrally; palpi gray, blackish brown on outer surfaces; antennae with from about 48 to 54 segments, apical 11 to 14 simple, with longest pectinations 1.6 to 1.8 mm. in length. Thorax above with mixture of white, grayish white, and dark brown scales, collar with narrow dark brown apex, patagia with poorly defined, narrow dark brown diagonal band; below grayish brown; legs brown with some gray scaling, tarsi blackish brown with apices of segments white. Abdomen above grayish brown, with numerous grayish white hairlike scales; below gray.

Upper Surface of Wings: Forewings elongate, thinly scaled with wing membrane visible between scales, having mixture of white, dark gray, and brownish gray scales, producing a more or less uniformly gray appearance; cross lines present, slender, brownish black, sometimes partially obsolescent; t. a. line arising on costa one-third distance from base as prominent spot, with outward projections on radial and cubital veins, then angled basad to meet inner margin one-fourth distance from base; discal spot absent; median line arising at middle of costa as triangular spot, proceeding more or less straight across wing, weakly convex in radial and cubital cells, with basal tooth on vein Cu, meeting inner margin near middle; t. p. line arising on costa three-fourths distance from base, weakly S-shaped, broadly concave in lower half of wing, tending to be thickened on veins, meeting inner margin two-thirds distance from base; subterminal area concolorous with median area; s. t. line white or grayish white, broad, complete or partially interrupted medially, with brownish black costal spot basally near apex and with broad, grayish brown, diffuse band distally; terminal line absent but small intravenular, blackish brown spots present; fringe concolorous with wing, intravenular spots continuing distally into fringe. Hind wings thinly scaled with small white scales, producing grayish white appearance, with some brown scaling distally; intradiscal and median lines present, complete; discal spot absent; extradiscal line broad, diffuse, reduced medially; s. t. line absent; terminal line weakly represented near anal angle in some specimens, with or without small intravenular spots; fringe concolorous with wing.

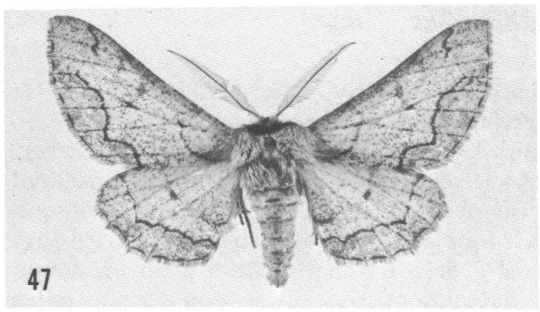
Under Surface of Wings: All wings pale gray, with maculation of upper surface incompletely represented.

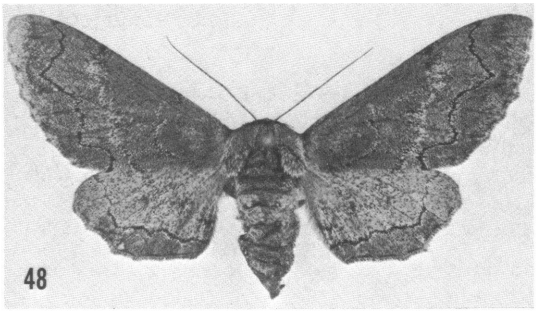
Length of Forewing: 18 to 22 mm.

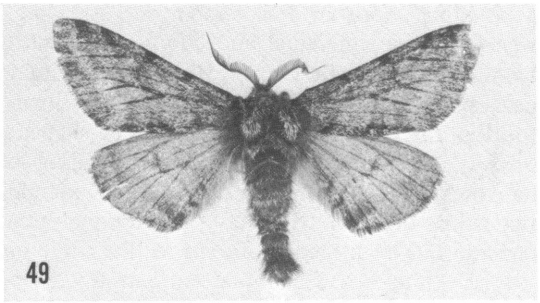
Female. Similar to male; fore tibia with very short process, 0.6 mm. in length; abdomen with tympanic organs about equal in size to those of males; wings fully developed, with color and maculation similar to those of males, with scaling tending to be slightly smaller and sparser, producing more hyaline wings.

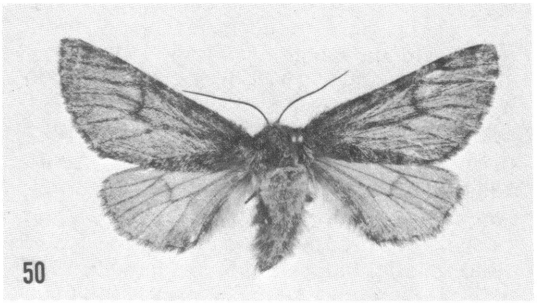
Length of Forewing: 20 to 25 mm.

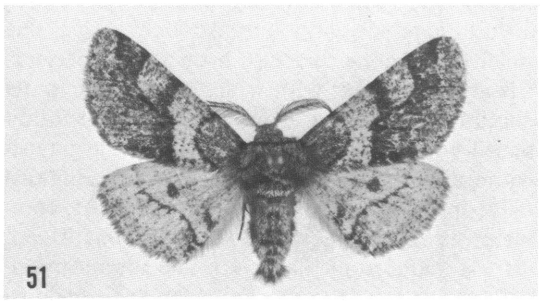
Male Genitalia. Uncus with convex sides, apex in form of ridge, terminating in ventral point; gnathos of equal width throughout, with raised median enlargement; valves slender, elongate, apices tending to be curved posteriorly and to

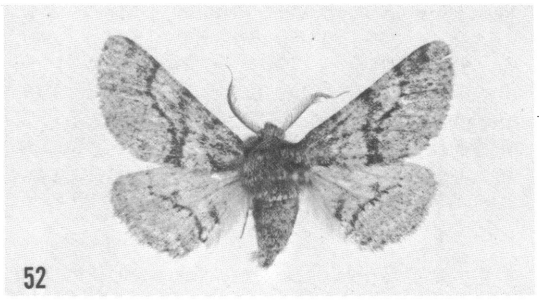


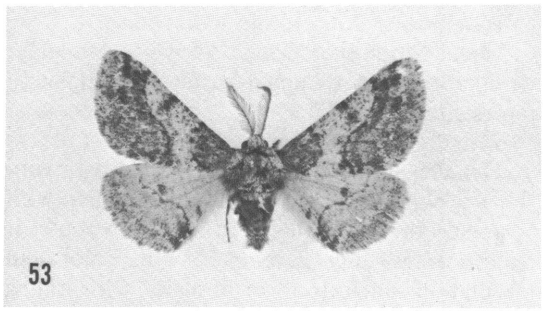


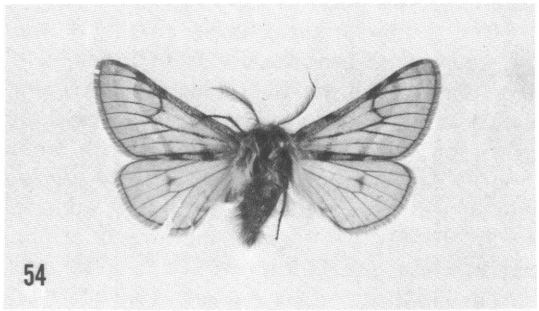












FIGS. 47-54. Adults of *Cochisea* and *Lycia*. 47, 48. *Cochisea sinuaria* Barnes and McDunnough. 47. Male, 5 miles N of Beverly Hills, California, November 8, 1955 (N. McFarland; AMNH). 48. Female, same data, November 22, 1954 (AMNH). 49, 50. *Lycia ursaria* (Walker). 49. Male, Pelham, New York, April 21-30, 1960 (A. B. Klots; AMNH). 50. Female, Bear Mountain, New York (AMNH). 51, 52. *L. ypsilon ypsilon* (S. A. Forbes). 51. Male, Carteret County, North Carolina, March 9, 1974 (J. B. Sullivan; AMNH). 52. Male, same data, March 21, 1974 (AMNH). 53. *L. ypsilon carlotta* (Hulst), male, Siesta Key, Florida, March 13, 1967 (C. P. Kimball; AMNH). 54. *L. rachelae* (Hulst), holotype male, Colorado (Bruce; AMNH). All ×1.3.

have outer margin rounded, each costa narrowly sclerotized, apical region with elongate setae; anellus with anterior end rounded, with flattened caudal margin, 0.5 to 0.6 mm. at widest point, posterior extension poorly defined, mostly membranous, 1.4 mm. in length; aedeagus 2.3 mm. in length, posterior end sclerotized laterally and, more weakly, ventrally; vesica unarmed, extending to left side when exserted.

Female Genitalia. Sterigma large, 0.8 mm. wide, anterior margin concave, lateral margins tapered distally, posterior margin truncate, thickened medially; ductus bursae broader than sterigma posteriorly, short, indented and tapering anteriorly; ductus seminalis arising ventrolaterally on right side from neck of corpus bursae; corpus bursae with slender, curved, tapering neck posteriorly, gradually increasing in width anteriorly; signum prominent, sagittate, variably sclerotized, 0.2 to 0.3 mm. wide, 0.4 mm. in length; apophyses posteriores 11.0 to 12.3 mm. in length.

Early Stages. The complete life history has been known for almost a century; for descriptions see (among others) Bowles (1876, p. 7), W. T. M. Forbes (1948, p. 65), and Sugden (1968, p. 27). Additional references are given by Tietz (1972, p. 661).

Food Plants. This species is polyphagous on deciduous trees and, to a lesser extent, on some shrubs. Food plants are listed by Bowles (1876, p. 7), Bruce (1887, p. 49), Beutenmüller (1890, p. 222), Smith (1910, p. 504), W. T. M. Forbes (1928, p. 603; 1948, p. 65), J. R. J. L. Jones (1951, p. 132), Tietz ([1952], p. 139; 1972, p. 661), Ferguson (1954, p. 317), Prentice (1963, p. 466), and Sugden (1968, p. 27).

Type. The holotype, male, was formerly in the collection of the Ontario Agricultural College, Guelph (Barnes and McDunnough, 1916a, p. 35); it is now in the Canadian National Collection.

Type Locality. Vicinity of Montreal, Quebec.

Distribution. North America, north of latitude 38°. The species is known to me from central and south-central Alaska. In Canada *ursaria* extends from Nova Scotia (Ferguson, 1954, p. 317) to central British Columbia, north to northern Alberta (Prentice, 1963, fig. 293). In the United States the species is found from the Atlantic states (Maine to New Jersey) west to Colorado, Utah, Nevada, and Washington (see fig. 55).

Flight Period. March, April, and May. An occasional specimen may be taken later in the north or in the Rocky Mountains.

Remarks. Three hundred forty-six specimens (303 males, 43 females) and 12 genitalic dissections (seven males, five females) have been studied.

This species appears closely related to the Old World *hirtaria* (Clerck). The present species tends to be slightly larger in size, and of a more uniform color. It is possible that *ursaria* is the more primitive species; it has a small process on the fore tibia of the female but this structure is lacking in *hirtaria.* In the Bistonini, the more primitive, winged, and usually flying females have the process, whereas the derived, nonflying forms with reduced wings do not have it.

Lycia ypsilon (S. A. Forbes)

Biston ypsilon S. A. Forbes, 1885, p. 95.

Diagnosis. The males of this species are smaller than those of *ursaria*, have shorter and broader forewings with a pale, contrastingly colored median area. The females are brachypterous; they are smoothly scaled and do not have red scaling.

Male. Head with vertex covered with pale gray and dark gray scales; front gray dorsally, dark gray or grayish black ventrally; palpi grayish black; antennae with from 48 to 56 segments, terminal 10 to 14 simple, longest pectinations 1.5 to 1.7 mm. in length. Thorax above with mixture of gray and dark gray scales, collar with apex narrowly grayish black, patagia with slender, diagonal band, and posterior margin of thorax with white or whitish gray scaling; below pale to dark gray; legs gray to dark gray, tarsi grayish black with ends of segments narrowly grayish white. Abdomen above gray, dark gray,

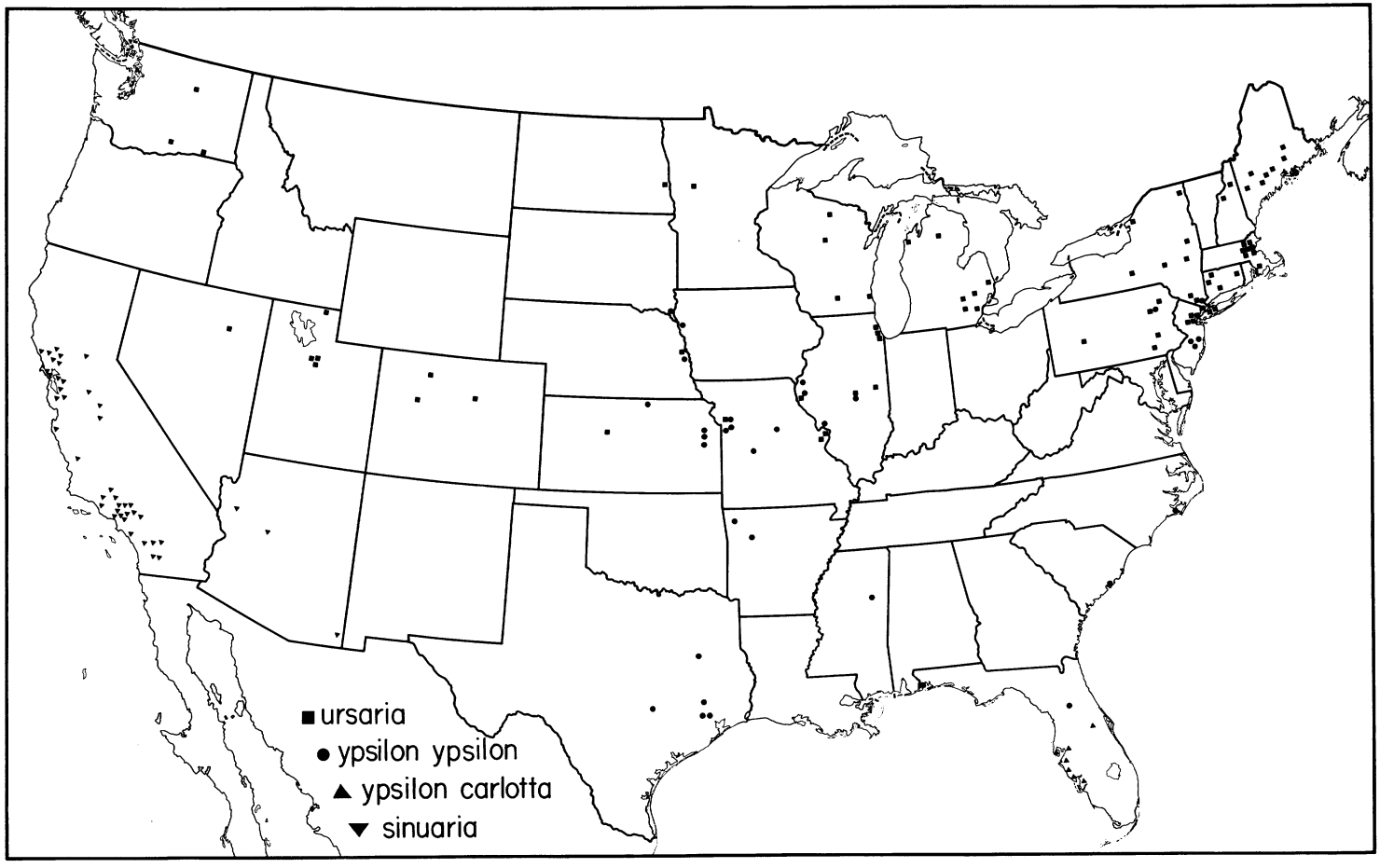


FIG. 55. Distribution of *Lycia* and *Cochisea sinuaria* Barnes and McDunnough in the United States.

or dark brownish gray, segments having paired posterior spots medially; below gray to dark gray.

Upper Surface of Wings: Forewings short, broad; white, grayish white, or pale gray in median area, basal and subterminal areas dark gray, grayish black, or brown, terminal area gray; cross lines black, prominent; t. a. line arising on costa one-fourth distance from base, broadly outwardly curved, swinging basally to meet inner margin one-fifth distance from base; discal spot present in most specimens, large, diffuse; median line arising at middle of costa, incorporating discal spot, curving basally, and remaining close to t. p. line, sometimes partially fusing with latter until just before inner margin, then swinging basally; t. p. line arising on costa three-fourths distance from base, S-shaped, with strong basal bend on or near cubital vein, meeting inner margin two-thirds distance from base; s. t. line indicated mainly by change in color from subterminal to terminal areas, and having basal, black costal dash near apex; terminal line represented by small, dark intravenular dots; fringe concolorous with wing. Hind wings grayish white or light gray, with variable number of scattered darker scales; intradiscal line represented in lower part of wing only; discal dot large, prominent; extradiscal line complete, outwardly dentate on veins, and with broad basal bend in lower part of wing; s. t. line pale gray, weakly indicated; terminal line absent; fringe concolorous with wing.

Under Surface of Wings: Pale gray, with variable number of scattered, darker scales; maculation of upper surface weakly represented.

Length of Forewing: 15 to 19 mm.

Female. (Not examined.) Gray, without reddish scaling on almost smoothly scaled body, with closely approximate pairs of dorsal black spots and black bars at ends of the very short wings; body 15 mm. long (W. T. M. Forbes, 1948, pp. 64, 65).

Male Genitalia. Similar to those of ***ursaria***, differing mainly as follows: smaller; uncus with longer, more pronounced apical ridge, in some specimens with constriction before apex; gnathos with wider median enlargement; valves straighter, each apex tending to be straight and with outer margin more truncate, apical region with fewer, shorter setae; anellus with anterior end varying from rounded to angulate, 0.4 to 0.6 mm. at widest point, posterior extension lightly sclerotized, about 1.2 mm. in length; aedeagus 1.8 to 2.0 mm. in length; vesica unarmed.

Female Genitalia. Unknown.

Early Stages. See nominate subspecies.

Food Plants. See nominate subspecies.

Remarks. Two subspecies are recognized. The nominate one has males with the subterminal area of the upper surface of the forewings dark gray to grayish black; it occurs over most of the eastern United States. Material from the western portion of the range, in Nebraska and Kansas, tends to have the subterminal area dark gray with a faint brownish tinge in some specimens; these are included with the nominate subspecies. Males from peninsular Florida have the subterminal area brown; this is *carlotta* Hulst.

The pattern of *ypsilon* males is similar to that of the Old World *hirtaria* (Clerck). The present species is smaller, and has the maculation more clearly and contrastingly represented.

Lycia ypsilon ypsilon (S. A. Forbes)

Figures 51, 52, 55, 57

Biston ypsilon S. A. Forbes, 1885, p. 95, pl. 10, fig. 4 (type male). Lugger, 1898, p. 243, fig. 190 (type male). Frison, 1927, p. 161.

Nacophora ypsilon: Dyar, "1902" [1903], p. 329. Smith, 1903, p. 77. Barnes and McDunnough, 1917, p. 119. Grossbeck, 1917, p. 100 (in part). Barnes and Benjamin, 1927, p. 71. Jerrel and Jaques, 1944, p. 465.

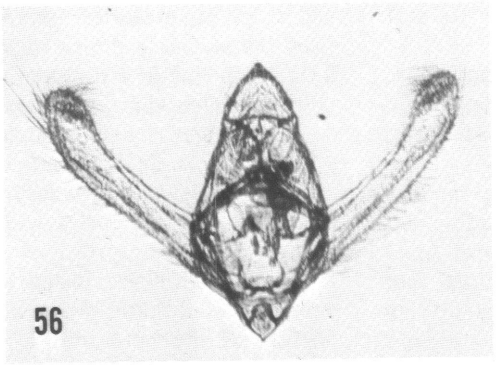
Nacophora ypsilon ypsilon: McDunnough, 1938, p. 165.

Lycia ypsilon: W. T. M. Forbes, 1948, p. 65. Kimball, 1965, p. 183 (in part). McFarland, "1966" [1968], p. 17. Heitzman, "1973" [1974], p. 176.

Diagnosis. The males have the upper surface of the forewings with the basal and subterminal areas dark gray or grayish black.

Male. Head with longest antennal pectinations 1.2 to 1.5 mm. in length. Thorax above with mixture of pale gray, dark gray, and grayish black scales; below gray. Abdomen above dark gray to grayish black, with some grayish white scaling, median spots weakly defined.

Upper Surface of Wings: Forewings with basal and subterminal areas more or less evenly and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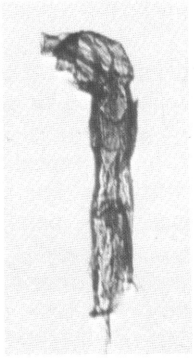

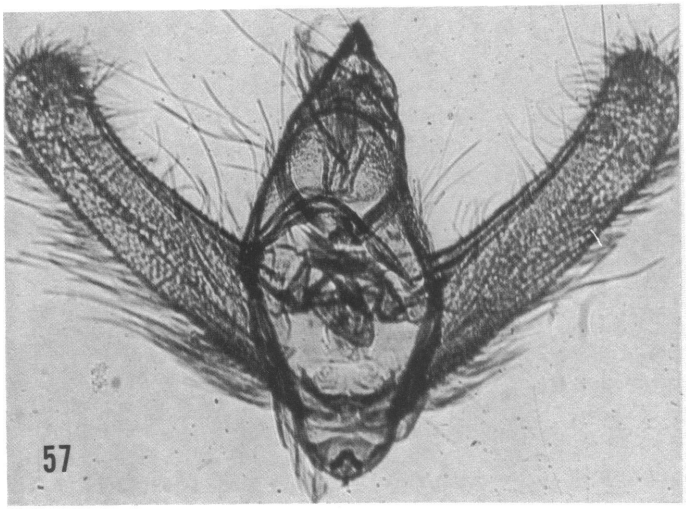
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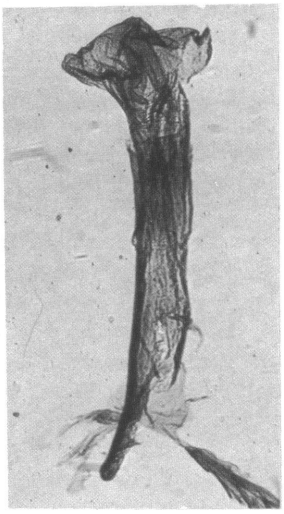

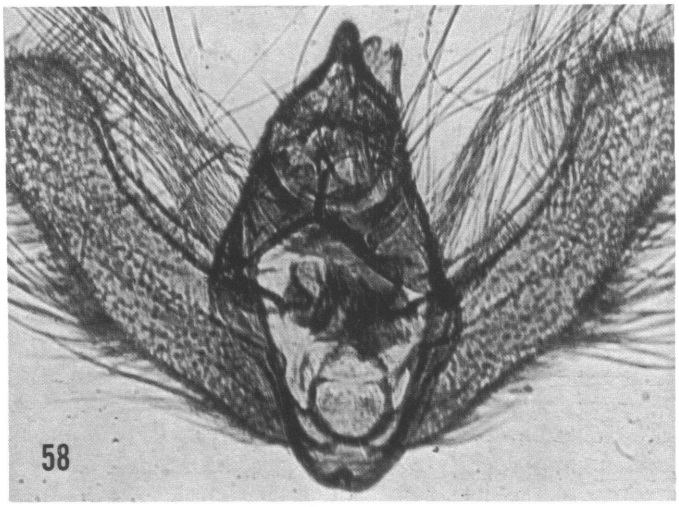
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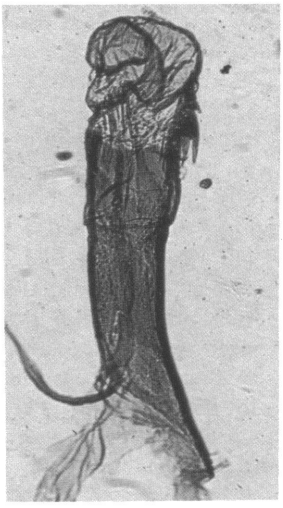


heavily suffused with dark gray and grayish black scales; terminal area gray. Hind wings gray, with scattered dark gray and grayish black scales.

Under Surface of Wings: Gray, more or less heavily suffused with dark gray scales.

Length of Forewing: 15 to 19 mm.

Female. Not examined; see species description.

Male Genitalia. As described for the species.

Female Genitalia. Unknown.

Early Stages. The caterpillar has been described by S. A. Forbes (1885, p. 95), Lugger (1898, p. 243), and W. T. M. Forbes (1948, p. 65).

Food Plant. The type was reared on apple (S. A. Forbes, 1885, p. 95; Frison, 1927, p. 161); this is the only food plant record known to me. The larvae have been reported as "causing some injury to young apple trees" (Lugger, 1898, p. 243).

Type. Holotype, male, in the collection of the Illinois Natural History Survey (Frison, 1927, p. 161).

Type Locality. Near Warsaw, Hancock County, Illinois.

Distribution. The eastern United States, south of latitude 43°, extending from Illinois and South Dakota to western Texas, east to northern Florida, and north to southern New York (see fig. 55).

Flight Period. January, February, and March in the southern portion of the range; April, May, and early June in the north.

Remarks. Two hundred fifty-eight specimens (all males) and five genitalic dissections have been studied.

Males from the central plain states of Nebraska and Kansas tend to have the darker areas of the forewings slightly tinted with brown. There may be a hybrid zone across northern Florida where this subspecies and *carlotta* interface. Specimens from the remainder of the range are rather uniform in coloration, although there is a fair amount of individual variation within a given population whenever the males have been collected in series. This variation manifests itself in the intensity of the dark areas, as they vary from pale gray to black. Males from the eastern portion of the range tend to be larger in size than specimens from the Ozark Plateau, Mississippi, and eastern Texas.

Lycia ypsilon carlotta (Hulst)

Figures 53, 55

Nacophora carlotta Hulst, 1896a, p. 361. Dyar, "1902" [1903], p. 329 (placed as synonym of *ypsilon*). Smith, 1903, p. 77. Barnes and McDunnough, 1917, p. 119. Rindge, 1955, p. 139.

Nacophora ypsilon carlotta: Barnes and Benjamin, 1927, p. 71 (placed as subspecies of *ypsilon*). McDunnough, 1938, p. 165.

Lycia ypsilon carlota (*sic*): W. T. M. Forbes, 1948, p. 65 (in part).

Lycia ypsilon form *carlotta*: Kimball, 1965, p. 183, pl. 22, fig. 25 (adult male).

Nacophora ypsilon: Grossbeck, 1917, p. 100 (in part).

Diagnosis. The males have the upper surface of the forewings with the basal and subterminal areas brown to grayish brown.

Male. Head with longest antennal pectinations 1.5 to 1.7 mm. in length. Thorax above with mixture of grayish white, pale gray, and grayish brown scales, being paler than in nominate *ypsilon*; below pale grayish brown. Abdomen above grayish brown, with some whitish scaling, median spots tending to be more clearly defined than in nominate *ypsilon.*

Upper Surface of Wings: Forewings with basal and subterminal areas pale brown, dark brown, or grayish brown; terminal area grayish white. Hind wings grayish white, with scattered brown and grayish brown scales.

Under Surface of Wings: Grayish white or pale gray, lightly suffused with brown and grayish brown scales.

Length of Forewing: 15 to 18 mm.

FIGS. 56-58. Male genitalia of *Lycia.* 56. *L. ursaria* (Walker), Provo, Utah, April 10, 1963 (N. M. Jorgensen; AMNH). 57. *L. ypsilon ypsilon* (S. A. Forbes), Independence, Missouri, April 17, 1972 (J. R. Heitzman; AMNH). 58. *L. rachelae* (Hulst), Alberta, April 16, 1906 (AMNH). *L. ursaria* is shown at one-half the magnification of the other two species.

Female. Unknown.

Male Genitalia. Similar to nominate *ypsilon*, differing mainly as follows: uncus tending to be slightly wider at base and slightly shorter; valves wider at base, more tapering in width.

Female Genitalia. Unknown.

Early Stages. Unknown.

Food Plant. Unknown.

Type. Hulst did not specify either the number or sex of the specimens he had before him when naming *carlotta*, although it must have been a male. Presumably only one was present, as a single wing expanse is given. The specimen from the Hulst collection is considered to be the holotype; it is in the American Museum of Natural History (Rindge, 1955, p. 139), with its genitalia mounted on slide FHR 17350.

Type Locality. Charlotte Harbor, Charlotte County, Florida.

Distribution. Peninsular Florida (see fig. 55). W. T. M. Forbes (1948, p. 65) gave the distribution of *carlota* (*sic*) as "Florida and Texas (doubtful)." He was incorrect in citing the latter state.

Flight Period. From January into May.

Remarks. Forty-one specimens (all males) and six genitalic dissections, including the type and its genitalia, have been examined.

Males from peninsular Florida have distinctly brown maculation, quite distinct from nominate *ypsilon.* Specimens from northern Florida (Gainesville and Pensacola) are basically gray in coloration, and are considered as belonging to the preceding subspecies. Therefore I disagree with Kimball (1965, p. 184) in his usage of *carlotta* as a color form of *ypsilon.*

In fact, I have debated as to whether or not *carlotta* should be given full specific rank. Variation occurs in the length of the antennal pectinations of the male, as they are longer than in nominate *ypsilon* (1.5 mm. in the latter, 1.5 to 1.7 mm. in *carlotta*), in the coloration of the body and wings, and in certain subtle differences in the male genitalia, such as the shape of the uncus and of the valves. Pending the receipt of adequate series of both sexes, especially females, and a knowledge of the early stages and food plants, I have decided to retain *carlotta* as a subspecies of *ypsilon.*

Lycia rachelae (Hulst)

Figures 45, 54, 58, 83

Apocheima rachelae Hulst, 1896a, p. 362. Dyar, "1902" [1903], p. 329. Smith, 1903, p. 78. Barnes and McDunnough, 1912, p. 35, pl. 16, fig. 6 (adult male). Gibson, 1913, p. 401, pl. 14, figs. 1-10 (early stages, adult male and female), text figs. 15 (larval head), 16 (ovipositor lobes). Holland, 1919, p. 345, pl. 44, fig. 12 (adult male). Rindge, 1955, p. 152.

Poecilopsis rachelae: Barnes and McDunnough, 1917, p. 119. McDunnough, 1938, p. 166. Povolny and Nosek, 1955, p. 199 (unnumbered illustrations of male genitalia and signum). Prentice, 1963, p. 467, fig. 294 (distribution in Canada).

Poecilopsis (*Apocheima*) *rachelae*: Criddle, 1919, p. 97.

Lycia rachelae: W. T. M. Forbes, 1948, p. 66. Sugden, 1968, p. 27.

Diagnosis. The males have thinly scaled, grayish white wings with black cross lines. The females are brachypterous, black, with some red scaling, and with many long, hairlike, white scales on the body and legs.

Male. Head with vertex pale orange dorsally, dark gray or grayish black ventrally; front and palpi grayish black, latter very long scaled below; antennae of about 37 segments, terminal four simple, with longest pectinations 1.0 mm. in length. Thorax above dull black, covered with very long, white or grayish white hairlike scales, especially on collar and patagia, with median stripe of pale orange to orange-red, with orange or orange-red scaling at base of each forewing; below gray, long scaled; legs shiny, dull black or brownish black. Abdomen above similar to thorax, dull black, with median orange or orange-red stripe, and with numerous white or grayish white hairlike scales; below brownish black, with elongate hairlike scales.

Upper Surface of Wings: Forewings moderately short, triangular, with outer margin outwardly oblique; thinly scaled, covered with erect or partially erect white scales, producing a grayish white or pale gray color, with variable number of grayish brown scales, and with orange scaling along costa; cross lines black, varying from clearly defined to obsolescent; t. a. line arising on costa three-tenths distance from base, outwardly

oblique across costa, then gently curved basad to meet inner margin one-fourth distance from base; discal spot on dc cross vein, tending to be thickened at angle; median line absent except for costal spot above discal spot and, in some specimens, above inner margin; t. p. line arising on costa three-fourths distance from base as prominent spot, then gently S-shaped, meeting inner margin seven-tenths distance from base; s. t. line absent or obsolescent, often indicated by diffuse gray band; terminal line dull black, narrow, complete; fringe concolorous with wing. Hind wings concolorous with forewings or slightly paler; maculation absent except for small prominent discal spot and incomplete median line; terminal line broader than on forewings; fringe concolorous with wing.

Under Surface of Wings: More sparsely scaled than on upper surface, hence appearing grayer; maculation of upper surface repeated.

Length of Forewing: 12 to 16 mm.

Female. Brachypterous; fore tibia apparently without process; tympanic organs greatly reduced in size; body and appendages dull black, covered with elongate, white, or grayish white hairlike scales, and with orange-red or reddish scaling.

Male Genitalia. Similar to those of *ursaria*, differing mainly as follows: smaller; uncus swollen ventrally posteriad of base, dorsally sharply narrowed, with narrow apex; gnathos with wider median enlargement; valves broader, each costa curved posteriorly and valve having bluntly pointed apex, apical region with broader area of shorter setae; anellus more ovate, 0.4 mm. at widest point, posterior extension 1.3 mm. in length; aedeagus 2.1 mm. in length; vesica armed ventrally with sclerotized strip having three elongate teeth and several shorter projections.

Female Genitalia. Similar to those of *ursaria*, differing mainly as follows: sterigma 0.7 mm. in width, anterior margin straight, lateral margins weakly concave, posterior margin concave; ductus bursae only slightly wider than sterigma, more evenly tapering and with transverse ridges; ductus seminalis arising nearer main body of corpus bursae; corpus bursae with longer neck posteriorly, of more even width, then swollen into elliptical sac; signum with three teeth anteriorly; apophyses posteriores 8.5 mm. in length.

Early Stages. Criddle (1919, p. 97) has described oviposition, with the females usually depositing single eggs. The early stages have been described by Gibson [1913, p. 401, pl. 14, figs. 1-4 (egg, larvae, pupae), text fig. 15 (head of mature larvae)], W. T. M. Forbes (1948, p. 66), and Sugden (1968, p. 27).

Food Plants. A general feeder on deciduous trees and on some shrubs. Hosts are listed by Gibson (1913, p. 401), W. T. M. Forbes (1948, p. 66), Prentice (who listed 10 food plants; 1963, p. 467), and Sugden (1968, p. 27).

Types. Hulst did not specify the number of specimens that he had when describing *rachelae*, or their sex; they were males, as a wing expanse is given. Barnes and McDunnough (1912, p. 35) illustrated a male that "agrees with the type in our possession from Glenwood Spgs., Colo."; this "type" is spurious, as the species was not described from that locality. The holotype is from the Hulst collection, now in the American Museum of Natural History (Rindge, 1955, p. 152).

Type Locality. "Colo. Bruce." The type was collected in grass about some salt springs.

Distribution. Northern North America. The species is known to me from two localities in Alaska. In Canada, *rachelae* extends from Manitoba west into central British Columbia, and to the far north of Alberta (Prentice, 1963, fig. 294). In the United States it has been taken in Colorado (by Bruce, and in Garfield County), Pennsylvania (Lackawanna County), and Massachusetts (Middlesex County).

Flight Period. April and May; Prentice (1963, p. 468) gave mid-April to mid-August.

Remarks. Forty-four specimens (27 males, 17 females) and three genitalic dissections (two males, one female), including the holotype, have been studied.

The cross lines of the upper surface of the forewings vary in strength, intensity, and width; males have maculation that goes from obsolescent to prominent and thick.

The closest relationships of *rachelae* are with the three Old World species of *Poecilopsis*, as they form a very closely allied group of species. *Poecilopsis* is now considered to be a synonym of *Lycia*.

GENUS *PHIGALIA* DUPONCHEL

Phigalia Duponchel, 1829, pp. 106, 296. Packard, 1876, p. 406. Gumppenberg, 1893, p. 374. Dyar, "1902" [1903], p. 330. Smith, 1903, p. 78. Barnes and McDunnough, 1917, p. 119. McDunnough, 1938, p. 166. W. T. M. Forbes, 1948, p. 66.

Coniodes Hulst, 1896a, p. 353. Dyar, "1902" [1903], p. 329. Smith, 1903, p. 78. Barnes and McDunnough, 1917, p. 119. McDunnough, 1938, p. 165. NEW SYNONYM.

Rhaphidodemas Hulst, 1896a, p. 362.

Raphidodemas (*sic*): Dyar, "1902" [1903], p. 330 (placed as synonym of *Phigalia*).

Diagnosis. The females are brachypterous; all four wings are present but greatly reduced. The males have bipectinate antennae. Both sexes have two pairs of spurs on the hind tibia; the dorsal surface of the abdomen is either covered with flattened, deeply bifurcate scales or with numerous spines of equal size.

Adult. Male: Head with eyes large, round, naked; tongue short; palpi very small; antennae bipectinate, of from 30 to 50 segments, apex with terminal two to seven segments simple, pectinations arising medially or mediobasally, longest pectinations from four to 10 times as long as basal segments, or 0.5 to 2.8 mm. in length, each pectination biciliate below. Thorax moderately slender; fore tibia without terminal spine, with process arising basad of middle of segment; hind tibia with two pairs of spurs. Abdomen slender; dorsal surface covered with either elongate, flattened, deeply bifurcate scales or with numerous spines of equal size.

Forewings broad, relatively short, outer margin only weakly curved; with 11 veins, R_1 and R_2 stalked or separate, R_1 uniting with Sc; hind wings with Sc approximate to R along basal third or half of cell.

Upper surface of wings pale gray, variably scaled with dark gray and grayish black scales; cross lines present, prominent or obsolescent; hind wings similar to forewings but paler.

Female: Similar to male, differing mainly as follows: antennae simple, of about 34 to 49 segments. Fore tibia with process rudimentary, greatly reduced but present in posteromedian depression; hind tibia with two pairs of spurs, smaller than in male, tympanic organs reduced to small, elongate structures with transverse hooklike process.

Wings brachypterous; all wings present, either 3 to 4 mm. in length, or reduced to minute pads on each side of thorax.

Male Genitalia. Uncus with concave sides, tapering to apical point, apex with two ventral points; gnathos heavily sclerotized, with wide, posteriorly directed V-shaped median process; valves simple, slender, elongate, costa broadly sclerotized, middle of valve with oblique, elliptical swelling bearing numerous short spines; anellus broad anteriorly, narrowing posteriorly with concave sides, 0.4 to 0.7 mm. in length; aedeagus simple, posterior end extended ventrally as pointed, striate process; vesica, when exserted, short to moderate in length and extending at angle to aedeagus, and having single spine.

Female Genitalia. Sterigma a weakly sclerotized, elongate, rather poorly defined area; ductus bursae short, weakly sclerotized; ductus seminalis arising from or near posterior end of corpus bursae on right side or ventrally near ductus bursae; corpus bursae large, membranous; signum absent, small, or with part of anterior end of corpus bursae sclerotized; apophyses posteriores 1.4 to 3.5 mm. in length.

Early Stages. See species references.

Food Plants. Polyphagous on deciduous trees.

Type Species. For *Phigalia*, *Geometra pilosaria* Denis and Schiffermüller, 1775; by original designation and monotypy.

For *Coniodes*, *plumigeraria* Hulst, 1896a; by original designation and monotypy.

For *Rhaphidodemas*, *titea* P. Cramer, 1782; by original designation.

Distribution. Holarctic.

Remarks. Phigalia contains four North American species. I am placing them in two species groups, based on the nature of the scaling or spining on the dorsal surface of the abdomen, and on the extent of the reduction of the wings of the females. To be certain whether spines are present, it may be necessary to scrape or brush the dorsal surface of the abdomen. This will remove the layer of scales covering the cuticle, these scales are present in both groups. Once an area has been denuded, it is easy to ascertain whether spines are present.

I would place the Old World *pilosaria* (Denis

and Schiffermüller) as a member of my group I, instead of having it in the genus *Apocheima* Hübner, as it is listed by Kloet and Hincks (1972, p. 66).

The two species (*titea* and *pilosaria*) known by me to occur in group I have melanic males. I have not seen any melanic specimens in the three species of group II, although a very few have been reported for one species.

The fore tibia of the female have a median or posteromedian depression, from which the tibial process arises. This process is variable in length, being 0.3 mm. long in *plumigeraria*, 0.2 mm. in *titea* and *pilosaria*, and microscopic in size in *denticulata* and *strigataria*. As far as can be seen, using a compound microscope, the process has the same basic structure in all species.

Some citations in the literature of this genus have been confused as to the proper application of specific names; care should be taken when consulting references.

Coniodes is placed in the synonymy because *plumigeraria*, its type species, is now considered to be a member of *Phigalia*.

KEY TO SPECIES

Based on Morphology and Color

1. Abdomen with upper surface covered with flattened, deeply bifurcate scales (group I) . . . . . *titea*
   Abdomen with upper surface covered with scales and numerous spines of equal size (group II). 2
2. Males 3
   Females. 5
3. Antenna of 30 to 34 segments, with longest pectinations 2.4 to 2.8 mm. in length . . . . . *plumigeraria*
   Antennae of 44 to 50 segments, with longest pectinations 0.5 to 0.7 mm. in length . . .4
4. Forewings with upper surface brownish gray, with t. p. line strongly outwardly dentate on veins and having deep concave bend in cell Cu_2 . . . . . *denticulata*
   Forewings with upper surface pale olivaceous gray, with t. p. line straighter, only weakly dentate and with small basal bend in cell Cu_2 at most . . . . . *strigataria*
5. Wings 2.0 to 2.6 mm. in length. . . *denticulata*
   Wings 0.8 to 1.9 mm. in length. 6
6. Wings 1.2 to 1.9 mm. in length, pale gray. . . . . *plumigeraria*
   Wings 0.8 to 1.2 mm. in length, dark grayish brown . . . . . *strigataria*

Based on Male Genitalia

1. Vesica with long, straight spine, at least 1.5 mm. in length . . . . . *strigataria*
   Vesica with short spine. 2
2. Vesica with thick coiled spine . . . . . *titea*
   Vesica with small, slender, curved or straight spine. 3
3. Each valve with raised spinose process extending across most of width of valve . . . . . *denticulata*
   Each valve with raised spinose process appearing as lobate process next to costa, not extending across inner face of valve. . . . . *plumigeraria*

Based on Female Genitalia

1. Apophyses posteriores 1.4 to 1.5 mm. in length . . . . . *plumigeraria*
   Apophyses posteriores 3.2 to 3.5 mm. in length 2
2. Signum present 3
   Signum absent, but part of anterior portion of corpus bursae broadly sclerotized . . . . . *strigataria*
3. Sterigma with reticulate transverse area, and with sclerotized lamella antevaginalis; ductus bursae sclerotized, 0.4 mm. wide . .*titea*
   Sterigma membranous, without reticulate area and without sclerotized lamella antevaginalis; ductus bursae membranous or lightly sclerotized, 0.2 mm. wide . . . . . *denticulata*

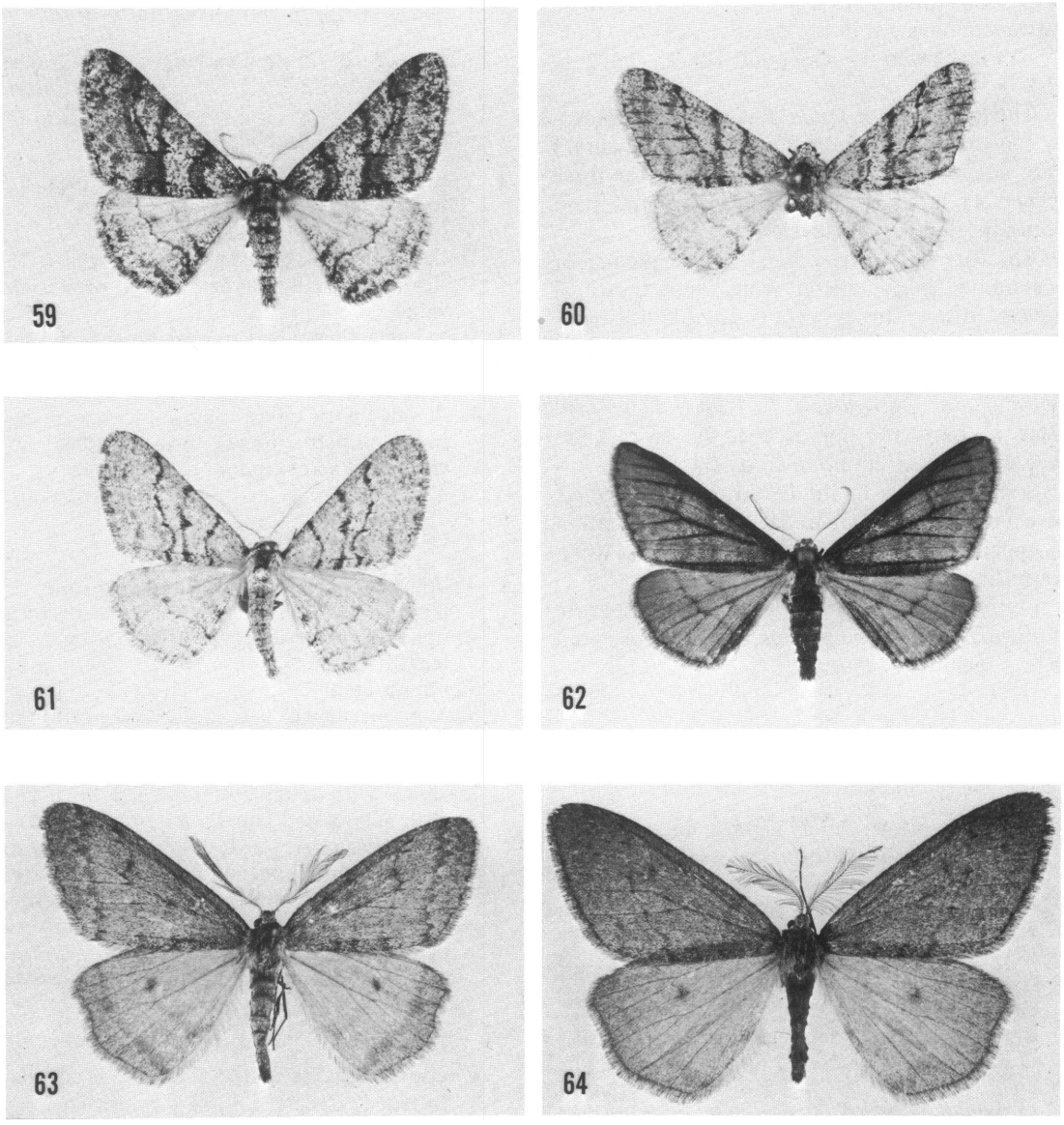
GROUP I

The dorsal surface of the abdomen is covered with flattened, deeply bifurcate scales (see fig. 1). The females have all four wings present although greatly reduced, being 3 to 4 mm. in length. The fore tibial process of the female is about 0.2 mm. in length.

Phigalia titea (P. Cramer)

Figures 1, 59-62, 71, 72, 77, 84

Phal[aena] Geomet[ra] titea P. Cramer, 1782, pp. 148, 176, pl. 275, fig. C (type male).
Phalaena titea: Packard, 1876, p. 442.



FIGS. 59-64. Males of *Phigalia*. 59-62. *P. titea* (Cramer). 59. Washington County, Arkansas, March 28, 1967 (R. L. Brown; AMNH). 60. Lectotype of *Rhaphidodemas nevadaria* Hulst, Colorado (Bruce; AMNH). 61. Niagara, North Carolina, April 4, 1955 (R. R. McElvare; AMNH). 62. Melanic specimen, Lewisboro, New York, April 12, 1966 (M. and T. M. Favreau; AMNH). 63, 64. *P. plumigeraria* (Hulst). 63. Laytonville, California, March 10, 1949 (R. F. Sternitzky; AMNH). 64. Wallace, Idaho, April 1, 1941 (O. Huellemann; AMNH). All ×1.4.

Boarmia titea: Walker, 1860b, p. 345.
Rhaphidodemas titea: Hulst, 1896a, p. 362.
Phigalia titea: Hulst, 1896b, p. 41. Dyar, "1902" [1903], p. 330. Smith, 1903, p. 78; 1910, p. 505. Barnes and McDunnough, 1917, p. 119. Holland, 1919, p. 347, pl. 44, fig. 16 (adult male). W. T. M. Forbes, 1928, p. 604; 1948, p. 66, fig. 26 (venation). McDunnough, 1938,

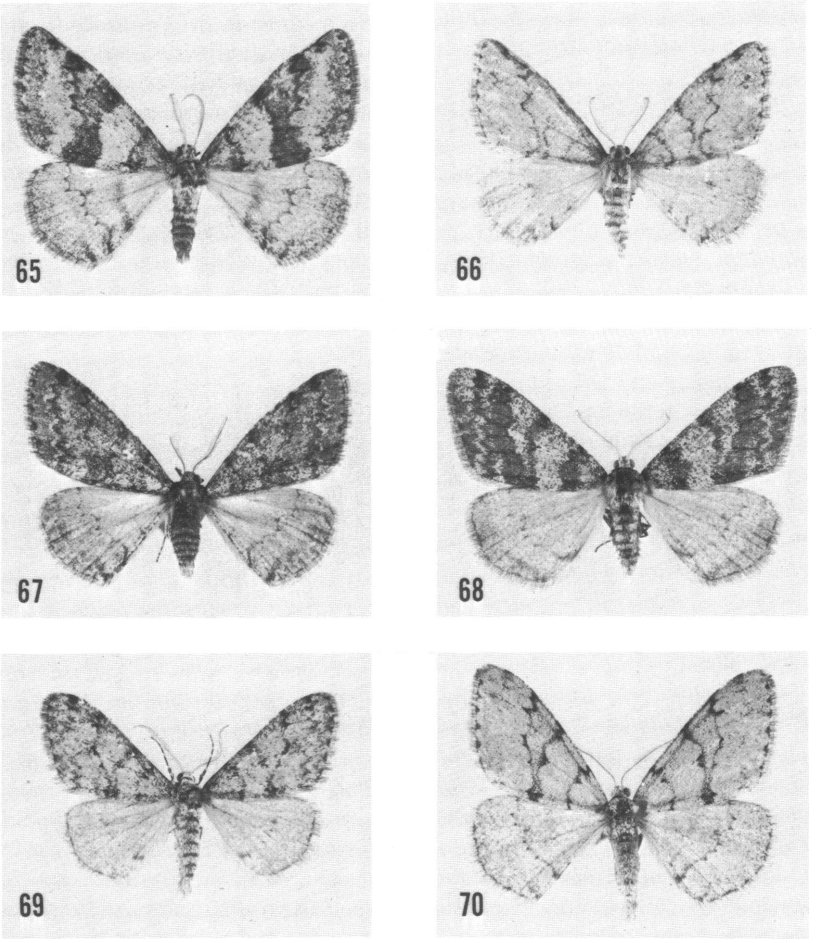
p. 166. Procter, 1938, p. 240; 1946, p. 278. F. M. Jones and Kimball, 1943, p. 117. Jerrel and Jaques, 1944, p. 465. Ferguson, 1954, p. 316. Moore, 1955, p. 72. Prentice, 1963, p. 462, fig. 290 (distribution in Canada). Kimball, 1965, p. 183. McFarland, "1966" [1968], p. 17. Talerico, 1968, p. 557, figs. 1 (eggs), 2 (larva), 3 (pupa), 4, 5 (adult male, female). Covell, 1970, p. 178. Heitzman, "1973" [1974], p. 176. Brower, 1974, p. 106.

[*Deileptenia*] *titearia* (*sic*): Hübner, [1825], p. 317.

Boarmia titearia: Guenée, 1857, p. 248. Walker, 1860b, p. 349 (synonym of *titea*).

Phigalia revocata Walker, 1862, p. 1527. Smith, 1891, p. 73. Hulst, 1896b, p. 41 (placed as synonym of *titea*).

Phigalia strigataria (misidentification, not Minot, 1869): Packard, 1876, p. 407, pl. 13, fig. 37 (adult female) (in part; not pl. 11, fig. 3). Grote, 1882, p. 50. Anon., 1882, p. 24.



FIGS. 65-70. Males of *Phigalia*. 65-67. *P. denticulata* Hulst. 65. Pearl, Mississippi, February 2, 1964 (B. Mather; AMNH). 66. Clinton, Mississippi, January 27, 1960 (B. Mather; AMNH). 67. Same data, February 6, 1966 (AMNH). 68-70. *P. strigataria* (Minot). 68. Rye, New York, March 25, 1933 (Ghika; AMNH). 69. Lewisboro, New York, April 9, 1969 (M. and T. M. Favreau; AMNH). 70. Bovina, Mississippi, March 1, 1973 (B. Mather; AMNH). All ×1.4.

Bruce, 1887, p. 49. Beutenmüller, 1890, p. 222. Smith, 1891, p. 73. Gumppenberg, 1893, p. 376. Hulst, 1896b, p. 41 (placed as synonym of *titea*). Lugger, 1898, p. 249, fig. 194 (female only) (in part; not fig. 194, male).

Phigalia cinctaria French, 1878, p. 157. Grote, 1882, p. 50. Anon., 1882, p. 24. Smith, 1891, p. 73 (placed as synonym of *strigataria*).

Rhaphidodemas nevadaria Hulst, 1896a, p. 362. Rindge, 1955, p. 149. NEW SYNONYM.

Phigalia nevadaria: Dyar, "1902" [1903], p. 330. Smith, 1903, p. 78. Barnes and McDunnough, 1916b, p. 186.

Phigalia titea nevadaria: Barnes and McDunnough, 1917, p. 119. McDunnough, 1938, p. 166.

Phigalia olivacearia form *mephistaria* Reiff, 1913, p. 308, pl. 10, figs. 8, 9 (holotype male, upper and under sides). NEW SYNONYM.

Phigalia olivacearia ab. *mephistaria*: Barnes and McDunnough, 1917, p. 119. McDunnough, 1938, p. 166. W. T. M. Forbes, 1948, p. 67.

Phigalia titea form *deplorans* Franclemont, 1938, p. 108. W. T. M. Forbes, 1948, p. 66.

Diagnosis. This species can be recognized by the characters given for group I. The males have a relatively large wingspread, and the t. p. line of the upper surface of the forewings has a deep basal bend in the lower part of the wing.

Male. Head with vertex having mixture of white and grayish black scales; front white dorsally, black or grayish black ventrally; palpi grayish black; antennae of from 46 to 48 segments, apex with terminal six segments simple, with pectinations arising medially, longest pectinations four times as long as basal segments, 0.7 to 0.8 mm. in length. Thorax above with mixture of white, gray, grayish black, and black scales, end of collar broadly dull black, patagia with narrow dark band, and with black marking near end of thorax; below gray, darker anteriorly; legs pale gray or grayish brown, variably covered with brownish black scales on outer surfaces and on tarsi, latter with ends of segments pale. Abdomen above with mixture of white, gray, grayish brown, and black scales, ends of segments tending to be narrowly black; below gray, with scattered brown and black scales.

Upper Surface of Wings: Forewings white or pale gray, with variable number of dark gray, grayish brown, brownish black and black scales, having median area paler than remainder of wing; cross lines black, prominent; t. a. line arising on costa one-fourth distance from base, convex crossing wing, meeting inner margin one-third distance from base, and having broad, dark basal shade band; median line arising on costa at middle of wing, broad, convex, with basal tooth on cubital vein, then proceeding more or less straight to middle of inner margin; discal spot absent; t. p. line arising on costa three-fourths distance from base, angled inwardly to radial veins, tending to be thickened on veins, convex to vein Cu_1, then swinging basally with prominent concave loop in cell Cu_2, meeting inner margin three-fourths distance from base, with entire line having broad, dark distal shade band occupying basal half or one-third of subterminal area; s. t. line obsolescent, indicated mainly by band of darker shading; terminal line black, narrow, with intravenular dots; fringe concolorous with wing. Hind wings similar to forewings but without dark scaling; maculation represented by incomplete median line, narrow extradiscal line, and partial s. t. line; terminal line represented by small intravenular dots; fringe concolorous with wing.

Under Surface of Wings: Forewings pale brownish gray, becoming pale gray posteriorly; hind wings pale gray, with scattered brown scales; maculation absent or obsolescent; discal dot weakly represented on forewings, strongly on hind wings; terminal line brownish black, narrow; fringe concolorous with wing.

Length of Forewing: 15 to 22 mm.

Female. Body with upper surface tending to be browner than that of male; wings pale gray, with scattered brown scales and tending to have single cross line (presumably t. p. and extradiscal) across all wings.

Length of Forewing: 3 to 4 mm.

Male Genitalia. Uncus with rounded apex having two outwardly divergent points about 0.1 mm. apart; gnathos with broad, laterally flattened, median area having small median projection; valves with each median swelling about 0.30 mm. long and 0.12 mm. wide, bearing numerous short spines; anellus rounded anteriorly, 0.4 mm. wide, posterior extension with concave sides, 0.6 mm. in length; aedeagus with short vesica, and with thick, coiled spine.

Female Genitalia. Sterigma with large, sclerotized lamella antevaginalis, extending anterior to middle of ductus bursae, extending slightly more

anteriad on right side than on left, median area of sterigma transversely reticulate, and with weakly sclerotized, slender elliptical area dorsally; ductus bursae sclerotized laterally, sides roughly parallel, 0.35 mm. wide, slightly wider than long, anterior end shallowly flared to join corpus bursae; ductus bursae arising ventrally, to left of midline, from triangular extension of posterior end of corpus bursae; corpus bursae with posterior end minutely setose, weakly constricted medially; signum prominent, sclerotized, 0.2 to 0.3 mm. in length, variable in shape, having several inwardly directed points; apophyses posteriores 3.1 to 3.7 mm. in length.

Early Stages. These have been described by (among others) Lugger (1898, p. 249), W. T. M. Forbes (1948, p. 66) and Talerico (1968, p. 557, figs. 1 (eggs), 2 (larva), 3 (pupa)). Additional references are in Tietz (1972, p. 641).

Food Plants. Polyphagous on trees, rarely on shrubs. Food plant lists are given by (among others) Bruce (1887, p. 49), Beutenmüller (1890, p. 222), Lugger (1898, p. 249), Smith (1910, p. 505), W. T. M. Forbes (1948, p. 66), Prentice (1963, p. 462; gave a list of 25 different trees); and Talerico (1968, p. 557).

Types. Titea, unknown and presumably destroyed.

Walker had a number of males before him when he described *revocata*; four of the original syntypes are in the collection of the British Museum (Natural History). Of these, I hereby designate as lectotype the specimen bearing the labels "Phigalia revocata" cut from a copy of Walker's list, and "Photographed BM negative No. C.25."

Cinctaria French was described from a single female; its present whereabouts is unknown.

Hulst described *nevadaria* from at least two male specimens, one being from Nevada and the second from Colorado. The former, now in the National Museum of Natural History is badly worn and stained (Barnes and McDunnough, 1916b, p. 186); it is *denticulata.* I designate, and have labeled, as lectotype of *nevadaria* the male from Colorado in the American Museum of Natural History (Rindge, 1955, p. 149); its genitalia are mounted on slide FHR 17458.

Reiff's holotype male of "mephistaria" is MCZ 16880. The specimen is without antennae and the left hind wing; the under side of the abdomen has been partly eaten away.

Franclemont's holotype male of "deplorans" is in his private collection.

Type Localities. Virginia (*titea*); United States (*revocata*); about 50 miles north of Carbondale, Illinois (*cinctaria*); "Colorado, Bruce" (*nevadaria*); West Roxbury, Suffolk County, Massachusetts ("mephistaria"); Ithaca, New York ("deplorans").

Distribution. Eastern North America. In Canada *titea* extends from Nova Scotia (Ferguson, 1954, p. 316) and New Brunswick west to central Saskatchewan (Prentice, 1963, fig. 290). In the United States it occurs from Maine to Florida, west to eastern Texas, the Ozark Plateau, the central plains states, both North and South Dakota, Colorado, and Utah (see fig. 71).

Flight Period. February and March in the south; April into early July in the north and northwest.

Remarks. Seven hundred nine specimens (669 males, 40 females) and 26 genitalic dissections (23 males, three females) have been studied.

This species is a defoliator of eastern deciduous forest trees but is not normally a commercial pest, due to its low population density.

Reiff described and illustrated a melanic male as form "mephistaria," associating it with *olivacearia.* All subsequent literature references have followed Reiff's placement. My study of the type showed that it did not have the upper surface of the abdomen spinose, and hence is not a member of my group II. Consequently I have placed it in the synonymy of *titea.* The melanic male was later redescribed as "deplorans" by Franclemont.

Melanism in *titea* has been discussed by Owen (1962, p. 697) and Sargent (1971, p. 122; 1974, p. 149).

Nevadaria is placed in the synonymy because the lectotype (fig. 60) does not differ, either by pattern, genitalia, or distribution, from *titea.*

Brachypterous males occur in *titea*; they look like females except for their pectinate antennae. Two such specimens from New Jersey have been studied in the collection of the American Museum of Natural History.

GROUP II

The dorsal surface of the abdomen is covered with numerous spines of equal size (see fig. 2). The females have wings that are smaller than

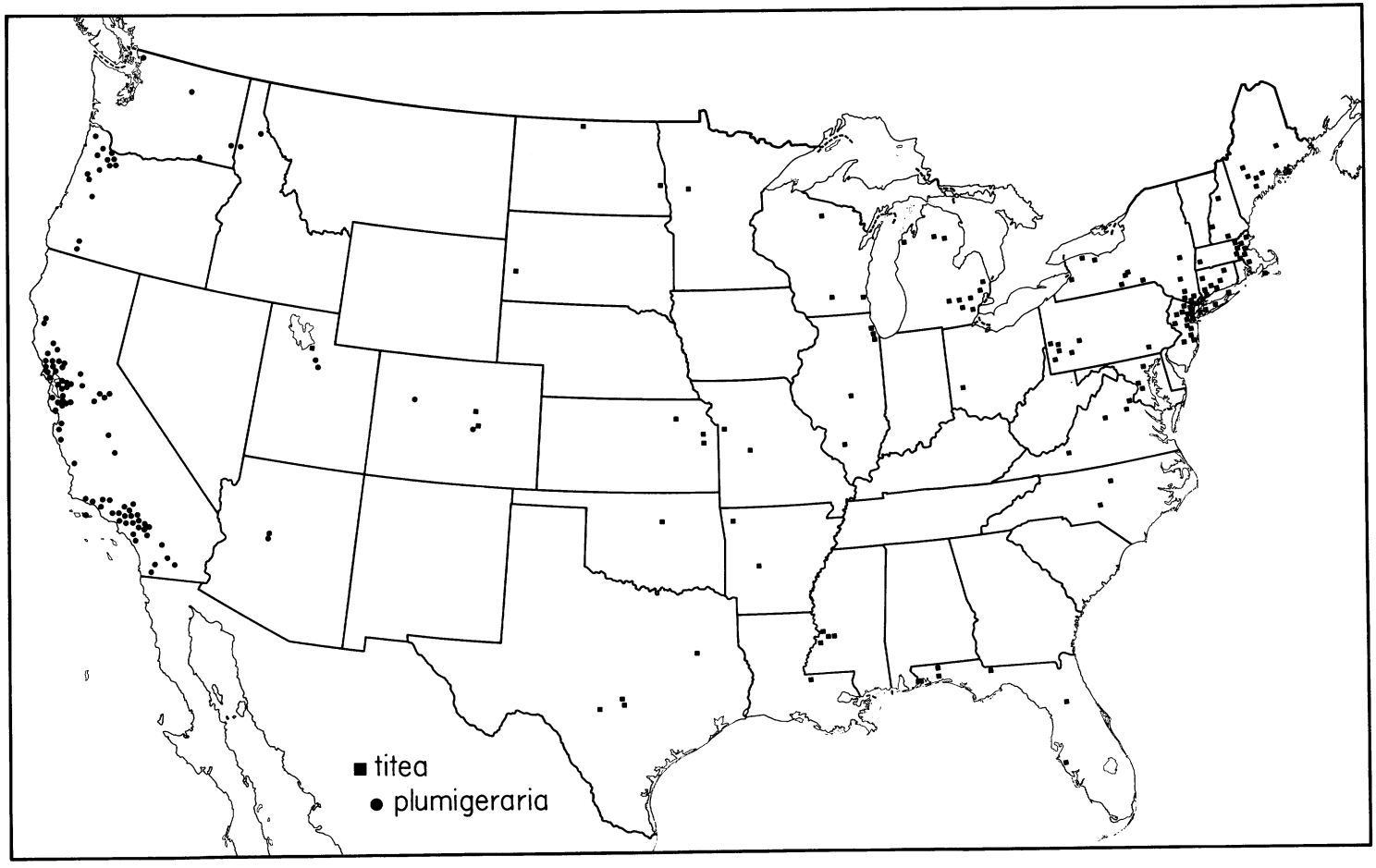


FIG. 71. Distribution of *Phigalia titea* (Cramer) and *P. plumigeraria* (Hulst) in the United States.

those found in the species of group I, being 0.8 to 2.6 mm. in length. The fore tibial process of the female ranges in length from 0.3 mm. (*plumigeraria*) to microscopic (*denticulata* and *strigataria*).

Phigalia denticulata Hulst
Figures 65-67, 73, 76, 78, 85

Phigalia denticulata Hulst, 1900, p. 219. Dyar, "1902" [1903], p. 330. Smith, 1903, p. 78. Barnes and McDunnough, 1912, p. 35, pl. 16, fig. 9 (adult male); 1917, p. 119. McDunnough, 1938, p. 166. W. T. M. Forbes, 1948, p. 67. Rindge, 1955, p. 141. Kimball, 1965, p. 183. Heitzman, "1973" [1974], p. 176.
Rhaphidodemas nevadaria Hulst, 1896a, p. 362 (in part).

Diagnosis. The males of this species are similar in pattern to those of *titea*, but tend to have more dentate t. p. and extradiscal lines. The color of the upper surface of the wings is a more uniform, even gray.

Male. Head similar to that of *titea*; antennae of from 42 to 44 segments, apex with terminal six segments simple, pectinations arising basomedially from swollen portion of segments, longest pectinations 3.3 to 3.5 times as long as basal segments, or 0.7 mm. in length. Thorax above and below similar to that of *titea* but tending to be darker. Abdomen above similar to that of *titea* but tending to have dark band across posterior end of each segment; below similar to *titea*.

Upper Surface of Wings: Forewings pale gray, evenly covered with dark gray, grayish brown, and brownish black scales, with median area concolorous with remainder of wing; cross lines black, narrow, variable in strength; t. a. line arising on costa one-fourth distance from base, going at right angle to costa or angled basally across vein Sc, then roundly convex, meeting inner margin three-tenths distance from base, with dark basal shade band narrow or obsolescent; median line arising near middle of wing, slender or obsolescent, outwardly angled to vein Cu_1, then proceeding more or less straight to just beyond middle of inner margin; discal spot absent; t. p. line similar in course to that of *titea* but tending to be outwardly dentate on veins and to be less strongly concave in cell Cu_2, and with distal shade band either obsolescent or completely absent; terminal line with intravenular dots; fringe concolorous with wing. Hind wings similar to forewings, lightly and variably covered with gray or grayish brown scales; maculation similar to that of *titea* but with extradiscal line tending to be more outwardly dentate on veins, and s. t. line more strongly represented.

Under Surface of Wings: Similar to that of *titea* but with all wings more heavily covered with gray and grayish brown scales.

Length of Forewing: 15 to 18 mm.

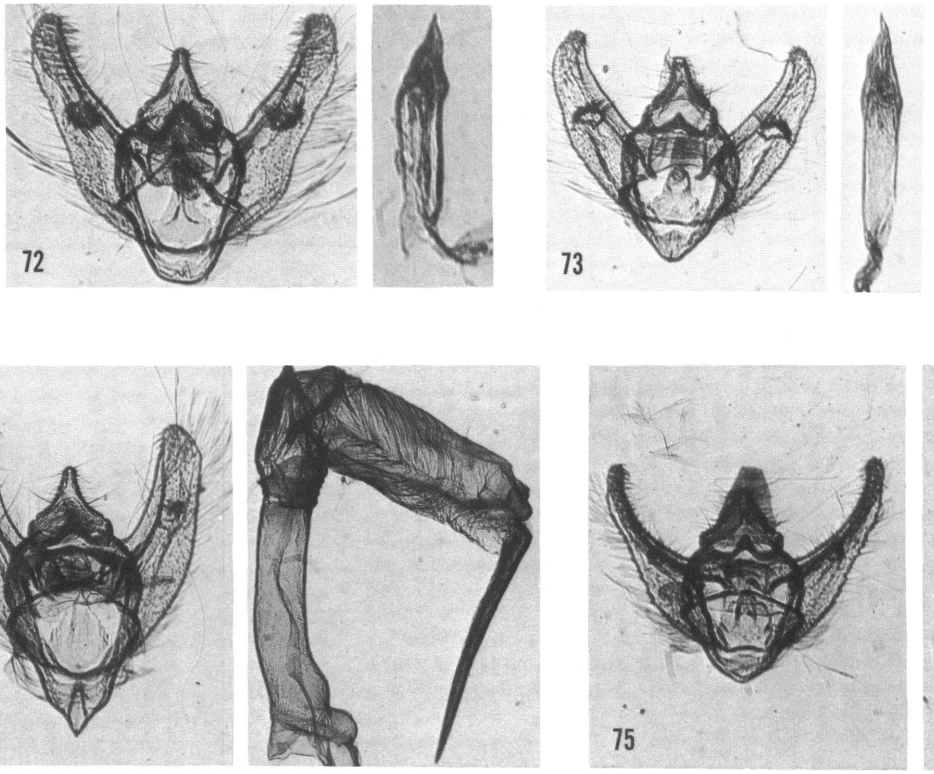
Female. Body with upper surface dark gray, with variable number of gray and grayish white scales; thorax with two rather poorly defined, dull black posterior spots; abdomen above becoming slightly paler posteriorly, with faint black geminate dorsal stripe, contrastingly pale gray below, with scattered grayish black scales; wings inconspicuous, dark gray to pale gray basally, tending to become paler gray distally, either without maculation or with single, narrow, partially represented black transverse band on all wings.

Length of Forewing: 2.0 to 2.6 mm.

Male Genitalia. Similar to those of *titea*, differing mainly as follows: smaller; uncus with truncate apex having two shorter, nondiverging points about 0.06 mm. apart; gnathos with median area tapering to point; valves with each median swelling about 0.25 mm. long and 0.10 mm. wide, bearing single row of short spines along posterior margin; anellus flattened anteriorly, with or without small median indentation, 0.3 mm. wide, posterior extension with apex having rounded median incision, 0.4 mm. in length; aedeagus with short, thick, curved spine.

Female Genitalia. Sterigma membranous, with elongate, slender, longitudinal, weakly sclerotized elliptical area; ductus bursae small, membranous or weakly sclerotized, slightly wider than long, 0.2 mm. wide; ductus seminalis arising from right side of corpus bursae near ductus bursae; corpus bursae elongate, posterior end minutely pitted, asymmetrical, with ductus bursae joining on left side, right side swollen, anterior end ovate or elliptical; signum small, indented into wall of corpus bursae, and having three inwardly directed points, one anterior and two posterior; apophyses posteriores 3.3 to 3.7 mm. in length.

Early Stages. Unknown.



FIGS. 72-75. Male genitalia of *Phigalia*. 72. *P. titea* (Cramer), lectotype of *Rhaphidodemas nevadaria* Hulst, Colorado (Bruce; AMNH). 73. *P. denticulata* Hulst, Bovina, Mississippi, January 24, 1972 (B. Mather; AMNH). 74. *P. strigataria* (Minot), Lewisboro, New York, April 17, 1969 (M. and T. M. Favreau; AMNH). 75. *P. plumigeraria* Hulst, holotype, California (AMNH).

Food Plant. Unknown.

Types. Hulst did not specify either the number of specimens or their sex when describing *denticulata*, although the species was obviously described from the male. I have studied three specimens that are labeled as types of *denticulata*; two of these, both rather worn, are in the National Museum of Natural History. The third, from the Hulst collection, now in the American Museum of Natural History (Rindge, 1955, p. 141), is hereby designated as the lectotype, and has been so labeled. Its genitalia are mounted on slide FHR 17412.

Hulst described *nevadaria* from two males; see the discussion of these under *titea*, where the lectotype was designated. The second specimen, labeled "Nevada," is badly worn and stained (Barnes and McDunnough, 1916b, p. 186). It can be identified with certainty by means of its genitalia, mounted on slide JFGC 922; these structures show it to be *denticulata*. This specimen is USNM 34283.

Type Locality. Central Texas, according to the original description. The lectotype bears a "Tex." label.

Distribution. The eastern United States (see fig. 76). Specimens are known from south of about latitude 42° N, ranging from the Atlantic to about longitude 100° W; the species is absent from peninsular Florida. Hulst's "type" specimen of *nevadaria* (= *denticulata*) from "Nevada" is thought to have incorrect data.

Flight Period. Most specimens have been captured in January, February, and March; a few fly in December and in April.

Remarks. Five hundred ninety-four specimens

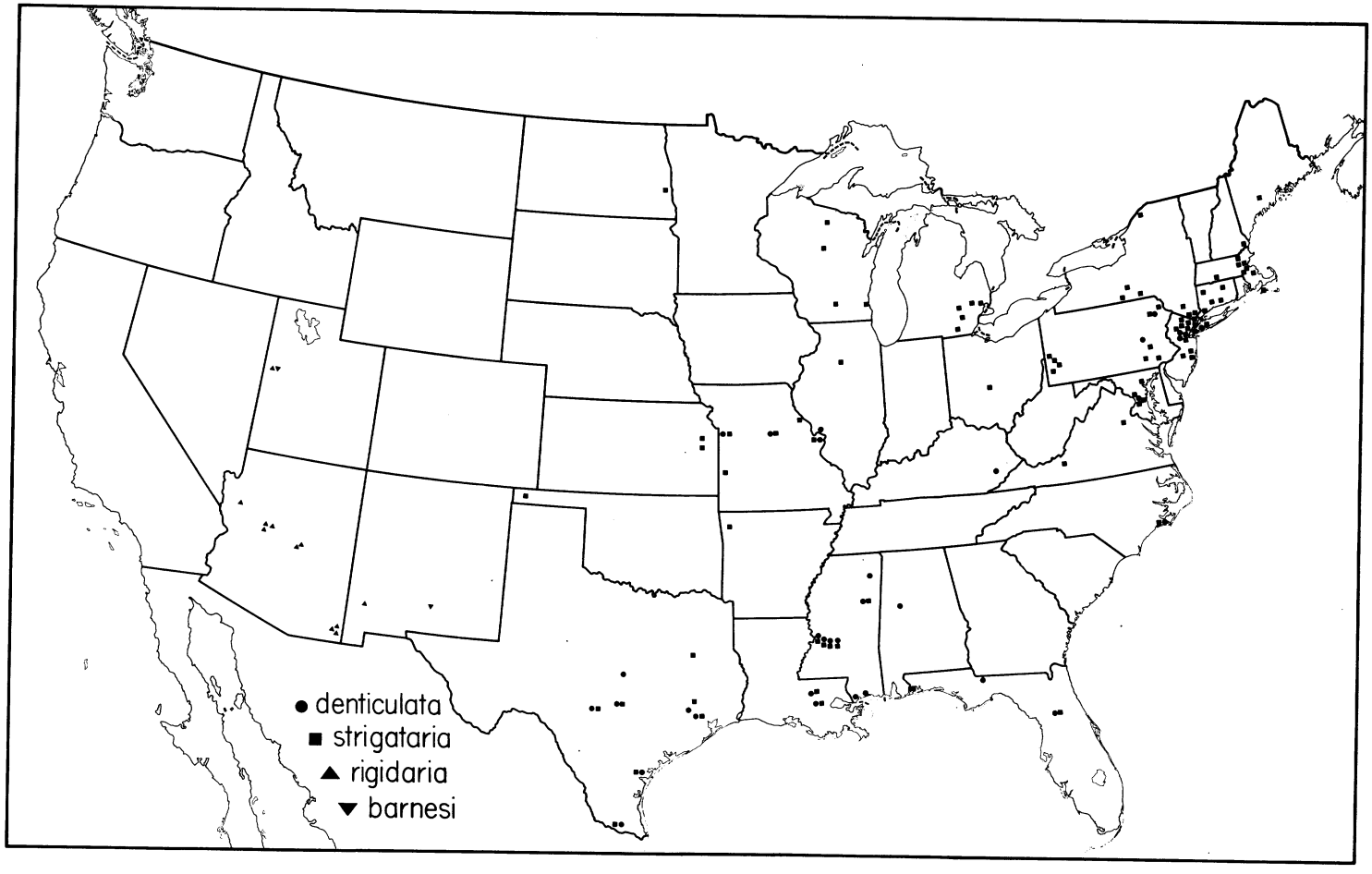


FIG. 76. Distribution of *Cochisea rigidaria* Barnes and McDunnough, *C. barnesi* Cassino and Swett, *Phigalia denticulata* Hulst, and *P. strigataria* (Minot) in the United States.

(531 males, 63 females) and 18 genitalic dissections (13 males, five females) have been studied, including the lectotype and its genitalia.

The males of this species are rather variable in the amount of dark scaling that is present on the upper surface of the forewings. Some specimens lack the black scaling entirely, thus having unicolorous pale gray wings. Others have a broad dark band basad of the t. a. line, and either the area between the median and t. p. lines or the area between the t. p. and s. t. lines is solidly filled in with grayish black or black. A few specimens have the forewings a unicolorous dark gray. In practically all specimens the distinctive denticulate cross lines are visible.

Females apparently heretofore have not been recognized; they were unknown to Forbes (1948, p. 67). They are very similar to the females of *strigataria*, and it is possible that the two have been confused and grouped together in the past. The members of this sex of *denticulata* tend to be slightly larger, somewhat darker in color, and to have longer wings than do the females of *strigataria*. The safest way to differentiate the two is by means of the genitalia; *denticulata* females have a signum in a smaller, more membranous corpus bursae, whereas the signum is absent in the larger and lightly sclerotized corpus bursae of *strigataria*.

The distribution of this species is basically the same as that of *titea*, although the present species does not extend as far to the north or to the west. Based on specimens examined in collections, *titea* appears to be the commoner species in the north, whereas *denticulata* is more often captured in some areas of the south. The present species appears to fly earlier than do the adults of *titea*.

Phigalia strigataria (Minot)

Figures 2, 68-70, 74, 76, 79, 86

Anisopteryx ? strigataria Minot, 1869, p. 84.

Phigalia strigataria: Packard, 1876, p. 407, pl. 11, fig. 3 (adult male) (partim; not pl. 13, fig. 37). Lugger, 1898, p. 249, fig. 194 (adult male) (partim; not fig. 194, female).

Hybernia olivacearia Morrison, 1874, p. 200. NEW SYNONYM.

Hibernia olivacearia: Packard, 1876, p. 407 (placed as synonym of *strigataria*).

Phigalia olivacearia: Grote, 1882, p. 50 (as valid species). Hulst, 1888b, p. 51. Smith, 1891, p. 73; 1903, p. 78; 1910, p. 505. Dyar, "1902" [1903], p. 330. Barnes and McDunnough, 1917, p. 119. W. T. M. Forbes, 1928, p. 604; 1948, p. 67. McDunnough, 1938, p. 166. F. M. Jones and Kimball, 1943, p. 117. Moore, 1955, p. 72. Prentice, 1963, p. 461. Kimball, 1965, p. 183. Shapiro, 1965, p. 94. McFarland, "1966" [1968], p. 17. Covell, 1970, p. 178. Heitzman, "1973" [1974], p. 176. Brower, 1974, p. 105.

Rhaphidodemas olivacearia: Hulst, 1896a, p. 362.

Diagnosis. The males of *strigataria* are smaller than those of the two preceding species. The upper surface of the forewings is paler, with less dark scaling than in *denticulata*, and is faintly olivaceous gray in color. The t. p. and extradiscal lines are straighter, and are not as outwardly dentate on the veins as those of *denticulata*. Compared with *titea*, the females of *strigataria* are smaller, and have noticeably smaller wings that are browner in color.

Male. Head similar to that of *denticulata*; antennae with from 42 to 44 segments, with about the terminal six simple, longest pectinations about three times as long as basal segments, or 0.7 mm. in length. Thorax and legs similar to those of *denticulata*. Abdomen similar to that of *denticulata* but paler.

Upper Surface of Wings: Forewings with mixture of pale gray, dull gray, grayish brown, and brownish black scales, producing a unicolorous gray to faintly olivaceous gray, with variable amount of darker scaling basad of t. a. and distad of t. p. lines; cross lines black, thin, obsolescent, similar in course to those of *denticulata* but differing in being straighter and with t. p. line less strongly outwardly dentate on veins; s. t. line varying from being absent to complete, well marked basally by dark shading; terminal line absent or weakly represented; fringe concolorous with wing. Hind wings similar to those of *denticulata*, tending to be slightly paler and to have less dark scaling; cross lines more weakly represented, with extradiscal line less dentate than that of *denticulata*.

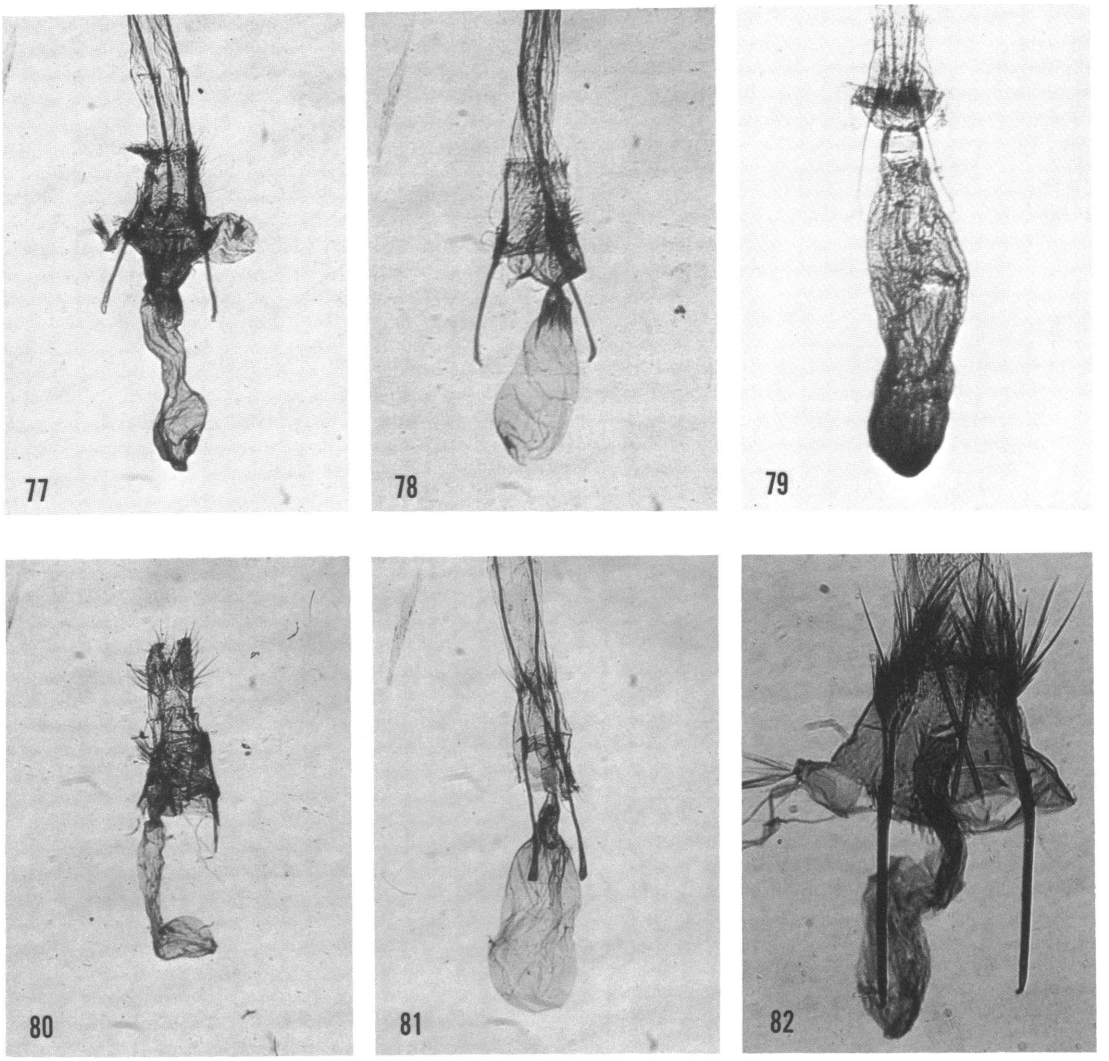
Under Surface of Wings: Similar to that of *denticulata*.

Length of Forewing: 14 to 18 mm.

Female. Similar to that of *titea*, differing mainly as follows: smaller, more slender; head, thorax, and abdomen browner, with practically no pale gray scaling on head, thorax, or wings; wings dark brownish gray, very small, without maculation.

Length of Forewing: 0.8 to 1.2 mm.

Male Genitalia. Similar to those of *titea*, differing mainly as follows: uncus shorter; gnathos



FIGS. 77-82. Female genitalia of *Phigalia* and *Paleacrita*. 77. *Phigalia titea* (Cramer), Scranton, Pennsylvania, April 5, 1919 (M. Rothke; AMNH). 78. *P. denticulata* Hulst, Queens, New York (G. P. Englehardt; AMNH). 79. *P. strigataria* (Minot), West Farms, New York (J. Angus; AMNH). 80. *P. plumigeraria* (Hulst), Corvallis, Oregon, emerged March 8, 1894 (F. L. Washburn; AMNH). 81. *Paleacrita vernata* (Peck), Ithaca, New York, March 20, 1915 (AMNH). 82. *P. longiciliata* Hulst, San Antonio Ranger Station, California, February 12, 1948 (R. E. Beer; AMNH). *P. longiciliata* is shown at twice the magnification of the other species.

with smaller median enlargement; valves with each median swelling bilobed, costal half low, without spines, distal half smaller, raised, covered with short spines; saccus more elongate, with minute anterior ridge; anellus rounded anteriorly, 0.3 to 0.4 mm. wide, posterior portion tapered to blunt point, 0.5 to 0.6 mm. in length; aedeagus with vesica about two-thirds length of aedeagus, in form of straight tube, bearing at apex long, slender, straight spine, 1.3 to 1.6 mm. in length, when exserted vesica extending ventrally and slightly anteriorly, spine turned and converging on anterior end of aedeagus.

Female Genitalia. Sterigma elliptical; ductus bursae smoothly sclerotized, slightly wider than long, joining end of corpus bursae on slight angle, with left side being longer than right; ductus seminalis arising ventrally; corpus bursae broad, elongate, with inner portion at anterior end partially sclerotized, extending more on left side than on right; signum absent; apophyses posteriores 3.3 to 3.4 mm. in length.

Early Stages. Undescribed.

Food Plant. Ulmus americana Linnaeus (Urticaceae; Prentice, 1963, p. 461). The larvae presumably feed on other deciduous trees also.

Types. Minot described *strigataria* from at least two males. One of these is in the Museum of Comparative Zoology; I hereby designate, and have labeled, it as the lectotype.

Morrison described *olivacearia* from a series of 15 males and 25 females. In the Museum of Comparative Zoology are both a male and a female, in excellent condition, labeled as types of *olivacearia.* I hereby designate, and have labeled, the male as lectotype; it is MCZ 14637.

Type Localities. "Taken around Boston," according to the original description; the lectotype is labeled Cambridge, Massachusetts (*strigataria*). Massachusetts, according to the original description; the lectotype is labeled Cambridge (*olivacearia*).

Distribution. Eastern North America (see fig. 76). In Canada this species is known from southern Ontario (Prentice, 1963, p. 461) and southern Quebec. In the United States it occurs from the Atlantic to about longitude 100° W; it is absent in peninsular Florida.

Flight Period. In the south *strigataria* flies in January, February, and March (rarely in December); in the north from March into May (rarely into June).

Remarks. Six hundred seventy-one specimens (640 males, 31 females) and 17 genitalic dissections (14 males, three females) have been studied, including the lectotypes of *strigataria* and *olivacearia.*

Packard (1876, p. 407), presumably having worked with the type specimens of both *strigataria* and *olivacearia*, was the first person to realize that both these names referred to a single species. Subsequent authors did not agree with him. Grote (1882, p. 50) listed the two as distinct species; Hulst (1896b, p. 41) placed *strigataria* as a synonym of *titea*, leaving *olivacearia* as a valid species. The names have since remained as Hulst placed them.

An examination of the lectotypes of *strigataria* and *olivacearia* showed that both had spinose abdomens. Therefore *strigataria* has to be removed from the synonymy of *titea* and placed in group II. I agree with Packard that these two names represent but one species; *strigataria* has priority over the better-known *olivacearia.*

There appears to be less variation in the coloration of the upper surface of the forewings of the males in *strigataria* than there is in *denticulata.* Variation in the amount of dark scaling does indeed exist, with the forewings varying from a unicolorous pale olivaceous gray to occasional specimens that have the basal shade band of the t. a. line and the area distad of the t. p. line grayish black.

I have not seen any melanic males of *strigataria*. Owen (1962, p. 698) reported four melanics from southern Michigan; he claimed them to be "mephistaria," but his identification should be verified.

The females of this species are quite similar to those of *denticulata*; see my discussion under Remarks for the preceding species.

The distribution of this species is basically the same as that of *denticulata*, although the present species extends more to the north and west, but not so far as *titea.* The flight period of *strigataria* appears to be slightly later than that of *denticulata.*

Phigalia plumigeraria (Hulst), new combination
Figures 63, 64, 71, 75, 80, 87

Boarmia ? plumogeraria Hulst, 1888a, p. 216. Rindge, 1955, p. 152.

Boarmia plumogeraria: Smith, 1891, p. 72. Beutenmüller, 1892, p. 194.

Coniodes plumogeraria: Barnes and McDunnough, 1917, p. 119. Essig, 1936, p. 700, fig. 577 (adults, eggs, larvae). McDunnough, 1938, p. 165. J. R. J. L. Jones, 1951, p. 132. Prentice, 1963, p. 460, fig. 290 (distribution in Canada). Sugden, 1968, p. 26.

Coniodes plumigeraria (emendation): Hulst, 1896a, p. 353; 1898, p. 214. Dyar, "1902" [1903], p. 329; 1903c, p. 168. Smith, 1903, p. 78. Holland, 1919, p. 345, figs. 205a, b (adult male, female), 206a-c (larvae; both from Coquillett).

Boarmia plumigeraria: Coquillett, 1897, p. 64, figs. 40a-c (larvae), 41a, b (adult male, female).

Conniodes (*sic*) *plumogeraria* form *immacularia* Cassino and Swett, 1922a, p. 150. McDunnough, 1938, p. 165.

Diagnosis. The males can be separated from all other members of the genus by the antennae having fewer segments and much longer pectinations, by their larger wings, and by the forewings above being a unicolorous gray with almost straight cross lines. The females are large, have pale gray scaling on the head, thorax and sides of the abdomen; the wings are pale gray, and about 1.5 mm. in length.

Male. Head with vertex having mixture of pale gray and dark grayish brown elongate scales; front grayish brown; palpi with mixed pale gray and grayish brown scales; antennae of from 30 to 34 segments, with terminal one or two nonpectinate, pectinations arising near base of segments, very long, 10 times as long as basal segments, or 2.4 to 2.8 mm. in length. Thorax above similar to vertex, with median tuft posteriad of collar; below pale grayish brown anteriorly, pale gray posteriorly; legs dark grayish brown, ends of tarsal segments narrowly grayish white. Abdomen above rather thinly scaled with pale gray scales, not completely covering brown spines; below pale gray.

Upper Surface of Wings: Forewings with even mixture of pale gray and darker gray scales, producing unicolorous gray; maculation weakly represented or partially obsolescent; cross lines, when present, grayish brown, and tending to be more or less straight; t. a. line outwardly oblique; median line weakly convex; discal dot varying from small and prominent to absent; t. p. line subparalleling outer margin, somewhat thickened on veins; s. t. line tending to be as strong or stronger than other lines, complete, inwardly dentate on veins; terminal line narrow, interrupted by veins; fringe concolorous with wing. Hind wings paler than forewings, pale gray, with scattered darker gray scales; discal spot prominent; cross lines absent except for trace of extradiscal line posteriorly, and for prominent s. t. line; terminal line complete, narrow; fringe concolorous with wing.

Under Surface of Wings: Similar to upper surface but forewings slightly darker; maculation absent except for discal dots on all wings and for partial s. t. lines; terminal lines complete, narrow; fringes concolorous with wings.

Length of Forewing: 18 to 24 mm.

Female. Similar to male, but with much shorter, tighter scaling; fore tibial process 0.3 mm. in length; body similar to that of male, with pale gray scaling predominating dorsally; abdomen with first segment tending to be brown, remaining segments brownish gray. Wings pale gray, with faint trace of single cross line.

Length of Forewing: 1.3 to 1.9 mm.

Male Genitalia. Similar to those of *titea*, differing mainly as follows: smaller; uncus with truncate apex having two minute, diverging points 0.1 mm. apart; gnathos with reduced median area tapering to point; valves with each median swelling about 0.10 mm. long and 0.07 mm. wide, bearing fewer spines; anellus flattened anteriorly, maximum width 0.4 mm., posterior extension relatively short, triangular, 0.5 mm. in length; aedeagus widest anteriorly, tapering posteriorly, with small triangular or rectangular sclerotized piece in vesica.

Female Genitalia. Sterigma poorly defined; ductus bursae bell-shaped, broadest posteriorly, slightly longer than wide; ductus seminalis arising on right side; corpus bursae elongate, slender, with anterior end lobate; signum absent; apophyses posteriores 1.4 to 1.5 mm. in length.

Early Stages. These have been described, among others, by Coquillett [1897, p. 64, fig. 40 a-c, larvae; and quoted by Holland (1919, p. 345), who also reprinted the larval figures], Dyar (1903c, p. 168), and Sugden (1968, p. 26). Additional references are given in Tietz (1972, p. 533).

Food Plants. The larvae are apparently general feeders on trees. The following have been given as hosts: *Salix* (Salicaceae); *Quercus* (Fagaceae); *Juglans* (Juglandaceae); *Malus*, *Prunus*, "various rosaceous plants" (Rosaceae); and *Acer* (Aceraceae). The above have been given by Coquillett (1897, p. 64), Dyar (1903c, p. 168), J. R. J. L. Jones, (1951, p. 132), Prentice, (1963, p. 461), and Sugden (1968, p. 26).

Types. The holotype, male, of *plumigeraria* is in the collection of the American Museum of Natural History, being from the Henry Edwards collection (Beutenmüller, 1892, p. 194). Its genitalia are mounted on slide FHR 17410. The specimen from the Hulst collection is not the type, as it is labeled Glenwood Springs, Colorado (Rindge, 1955, p. 152).

The holotype, male, of *immacularia* is MCZ 16907, with its genitalia mounted on Cassino's slide 1284.

Type Localities. For *plumigeraria*, California. The holotype bears Henry Edwards's number 4179; the entry for this number in Edwards's catalogue merely gives California, collected by Henry Edwards in January at a gas lamp. For *immacularia*, Wallace, Shoshone County, Idaho.

Distribution. Western North America, from southern California and the western foothills of the Sierra Nevadas in central California to southern Vancouver Island, British Columbia (Prentice, 1963, p. 460, fig. 290). The species is apparently relatively common as far north as the Columbia River. Specimens are known from eastern Washington, Idaho, and south-central British Columbia; all these localities are in the drainage system of the Columbia River. The species is also known from Utah, Colorado, and Arizona. (See fig. 71.)

Flight Period. The majority of specimens have been taken in late December, January, February, and March. A few moths have been taken in April, May, June, July, August, September, and October; it is possible that some of these dates may be labeling errors.

Remarks. Five hundred forty-seven specimens (535 males, 12 females) and 13 genitalic dissections (11 males, two females) have been studied, including the holotypes of *plumigeraria* and *immacularia.*

The spelling of the specific name of this species has been in a state of confusion. The original spelling was *plumogeraria* (Hulst, 1888a, p. 216); Hulst's holographic type label also has this spelling. Nevertheless, in the subsequent times that Hulst cited this name in the literature he spelled it *plumigeraria* (1896a, p. 353; 1898, p. 214). In the latter publication he said: "This insect was described from the ♂ only as *Boarmia plumigeraria* . . ." It thus seems to me that Hulst intended to use *plumigeraria*, and that *plumogeraria* should be considered to be an incorrect original spelling, justifiably emended.

Cassino and Swett named *immacularia* from northern Idaho, using specimens "entirely without maculations on the primaries or secondaries" (1922a, p. 150). Nearly 50 males have been examined from the type locality, and this population usually has the cross lines present, although they are less prominent than those on specimens from Oregon and California. This difference probably reflects the different climatic conditions where the moths occur; this is noticeable also in the western population of *Erannis tiliaria.* Consequently I do not believe the name *immacularia* can be retained in a subspecific sense, and so should be placed in the synonymy.

GENUS *PALEACRITA* RILEY

Paleacrita Riley, 1876, p. 278. Hulst, 1896a, p. 257. Dyar, "1902" [1903], p. 266. Smith, 1903, p. 65. Mosher, 1917, p. 54. W. T. M. Forbes, 1948, p. 67.

Palaeacrita (*sic*): Barnes and McDunnough, 1917, p. 119. McDunnough, 1938, p. 166.

Diagnosis. The species of this genus can be distinguished by the upper surface of the abdomen having two rows of spines per segment (see fig. 3); those on segments two and three are larger and thicker than the others. The males have antennal segments that have either one or

two swellings, from which arise an elongate group of setae. The females have simple, setose antennae. The latter sex has greatly reduced wings, less than 1 mm. in length.

Adult. Male: Head with eyes large, round, naked; tongue absent; palpi either very short, just reaching front, or more elongate, slender, projecting beyond front; antennae of from 30 to 41 segments, each segment with either one or two swellings, and with elongate setae arising from each swelling, extending to apex, with setae 0.4 to 1.0 mm. in length. Thorax slender; fore tibia without terminal spine, with process arising before, at, or beyond middle of segment; hind tibia with two pairs of slender spines having elongate points. Abdomen slender; dorsal surface with two rows of spines per segment, those on segments two and three larger and thicker than others.

Forewings either broad and relatively short, or elongate, with pointed apex; with 12 veins, crowded together near end of cell, R_1 arising before end of cell, separate, R_2 from before upper angle, separate or shortly anastomosed with R_{3+4}, R_{3+5} from angle; hind wings with Sc approximate to R along basal third or half of cell; Rs and M_1 either stalked or free.

Upper surface of wings gray, with reduced maculation, cross lines usually obsolescent or absent; hind wings paler than forewings, without maculation except for discal dot.

Female: Similar to male, differing mainly as follows: eyes reduced; antennae simple, with elongate setae, of about 29 to 32 segments; legs and body with elongate setae; fore tibia without process or depression; hind tibia with two pairs of very small spurs; tympanic organs reduced to small sclerotized plate.

Wings brachypterous, reduced to less than 1 mm. in length.

Male Genitalia. Uncus elongate, slender, apex with either two divergent ventral points or appearing as single one; gnathos slender, median area either V-shaped or as elongate, rounded projection; valves varying from simple and evenly tapering to having broad base and narrow terminal portion, costa broadly sclerotized, with either small, median, longitudinal, setose swelling, or large, prominent, curved, heavily spined process; anellus broad, ovate or elongate; aedeagus simple, subequal in length to combined lengths of uncus, tegumen and saccus; vesica unarmed or with small, inconspicuous sclerotized strip.

Female Genitalia. Sterigma weakly sclerotized, elongate, poorly defined, lamella antevaginalis either membranous and not differentiated or heavily sclerotized and broad; ductus bursae an elongate, simple tube; ductus seminalis arising either dorsally from posterior end of corpus bursae, or from right side medially of ductus bursae; corpus bursae membranous, elliptical; signum absent or present; apophyses posteriores 0.9 to 4.0 mm. in length.

Early Stages. See species references.

Food Plants. Polyphagous on deciduous trees (*vernata*, ? *merriccata*); *Adenostoma*, evergreen shrubs of the family Rosaceae (*longiciliata*).

Type Species. Phalaena vernata Peck, 1795; by original designation and sole included species.

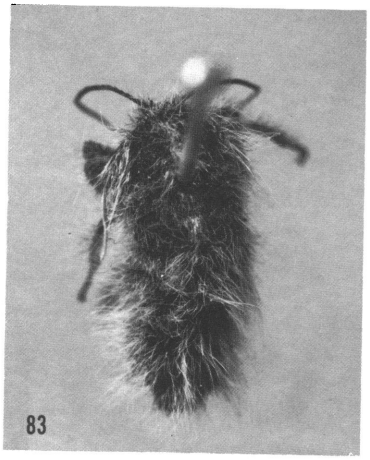
Distribution. North America.

Remarks. Paleacrita contains three species. The relationships among them are not altogether clear. When the males are compared, using the type of antennae, wing shape, and genitalia, a mosaic of characters results. However, the species form an easily recognized, compact genus. *Paleacrita merriccata* is very similar to *vernata* except for the antennae and genitalia; the latter structures for *merriccata* are very different in both sexes.

The Old World genus *Apocheima* Hübner has characters that are, in some respects, intermediate between *Phigalia* and *Paleacrita.* The males of *Apocheima hispidaria* (Denis and Schiffermüller), the type species, have pectinate antennae. The dorsal surface of the abdomen is covered with numerous spines of equal size with the exception of segments two and three; on these, there is an anterior row of short thick spines, a median row of elongate thick spines, and a posterior row of longer, thin spines. The species of group II of the North American *Phigalia* have these two segments covered with several rows of more or less equal sized spines; *Paleacrita* has only the double row of enlarged, thick spines on these segments.

The scientific names of many of the citations in the literature, particularly those of the last century, cannot be relied upon. There has been

considerable confusion between *Paleacrita vernata* (Peck), the spring canker-worm, and *Alsophila pometaria* (Harris), the fall canker-worm; some authors even interchanged the two. Consequently, considerable care should be taken when consulting and citing references.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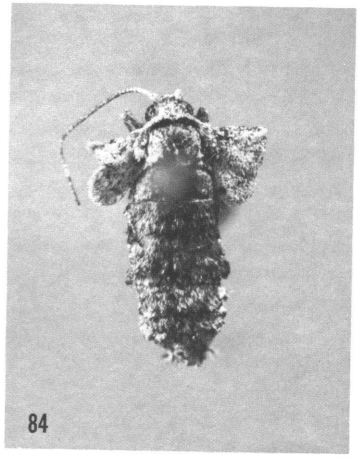
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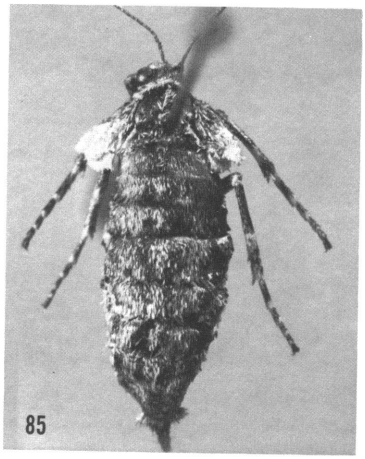
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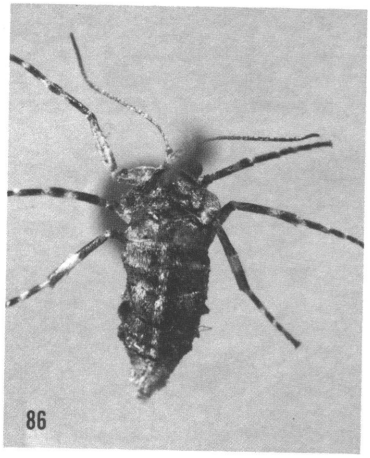
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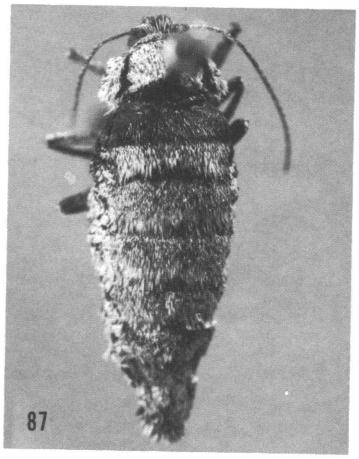
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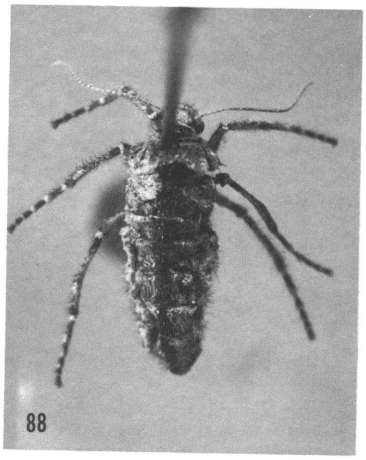
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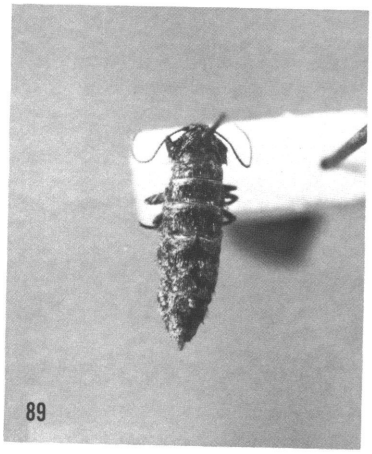
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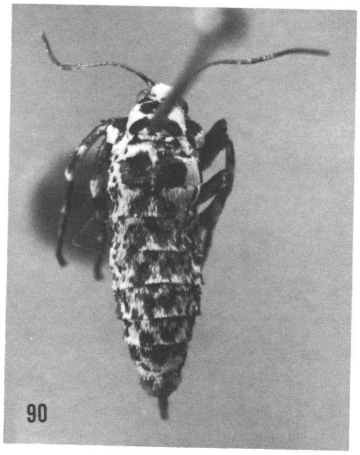
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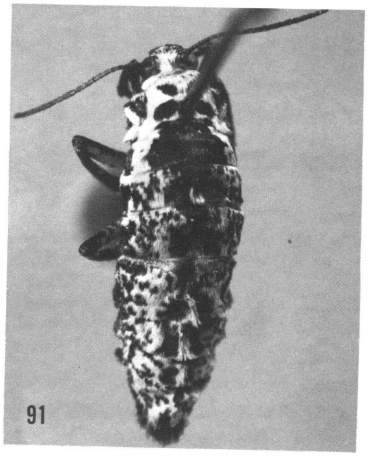
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KEY TO SPECIES

Based on Morphology and Distribution

1. Males 2
   Females 4
2. Antennae with one swelling per segment . . . 3
   Antennae with two swellings per segment . . . . . *vernata*
3. Antennal setae 1 mm. in length; forewings elongate, with small black discal dot . . . . . *longiciliata*
   Antennal setae 0.5 mm. in length; forewings broad, with large, prominent white discal spot . . . . . *merriccata*
4. Body above mostly pale gray, with some dark scaling, and some specimens with dark mid-dorsal stripe; legs tending to be dark brown, with ends of tarsal joints grayish white . . . . . *vernata*
   Body above darker gray or grayish brown, without median dorsal stripe; legs tending to be dark gray, with ends of tarsal joints weakly or not contrastingly colored 5
5. From California . . . . . *longiciliata*
   From eastern North America . . . . *merriccata*

Based on Male Genitalia

1. Each valve with small, inconspicuous raised spinose ridge adjacent to and paralleling costa 2
   Each valve with large, prominent, curved, lengthily spinose area across face of valve . . . . . *merriccata*
2. Valves with outer margin rounded, tapering to apex . . . . . *vernata*
   Valves with very broad base, outer margin approaching costa medially, with slender apex . . . . . *longiciliata*

Based on Female Genitalia

1. Signum present . . . . . *merriccata*
   Signum absent 2
2. Apophyses posteriores about 4.0 mm. in length . . . . . *vernata*
   Apophyses posteriores 0.9 mm. in length . . . . . *longiciliata*

Paleacrita vernata (Peck)

Figures 3, 81, 88, 92-94, 100, 102

Phalaena vernata Peck, 1795, p. 415.

Anisopteryx vernata: Packard, 1876, p. 402, pl. 11, fig. 2, (adult male), pl. 13, figs. 6 (larva), 39 (adult female). Hulst, 1888b, p. 51. Beutenmüller, 1890, p. 222. Gumppenberg, 1893, p. 397.

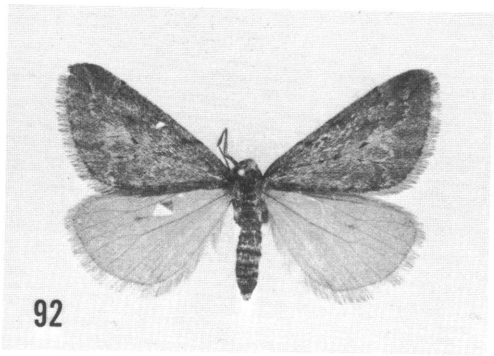
Paleacrita vernata: Riley, 1876, p. 274, figs. 14a-d (egg, larva), 15a, b (venation), 15c (antennal segment), 16a (adult male), 16b-e (adult female), 17 (pupa). Hulst, 1896a, p. 257. Lugger, 1898, p. 251, fig. 195 (adults, larvae; after Riley, 1876). Dyar, 1902, p. 428; "1902" [1903], p. 266. Smith, 1903, p. 65; 1910, p. 504, figs. 211a-e (adult male and female), 212a-d (egg, larva; after Riley, 1876). Mosher, 1917, p. 55, figs. 3C, D (pupae). Holland, 1919, p. 324, figs. 195, 196 (larva, adults; after Riley, 1876), *partim*, not pl. 42, figs. 25, 26. W. T. M. Forbes, 1928, p. 604; 1945, p. 186; 1948, p. 68, figs. 28, 29 (venation). Bowman, 1944, p. 192. Jerrel and Jaques, 1944, p. 465. Gray, 1953, p. 127. Prentice, 1963, p. 463, fig. 291 (distribution in Canada). Muller, "1968" [1969], p. 266. Heitzman, "1973" [1974], p. 176.

Palaeacrita (*sic*) *vernata*: Barnes and McDunnough, 1917, p. 119. McDunnough, 1938, p. 166. Moore, 1955, p. 72. McFarland, "1966" [1968], p. 17. Covell, 1970, p. 178. Brower, 1974, p. 106.

Anisopteryx sericeiferata Walker, 1862, p. 1697. Packard, 1873, p. 88 (placed as synonym of *vernata*).

Paleacrita autumnata (misidentification, not Packard, 1876): Dyar, "1902" [1903], p. 266

FIGS. 83-91. Females. 83. *Lycia rachelae* (Hulst), Aweme, Manitoba, emerged May 3, 1904 (AMNH). 84. *Phigalia titea* (Cramer), Lewisboro, New York, April 11, 1969 (M. and T. M. Favreau; AMNH). 85. *P. denticulata* Hulst, Hyattsville, Maryland, March 10, 1956 (Ghika; AMNH). 86. *P. strigataria* (Minot), Rye, New York, March 16, 1934 (Ghika; AMNH). 87. *P. plumigeraria* (Hulst), Corvallis, Oregon, February, 1962 (LAM). 88. *Paleacrita vernata* (Peck), Rye, New York, March 17, 1928 (Ghika; AMNH). 89. *P. longiciliata* Hulst, 10 miles NE of Gilroy, California, October 29, 1958 (G. Okuimura; AMNH). 90. *Erannis tiliaria tiliaria* (Harris), Rye, New York, November 14, 1928 (Ghika; AMNH). 91. *E. tiliaria vancouverensis* Hulst, William Head, British Columbia, November 5, 1958 (AMNH). All ×3.7.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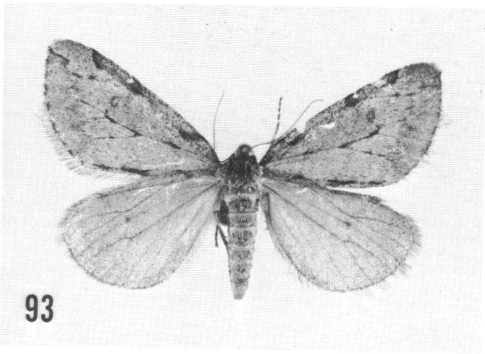
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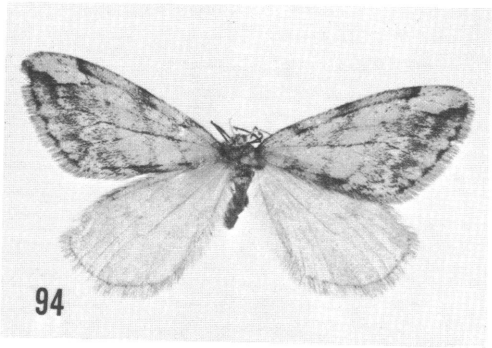
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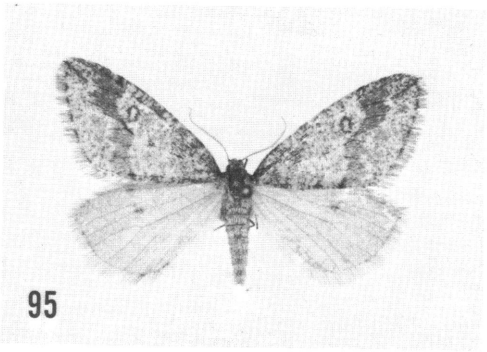
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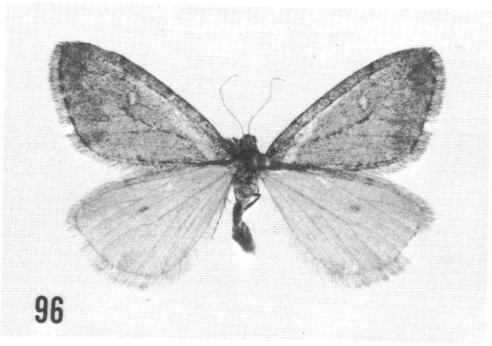
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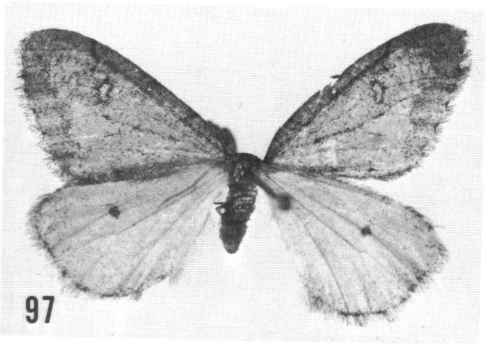
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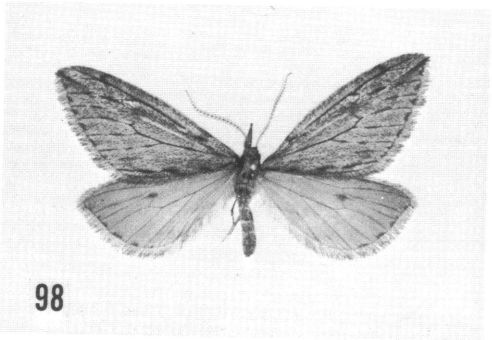
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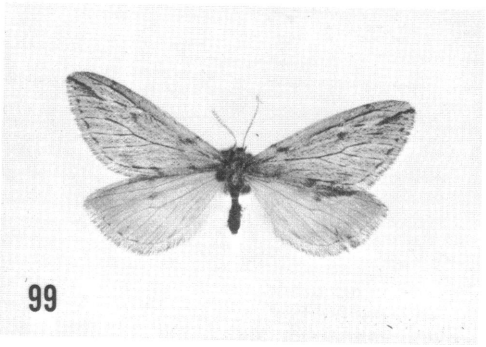
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(synonym of *vernata*). W. T. M. Forbes, 1948, p. 68 (in part).

Palaeacrita (*sic*) *autumnata* (in part): Barnes and McDunnough, 1917, p. 119. McDunnough, 1938, p. 166.

Paleacrita speciosa Hulst, 1898, p. 113. Dyar, "1902" [1903], p. 266. Smith, 1903, p. 65. Rindge, 1955, p. 154. NEW SYNONYM.

Palaeacrita (*sic*) *speciosa*: Barnes and McDunnough, 1917, p. 119. McDunnough, 1938, p. 166. Sorensen, 1967, p. 57.

Diagnosis. The males can be recognized by each antennal segment having two swellings. The forewings are relatively short and broad; the discal dot is small or absent. The females have the body and appendages with numerous, erect, elongate, hairlike scales.

Male. Head with vertex pale gray to grayish brown; front dark grayish brown; palpi dark brown, very short, just reaching front; antennae of about 32 or 33 segments, each segment with two setose swellings, setae about 0.4 mm. in length. Thorax above grayish brown, collar pale gray at base, patagia with faint, poorly defined band; below gray; legs grayish brown, with variable amount of black scaling, ends of tarsal segments tending to be gray; fore tibia with process arising just distad of middle of segment. Abdomen gray or grayish brown above and below.

Wings: Forewings relatively short and broad; hind wings with Rs and M_1 stalked.

Upper Surface of Wings: Forewings pale gray or gray, with variable number of evenly spaced grayish brown scales; cross lines obsolescent or absent in most specimens, rarely well defined, dull black when present; t. a. line arising on costa one-fourth distance from base, outwardly angled or curved to cell or vein Cu, then angled posteriorly and going straight to anal vein, usually fading out before reaching inner margin; median line present or absent, arising at middle of costa about three-fourths distance from base, extending in two concave arcs to meet inner margin about two-thirds distance from base; apex of wing either concolorous with remainder of wing or with white patch, delimited posteriorly by black line on vein M_1 to subterminal area, then angled toward apex, meeting outer margin in cell R_4; subterminal area either concolorous with remainder of wing or appearing as broad dark band distad of t. p. line; s. t. line obsolescent; terminal line either obsolescent or appearing as series of black intravenular dots; fringe concolorous with wing. Hind wings pale grayish white, with a few grayish brown scales distally; without maculation except for small discal dot.

Under Surface of Wings: Forewings pale grayish brown; hind wings white with numerous, evenly spaced dark grayish brown scales; without maculation except for discal dots, present or absent on forewings, present on hind wings.

Length of Forewing: 11 to 18 mm.

Female. Body and all appendages with numerous, erect, elongate hairlike setae; body colored as in male; legs tending to be paler, more unicolorous than those of male.

Male Genitalia. Uncus with apex curved ventrally, slightly widened and terminating in two small lateral points; gnathos with elongate, apically rounded, finely rugose median projection; valves simple, tapering from broad base to rounded apex, each costa with inner margin having small, median, longitudinal setose swelling; anellus elongate; aedeagus with longitudinal striations posteriorly, vesica unarmed or with very small, inconspicuous sclerotized strip.

Female Genitalia. Sterigma scarcely differentiated, elongate, with a few transverse striations; ductus bursae with elongate, narrow posterior section, 0.7 mm. in length, slightly tapering anteriorly, joining shorter, more heavily sclerotized, wide anterior section, increasing in width anteri-

FIGS. 92-99. Males of *Paleacrita*. 92-94. *P. vernata* (Peck). 92. Independence, Missouri, March 8, 1972 (J. R. Heitzman; AMNH). 93. Severn Bridge, Ontario, April 5, 1967 (G. E. Scott; AMNH). 94. Holotype of *P. speciosa* Hulst, Glenwood Springs, Colorado, "4/3 1893" (W. Barnes; AMNH). 95-97. *P. merriccata* Dyar. 95. New Brighton, Pennsylvania, March 15, 1902 (H. D. Merrick; AMNH). 96. 2 miles NW of Meyersville, New Jersey, March 23, 1963 (J. M. Burns; AMNH). 97. Prairieville, Louisiana, March 2, 1974 (V. A. Brou; AMNH). 98, 99. *P. longiciliata* Hulst. 98. Laytonville, California, December 23, 1948 (R. F. Sternitzky; AMNH). 99. San Diego, California, December 12, 1911 (Ricksecker; AMNH). All × 1.5.

orly; ductus seminalis arising dorsally; corpus bursae attached to ductus bursae on angle, posterior end longer than anterior, remainder of corpus bursae large, elliptical; signum absent; apophyses posteriores 4.0 to 4.2 mm. in length.

Early Stages. I have not made an attempt to make a complete list of the references to the early stages of *vernata*, the spring canker-worm; a number are listed in Tietz (1972, p. 667). In the past there has been a good deal of confusion between *vernata* and *Alsophila pometaria* (Harris), the fall canker-worm; the listing in Tietz was not critically done and may include both species under the name *vernata.* One of the best comparisons of the eggs, larvae, chrysalises, and adults of *vernata* and *pometaria* was by Riley (1876). Some descriptions of the early stages are found in Dyar (1902, p. 428), Mosher (1917, p. 55) and W. T. M. Forbes (1948, p. 68).

Food Plants. Polyphagous on deciduous trees (Prentice, 1963, p. 463; Tietz, 1972, p. 667). When the larval population reaches epidemic proportions and defoliates the primary host plants, the caterpillars come to the ground on silken threads and complete their development on available shrubs and herbs. In North Dakota in 1970 and 1971 defoliation of *Ulmus* (Siberian elm) was followed by an attack on adjacent fields of flax (*Lisum*) (Stein, 1974, p. 783, figs. 1a, 1b).

Types. Unknown and presumed lost (*vernata*).

Walker described *sericeiferata* from five male specimens; three are still in the collection of the British Museum (Natural History). I hereby designate as the lectotype the one bearing the label "*Anisopteryx sericeiferata*" cut from a copy of Walker's list (1862).

Hulst did not specify either the number or the sex of the specimens of *speciosa* although the original description obviously applies to the male. The specimen labeled as type from the Hulst collection is the holotype; it is in the American Museum of Natural History (Rindge, 1955, p. 154).

Type Localities. None given for *vernata*, although Peck made his observations at Kittery, Maine (Packard, 1876, p. 404); this should be considered the type locality of *vernata.* United States (*sericeiferata*). Glenwood Springs, Garfield County, Colorado (*speciosa*).

Distribution. North America (see fig. 100). In Canada, *vernata* is found from Nova Scotia into Saskatchewan (Prentice, 1963, p. 463, fig. 291). In the eastern United States, it extends from Maine to Tennessee and North Carolina in the mountains. It is found in the central United States from Michigan to North Dakota, south to Mississippi, Louisiana, and eastern Texas. It is known from Colorado, and there is one record from Siskiyou County, California.

Essig (1936, p. 699) recorded *Paleacrita vernata* from Berkeley, California, and from several western states. However, the specimens that were under this name in the California Insect Survey collection have been identified by me as *longiciliata.* The one record, given above, for Siskiyou County, California, is correct; specimens have been collected at Yreka by S. G. Jewett, Jr., and are in his collection and that of the American Museum of Natural History. Essig cited Quaintance (1907, p. 17) in his paragraph on *vernata*; the distribution data given by Essig did not come from that article.

Flight Period. January, February, and March in the south; March, April, and May in the north. An occasional specimen in New England may be caught in June and July.

Remarks. Eight hundred ninety specimens (758 males, 132 females) and 13 genitalic dissections (nine males, four females) have been studied, including the type of *speciosa.*

The males of *vernata* tend to have rather variable maculation. The majority of specimens have the upper surface of the forewings more or less unicolorous gray with indistinct maculation. Another form has grayish white forewings with distinct cross lines and a large white apical patch. The holotype of *speciosa* is so marked; I have seen very few specimens from Colorado and so cannot say whether this is the predominant form in that area. However, the *speciosa*-type of maculation appears throughout much of the range of *vernata*; specimens are before me from most of the midwestern states (Texas to Minnesota and Wisconsin). Material from Ontario and the New York-New Jersey area tends to be somewhat intermediate between the darker unicolorous form and the *speciosa*-type. Sorensen (1967, p. 57) has already commented on the occurrence of the *speciosa*-type of maculation at Minneapolis, Minnesota, quoting some of my remarks to him. The

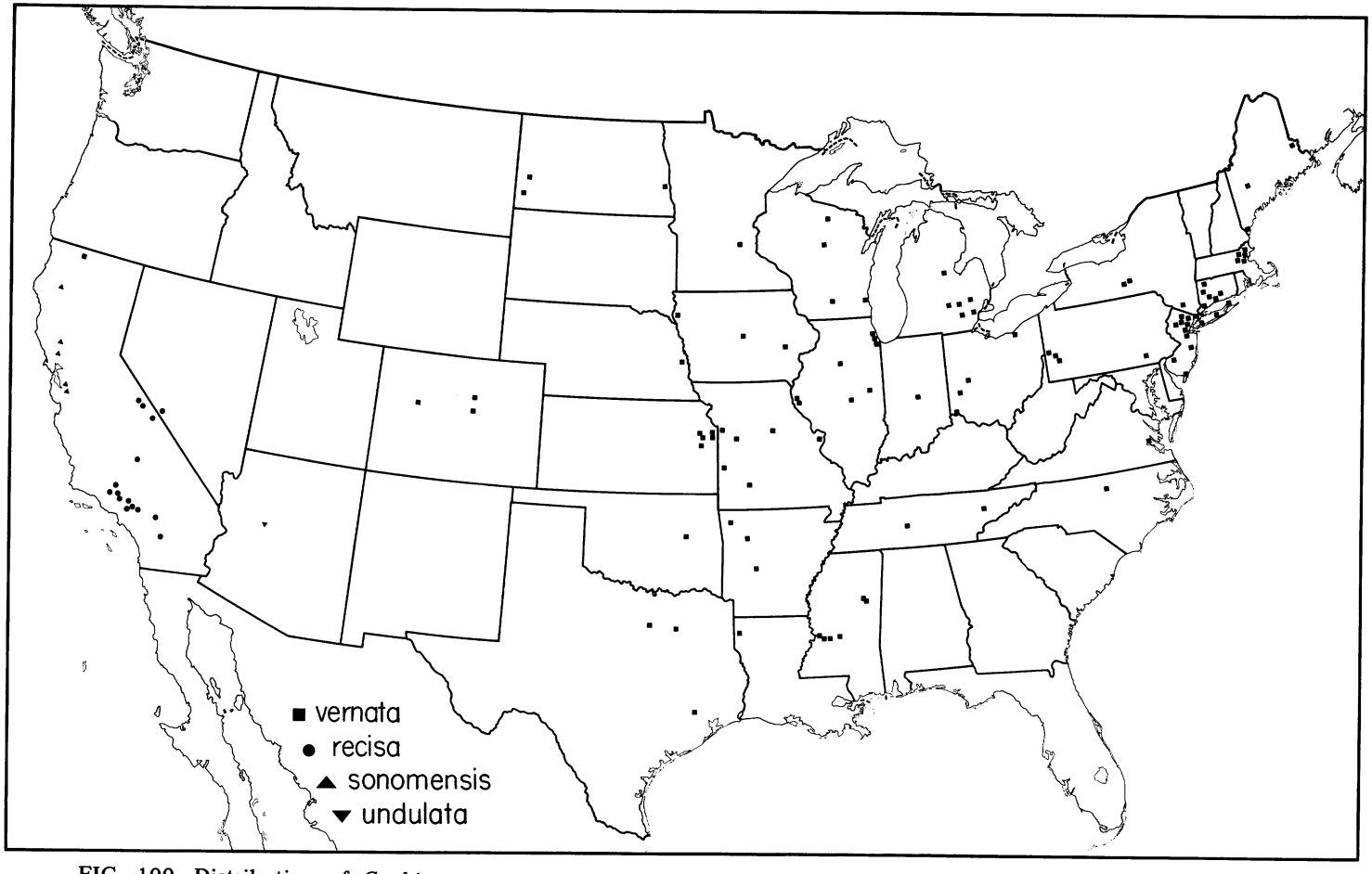


FIG. 100. Distribution of *Cochisea recisa*, new species, *C. sonomensis* McDunnough, *C. undulata*, new species, and *Paleacrita vernata* (Peck) in the United States.

genitalia of the two forms are indistinguishable. Thus it appears that *speciosa* represents only a color form of *vernata* that becomes commoner in the western portion of the range of that species, and is not a distinct species or even a subspecies. Consequently, it is placed in the synonymy.

Gray (1953, p. 127) has compared the females of *vernata* and two other species of wingless geometrids occurring in the northeast. Specimens of *vernata* can be recognized by the spines on the upper surface of the abdomen; this is true for both males and females.

Many of the early workers thoroughly confused *vernata*, the spring canker-worm, and *Alsophila pometaria* (Harris), the fall canker-worm; I have made no attempt to sort these references nor to include them in this paper. Packard did correctly separate these two species, describing, comparing, and illustrating the adults and early stages of *vernata* [1876, p. 402, pl. 11, fig. 2 (male), pl. 13, fig. 39 (female), pl. 13, fig. 6 (larva)] and *pometaria*, which he renamed *Anisopteryx autumnata* [*op. cit.*, p. 400, pl. 11, fig. 1 (male), pl. 13, fig. 38 (female)]. Both Mann (1876, p. 164) and Hulst (1888b, p. 51) placed *autumnata* as a synonym of *pometaria*. Subsequent authors treated *autumnata* Packard either as a synonym of *vernata*, or placed it in the synonymy of both *vernata* and *pometaria*; references are given in the species bibliography above. I agree with Mann and Hulst, as the original description of *autumnata* unmistakably describes and illustrates what is now known as *pometaria*. Packard based his description on six males and one female. I have been able to find only a female labeled as being from the Packard collection and bearing Packard's type label. This specimen is hereby designated, and has been labeled, as the lectotype of *Anisopteryx autumnata*; it is MCZ cotype 30354, and is without a locality label. The lectotype is in good condition but lacks the right antenna; it is an example of *pometaria* Harris, 1841. Hence *autumna* becomes a junior synonym of that species, and is removed from association with *vernata*. The whereabouts and identification of Packard's six syntype males remains an unanswered question. No specimens in the collection of the Museum of Comparative Zoology are so labeled in the series of *pometaria*, *vernata* or any other Bistonini, with the exception of one male from "Ill."; this cannot be considered a syntype, as the locality was not given in the original description.

Paleacrita merriccata Dyar
Figures 95-97, 101, 103

Paleacrita vernata merriccata Dyar, "1902" [1903], p. 266. Smith, 1903, p. 65.
Paleacrita merriccata: W. T. M. Forbes, 1948, p. 68. Heitzman, "1973" [1974], p. 176.
Palaeacrita (*sic*) *merriccata*: Barnes and McDunnough, 1917, p. 119. McDunnough, 1938, p. 166. McFarland, "1966" [1968], p. 17.

Diagnosis. The males can be separated from those of *vernata* by each antennal segment having but one swelling, and by the large, round, white discal dot of the forewing.

Male. Head similar to that of *vernata*; palpi shorter, not reaching front; antennae of about 37 to 41 segments, each segment with single setose swelling, setae about 0.5 mm. in length. Thorax similar to that of *vernata*, more unicolorous above; legs similar to those of *vernata*; fore tibia with process tending to arise slightly more distad than that of *vernata*. Abdomen similar to that of *vernata*.

Wings: Similar in shape and venation to those of *vernata*.

Upper Surface of Wings: Forewings similar to those of *vernata*, less variable in maculation, with cross lines obsolescent; discal dot white, 0.7 to 0.8 mm. long, narrowly outlined in dark grayish brown; t. p. line usually represented by dark costal dash; cubital vein variably dark scaled where cross lines would cross; s. t. line tending to be slightly stronger than that of *vernata*, grayish white, irregular in course, with terminal area tending to be darker than remainder of wing; terminal line and fringe similar to those of *vernata*. Hind wings similar to those of *vernata*.

Under Surface of Wings: Similar to those of *vernata*, with hind wings slightly darker; most specimens without maculation except for t. p. dash on costa, small white discal spot on forewing, and dark discal dot on hind wings.

Length of Forewing: 14 to 18 mm.

Female. Body and all appendages with numerous, erect, grayish black hairlike setae; body darker gray than that of male, with abdomen becoming paler gray posteriorly, with narrow,

transverse black bands on posterior ends of segments four, five, and six; legs dull gray and dark gray, tarsal joints only weakly differentiated with paler scales.

Male Genitalia. Uncus tapering to point posteriorly, apex extended anteriorly to about middle of uncus, terminating in two lateral points; gnathos with median area finely denticulate, V-shaped; valves with sides slightly narrowing to beyond middle, then tapering, ending before apex, with large, prominent, curved, heavily spinose area medially, and with sacculus raised, sclerotized and bearing three or four elongate teeth; anellus elongate, tapering from wide base; saccus very long and slender; aedeagus long and slender, vesica with small sclerotized strip.

Female Genitalia. Sterigma membranous except for weakly sclerotized, narrow anterior and lateral strip; lamella antevaginalis sclerotized, broad, 0.2 mm. wide, approximately U- or V-shaped, with posterior ends having median margins curving ventromedially; ductus bursae heavily sclerotized, 0.7 mm. in length, slender, with longitudinal ribs; ductus seminalis arising medially from right side of ductus bursae; corpus bursae with asymmetrical posterior end, diagonally swollen, with bulge on left side farther posteriad than one on right, anterior portion rounded; signum located ventromedially, partially on right side, and having two inwardly pointing projections; apophyses posteriores 3.5 mm. in length.

Early Stages. Unknown.

Food Plant. Unknown.

Type. No type specimens were mentioned in the original description. In the collection of the National Museum of Natural History is a series of 21 males that are probably syntypes; one bears a handwritten label "var. merriccata Dyar." This last specimen is hereby designated, and has been labeled, as the lectotype.

Type Locality. None was given with the original description. The lectotype is from New Brighton, [Beaver County], Pennsylvania, March 22, 1902 (H. D. Merrick).

Distribution. Eastern North America (see fig. 101). The range is either disjunct throughout this area, or else it is relatively poorly known as yet. The species is present in New Jersey and adjacent New York and Connecticut, southern Ontario, western Pennsylvania, central Illinois (Forbes, 1948), eastern Missouri (Forbes, 1948; Heitzman, "1973" [1974]), west central Mississippi, Louisiana, and eastern Texas. McFarland ("1966" [1968], p. 17) reported this species from northeastern Kansas; this may be in error, as no specimens of *merriccata* are in his collection.

Flight Period. Northern specimens have been taken during March, April, and May; southern specimens fly during January and February.

Remarks. Ninety-eight specimens (97 males, one female) and six genitalic dissections (five males, one female) have been studied, including the lectotype.

The males of *merriccata* are easily distinguished from those of *vernata* by pattern, antennae, and genitalia. Within this species the forewings vary from having obsolescent to prominent cross lines, and with some specimens possessing a broad dark band distad of the t. p. line. Examples from the south tend to be larger, darker, and to have more suffused maculation than do males from the northern portion of the range.

The female of *merriccata* is darker than that sex of *vernata*, with darker hairlike scaling on the body and appendages. The body covering of *vernata* consists of scales having each with its distal end divided into numerous fine, elongate, projecting finger-like points; in *merriccata* the ends of these scales are much less pronounced.

The only other known description of the female of *merriccata* is that published by W. T. M. Forbes (1948, p. 68). His notes do not agree at all with the true female of this species; in fact it is highly probable that he had two species before him, the New Jersey material being *vernata*. I have been unable to locate the specimens studied by Forbes.

The genitalia of both sexes of *merriccata* are very different from those of the other two species in this genus. However, based on the abdominal spining, antennae, wings, and legs, I retain *merriccata* in *Paleacrita*.

Paleacrita longiciliata Hulst

Figures 82, 89, 98, 99, 101, 104

Paleacrita longiciliata Hulst, 1898, p. 113. Dyar, "1902" [1903], p. 266. Smith, 1903, p. 65.

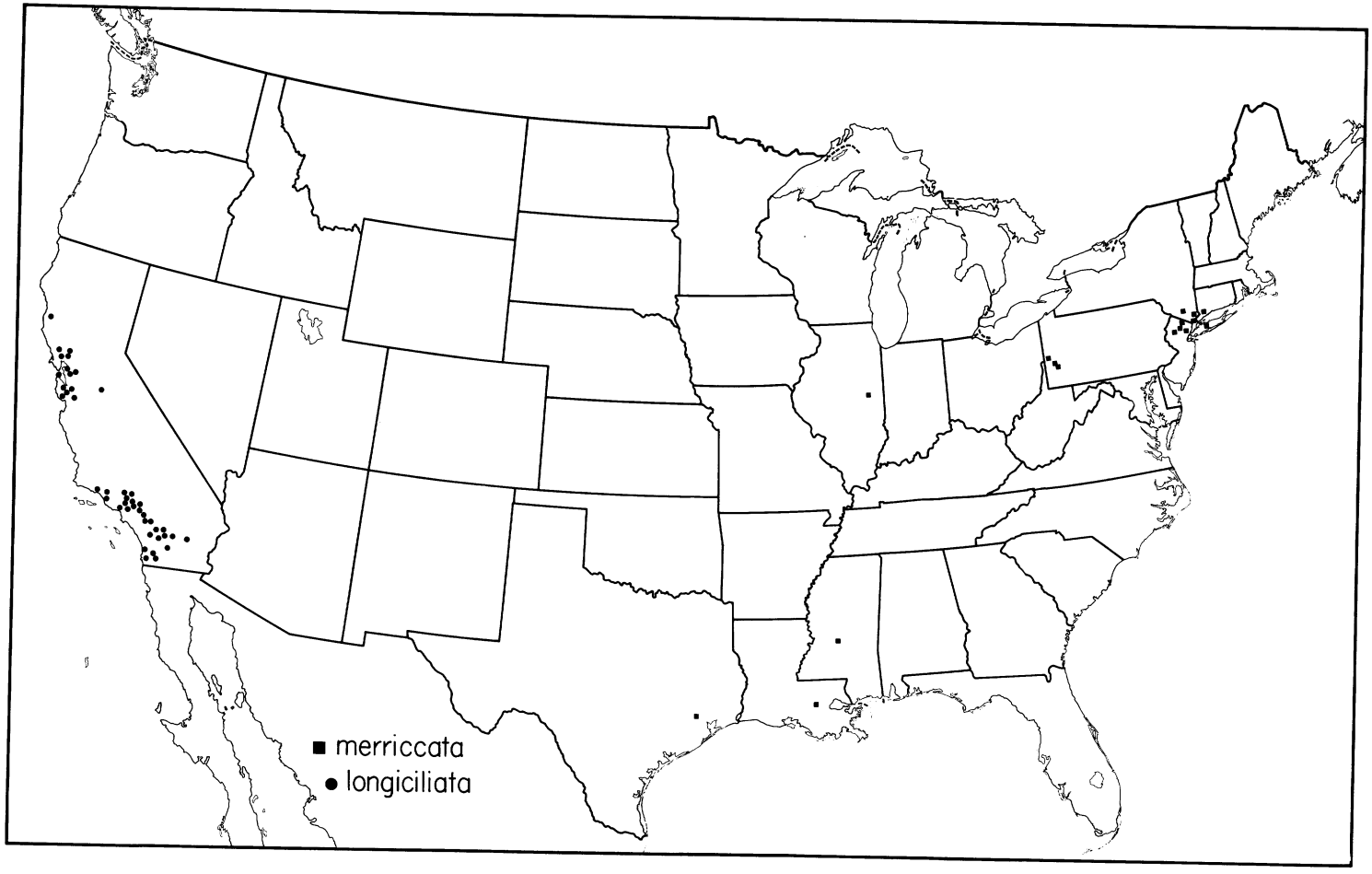


FIG. 101. Distribution of *Paleacrita merriccata* Dyar and *P. longiciliata* Hulst in the United States.

Barnes and McDunnough, 1913, p. 6, pl. 2, fig. 11 (adult male). Rindge, 1955, p. 147.

Palaeacrita (*sic*) *longiciliata*: Barnes and McDunnough, 1917, p. 119. McDunnough, 1938, p. 166.

Diagnosis. The males have antennal segments with one swelling bearing very long setae (up to 1 mm. in length); their forewings are elongate and have an acute apex. The females are without the numerous elongate hairlike scales that are found in *vernata.*

Male. Head with vertex, front and palpi dark grayish brown; palpi extending beyond front; antennae of about 30 segments, each segment with single swelling and bearing elongate setae, up to 1 mm. in length. Thorax above dark grayish brown, tending to have two longitudinal blackish brown bands posteriorly, separated by grayish white area; below pale grayish brown; legs brown, with ends of tarsal segments narrowly grayish white; fore tibia with process arising basad of middle of segment; hind tarsi with spurs very slender, scaled. Abdomen grayish brown above and below.

Wings: Forewings elongate, with acute apex; hind wings with Rs and M_1 arising from cross vein.

Upper Surface of Wings: Forewings unicolorous gray or grayish brown, with brownish black scales in cells and along veins; without definite cross lines, these indicated by costal dots for t. a. and t. p. lines, and by dark scaling on veins, with t. p. "line" being most clearly represented; discal spot small, round, grayish black; terminal line represented by large dark intravenular spots; fringe concolorous with wing. Hind wings unicolorous pale grayish brown, slightly translucent; without maculation except for small dark discal spot and narrow terminal line; fringe concolorous with wing.

Under Surface of Wings: All wings unicolorous grayish brown; without maculation except for small discal dots, and incomplete t. p. and extradiscal lines in some specimens; terminal line very narrow, inconspicuous; fringe concolorous with wings.

Length of Forewing: 12 to 17 mm.

Female. Body and appendages without elongate, erect hairlike scales as found in *vernata*; brownish black, with scattered gray scales; hind tibia with spurs reduced, upper pair less than 0.1 mm. in length.

Male Genitalia. Similar to those of *vernata*, differing mainly as follows: uncus with apex tapering to apex, either terminating in two points close together or connected by very short transverse ridge; gnathos with median swelling slightly broader and shorter; valves with broad base, sharply narrowed medially, apex digitate, each costa with narrower sclerotized area, longitudinal setose swelling appearing separate from costa; anellus ovate; aedeagus with narrow sclerotized strip on right side posteriorly, vesica unarmed.

Female Genitalia. Sterigma scarcely differentiated; ductus bursae an elongate, slightly curved tube about 0.5 mm. in length; ductus seminalis arising dorsally; corpus bursae broad, elliptical; signum absent; apophyses posteriores 0.9 mm. in length.

Early Stages. Undescribed.

Food Plant. Adenostoma (Rosaceae).

Type. Hulst did not mention the number or sex of the specimens he had when describing *longiciliata.* The species was obviously described from the male, as the wing pattern is given; he may have had but a single specimen, as only one wing expanse is given. The male from the Hulst collection is considered to be the holotype; it is in the American Museum of Natural History (Rindge, 1955, p. 147).

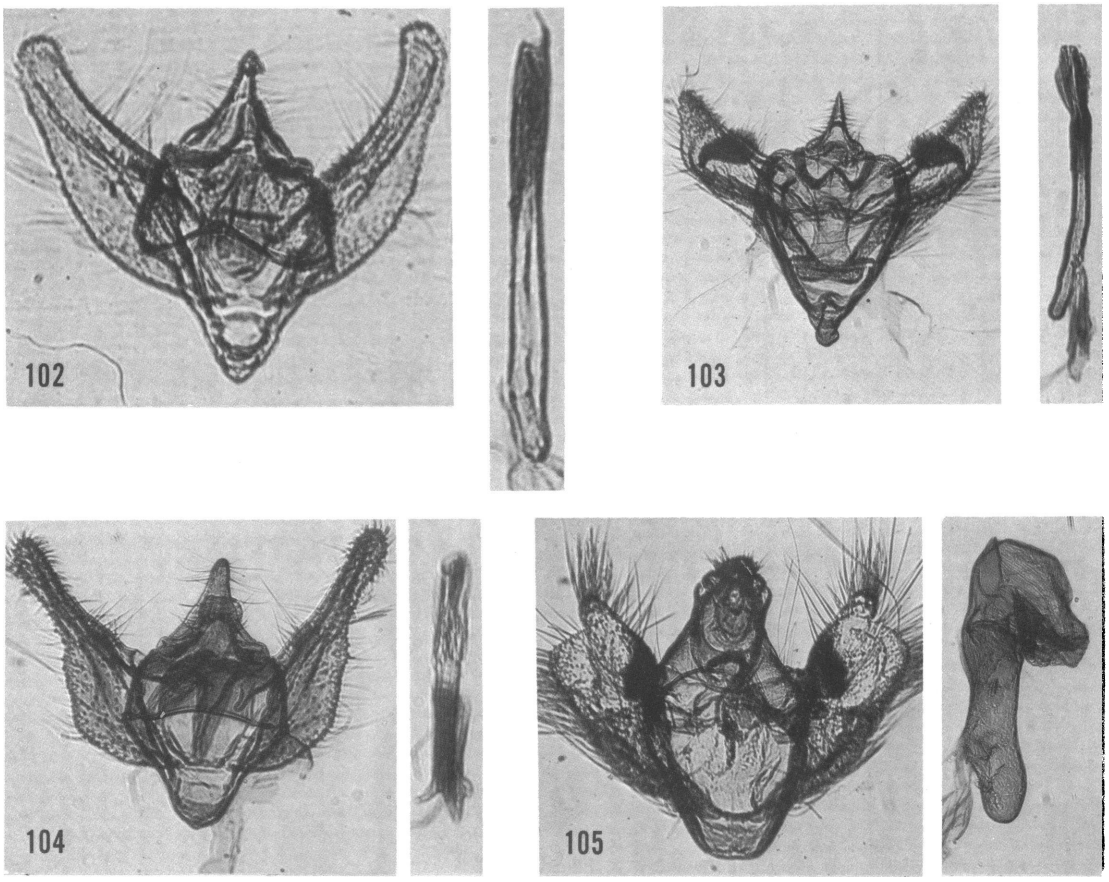
Type Locality. Palo Alto, Santa Clara County, California.

Distribution. California, from San Diego to Mendocino counties (see fig. 101). In southern California the species extends out into the Sonoran Desert in San Diego and Riverside counties.

Flight Period. From November until May; most specimens have been captured in December, January, and February.

Remarks. Two hundred seventy-seven specimens (274 males, three females) and seven genitalic dissections (six males, one female) have been studied, including the holotype.

Essig (1936, p. 699) recorded *vernata* from California, but the specimens in the California Insect Survey were all *longiciliata*; see discussion under Remarks for *vernata.*



FIGS. 102-105. Male genitalia of *Paleacrita* and *Erannis*. 102. *Paleacrita vernata* (Peck), New Canaan, Connecticut, April 22, 1962 (M. Statham; AMNH). 103. *P. merriccata* Dyar, Lewisboro, New York, April 9, 1969 (M. and T. M. Favreau; AMNH). 104. *P. longiciliata* Hulst, Newhall, California, January 6, 1947 (F. H. Rindge; AMNH). 105. *Erannis tiliaria tiliaria* (Harris), holotype of *E. coloradensis* Hulst, Glenwood Springs, Colorado, October, 1892 (W. Barnes; AMNH). *P. vernata* and *longiciliata* are shown at twice the magnification of the other species.

GENUS *ERANNIS* HÜBNER

Erannis Hübner, [1825], p. 320. Hulst, 1896a, p. 363. Dyar, "1902" [1903], p. 330. Smith, 1903, p. 78. Barnes and McDunnough, 1917, p. 119. Mosher, 1917, p. 56. McDunnough, 1938, p. 166. W. T. M. Forbes, 1948, p. 67.

Diagnosis. The males of this genus can be recognized by the antennal segments having two pairs of short, squat projections, each bearing numerous long setae, by the large wings, and by the slender scaled abdomen. The females are wingless, relatively large, and are colored black and white.

Adult. Male: Head with eyes large, round, naked; tongue rudimentary; palpi very short; antennae of from about 37 to 41 segments, each segment with two pairs of short, squat projections, one basal, the second mediodistal on segment, 0.1 mm. in length, each bearing numerous long setae, terminal five antennal segments simple. Thorax slender, with broad posterior tuft; fore tibia without terminal spine, with process arising near middle of segment; hind tibia with two pairs of spurs. Abdomen slender; dorsal surface with elongate, apically bifurcate scales.

Forewings large, broad, with attenuate apex;

with 12 veins, crowded together near end of cell, R_{1+2} stalked, R_{3+5} from angle; hind wings with Sc approximate to R near base only; Rs and M_1 separate.

Upper surface of forewings pale yellowish brown to dark brown, median and terminal areas varying from slightly paler to white; cross lines moderately to strongly represented; hind wings grayish white, with small discal dot.

Female: Similar to male, differing mainly as follows: eyes reduced; antennae simple, scaled, nonsetose, of about 34 to 37 segments; legs and body nonsetose; fore tibia without process; tympanic organs reduced to small, elongate platelike objects with hooklike process.

Wings apparently absent, reduced to minute pad on each side of thorax, 0.5 mm. in length.

Body and legs covered with black and white scales.

Male Genitalia. Uncus broad anteriorly, lateral margins sharply narrowed, elongate apical region tapering to ventrally curving point; gnathos very large, longer than uncus, lateral margins broad, medially with ventroposteriorly curving, triangular liplike process; valves with costa angulate, with short apex rounded and bearing numerous elongate setae, outer margin of valve incised below apex, then extending outwardly, becoming rounded and bearing elongate setae; costal base curved ventrodistally, sclerotized, bearing on posterior margin band of numerous thick setae; sacculus weakly sclerotized, slightly swollen, with sclerotized area extending to middle of valve, narrowed, curved basad, and having short digitate process near base of valve and anteriad of costal base; anellus large, anterior end smoothly sclerotized, rounded anteriorly, posterior end more heavily sclerotized, narrowed apically, having longitudinal ridges; aedeagus narrowed anteriorly on dorsal side, with ductus ejaculatorius entering aedeagus one-fourth distance from base, posterior end with dorsal side sclerotized, rounded apically, ventral side membranous, entire structure subequal in length to combined lengths of uncus, tegumen, and saccus; vesica, when exserted, extending ventrally and slightly anteriorly, short, apically curving to left, and bearing elongate band of spines.

Female Genitalia. Sterigma heavily sclerotized, with ovate to shortly triangular median area and elongate, posterodistal area laterally on each side; ductus bursae sclerotized, broad, square or somewhat U-shaped; ductus seminalis arising ventrally; corpus bursae with broad posterior portion, narrowed on right side, longitudinally striate, weakly constricted medially, then enlarging into rounded membranous sac; signum absent; apophyses posteriores 2.5 to 3.0 mm. in length.

Early Stages. See subspecies references.

Food Plants. Polyphagous on deciduous trees and shrubs.

Type Species. [*Phalaena*] *defoliaria* Clerck, 1759; by subsequent designation of Hulst (1896a, p. 363).

Distribution. Holarctic.

Remarks. I am treating our North American *Erannis* as a single species, *tiliaria* (Harris), consisting of two subspecies. There is some question as to whether or not *tiliaria* is really distinct from the Old World *defoliaria* (Clerck). The two are very similar to each other in structure, color, and pattern. There are apparently constant, small differences in the maculation and in the genitalia; a long series of genitalic dissections would be necessary to be absolutely certain of the genitalic variation. The differences between the two are discussed in detail below.

In the collection of the American Museum of Natural History is a series of specimens from the Ghika collection labeled as being hybrids of *defoliaria* and *tiliaria*; unfortunately there are no notes or correspondence that pertain to these rearings. Apparently Ghika crossed *tiliaria* (from Rye, New York) and *defoliaria* (from Germany) and vice versa, in 1930 and 1934. These two will cross and produce offspring, which could indicate that they are conspecific. However, nothing is known about the fertility of the F_1 generation. Due to the lack of data on these experiments, I am keeping the two as separate entities for the time being.

Erannis tiliaria (Harris)

Hybernia tiliaria Harris, 1841, p. 342.

Diagnosis. See generic diagnosis.

Male. Head with vertex yellowish brown to pale brown; front brown to grayish brown; palpi grayish brown to dark brown. Thorax above yellowish brown to pale brown, with grayish white scaling on patagia and posterior tuft; below

grayish brown anteriorly, pale gray posteriorly; legs with mixed gray, brown, and blackish brown scales, tarsi with ends of segments narrowly grayish white. Abdomen above yellowish brown with scattered dark brown scales; below pale grayish brown with scattered dark brown scales.

Upper Surface of Wings: Forewings varying from grayish white or pale yellowish brown to pale ochraceous salmon or brown, either unicolorous or with basal, median, and terminal areas pale, having broad brown or dark brown bands basad of t. a. and distad of t. p. lines; cross lines usually present, dark brown, obsolescent or absent in some specimens; t. a. line arising on costa one-third distance from base, outwardly angled below radial vein and in cubital cell, angled basad to meet inner margin about three-tenths of distance from base; discal spot blackish brown, prominent; median line absent; t. p. line arising on costa three-fourths distance from base, weakly concave to cell M_1, with inward teeth on veins, outwardly bowed, then broadly concave, thickened on veins, meeting inner margin three-fourths distance from base; s. t. line varying from broad, diffuse, partially shaded by dark brown, to obsolescent or absent; terminal line absent; fringe either concolorous with wing or with basal portion more or less darkened opposite veins. Hind wings pale grayish white, more or less evenly covered with widely spaced pale grayish brown to grayish brown scales; without maculation except for grayish brown discal dot; terminal line absent; fringe concolorous with wing.

Under Surface of Wings: Forewings grayish white to pale brown, with variable amount of dark gray and grayish brown scales; maculation varying from obsolescent, having discal dot and faint trace of t. p. line, to similar to that of upper surface but more weakly represented. Hind wings pale grayish white, evenly covered with grayish brown or dark brown scales; maculation similar to that of upper surface.

Length of Forewing: 17 to 25 mm.

Female. Head with vertex white; front and palpi brownish black. Thorax above white, with paired black spots on each segment; below brownish black; legs black or brownish black and white. Abdomen above and below white, variably spotted with black, more or less grouped on dorsal surface to form two irregular longitudinal bands.

Wing pads minute, black anteriorly, white posteriorly.

Male Genitalia. As described for the genus.

Female Genitalia. As described for the genus.

Early Stages. See references for each subspecies.

Food Plants. Polyphagous on shrubs and deciduous trees, rarely on conifers, sometimes causing defoliation.

Distribution. Transcontinental.

Remarks. This species is divided into two subspecies. The eastern males are paler in color, the forewings being somewhat unicolorous or only relatively slightly contrasting in color; the western males have the cross bands dark brown, contrasting with the paler areas of the wing.

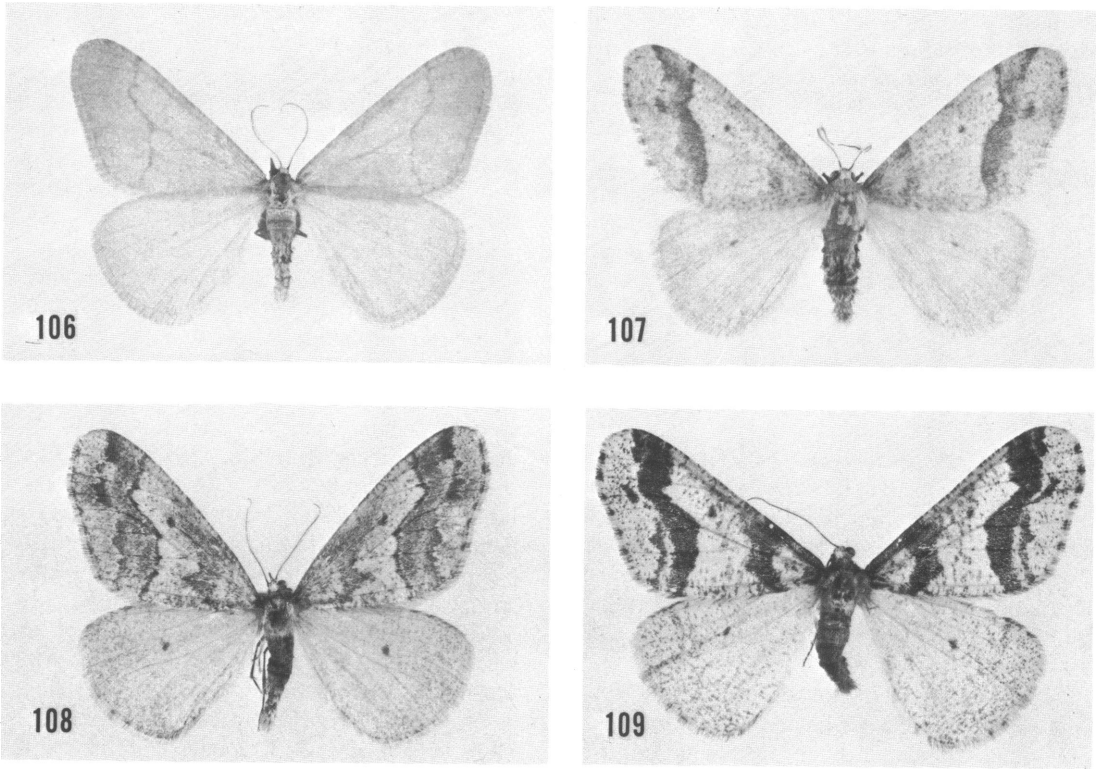
This species is closely related to the Old World *defoliaria* (Clerck). The present species can be recognized, in the males, by the t. p. line tending to meet the inner margin at more or less of a right angle; in *defoliaria*, the line is angled outward. The females of the European species tend to have the dorsal surface of the abdomen with a greater number of smaller black spots than do those of *tiliaria.* In the male genitalia, the anellus of *tiliaria* is broadly and smoothly sclerotized, whereas in *defoliaria* it tends to be smaller and may have two diverging ridges. There also appear to be some differences in the shape of the valves; in *tiliaria* the costal lobe tends to be larger and broader, and the outer margin less curved, with a more strongly developed sacculus than in *defoliaria.* In the female genitalia, *tiliaria* tends to have a broader ductus bursae, and the posterior portion of the corpus bursae is widest near the ductus bursae, then tapering, being shorter and straighter than in *defoliaria.*

Harris stated (1841, p. 342), when describing *tilaria*, that his species "... closely resembles ... *defoliaria* of Europe; but differs from it so much in the larva state, that I have not the slightest doubt of its being a distinct species ..." Differences in the early stages need to be verified.

Erannis tiliaria tiliaria (Harris)

Figures 46, 90, 105-107, 110

Hybernia tiliaria Harris, 1841, p. 342. Packard, 1876, p. 409, pl. 4, fig. 17 (venation). Grote, 1882, p. 49. Bruce, 1887, p. 49. Beutenmüller, 1890, p. 222. Smith, 1891, p. 73. Lugger,



FIGS. 106-109. Males of *Erannis*. 106, 107. *E. tiliaria tiliaria* (Harris). 106. Clove Valley, New York, October 29, 1912 (AMNH). 107. Big Indian Valley, New York, November 2, 1908 (R. F. Pearsall; AMNH). 108, 109. *E. tiliaria vancouverensis* Hulst. 108. Wallace, Idaho, October 29, 1943 (O. Huellemann; AMNH). 109. 4 miles west of Oregon City, Oregon, February 16, 1972 (S. G. Jewett, Jr.; AMNH). All X1.4.

1898, p. 247, fig. 193 (larvae, adult male, and female).

Hibernia (*sic*) *tiliaria*: Anon., 1882, p. 24. Gumppenberg, 1893, p. 405.

Erannis tiliaria: Hulst, 1896a, p. 363. Dyar, "1902" [1903], p. 330; 1903b, p. 116. Smith, 1903, p. 78; 1910, p. 505. Barnes and McDunnough, 1917, p. 119. Mosher, 1917, p. 57, fig. 3A, B (pupae). Holland, 1919, p. 347, pl. 44, fig. 17 (adult male). W. T. M. Forbes, 1928, p. 604; 1948, p. 67, fig. 27 (venation). McDunnough, 1938, p. 166. F. M. Jones and Kimball, 1943, p. 117. Ferguson, 1954, p. 316. Moore, 1955, p. 72. Prentice, 1963, p. 464, fig. 292 (distribution in Canada). Covell, 1970, p. 178. Heitzman, "1973" [1974], p. 176. Brower, 1974, p. 106.

Erannis coloradata Hulst, 1896a, p. 363. Dyar, "1902" [1903], p. 331. Smith, 1903, p. 78. Barnes and McDunnough, 1917, p. 119. McDunnough, 1938, p. 166. Rindge, 1955, p. 139. NEW SYNONYM.

Diagnosis. The males can be recognized by the upper surface of the forewings being a more or less unicolorous yellowish brown, brown, or pale ochraceous salmon; some specimens have darker shading by the cross lines but it is not a deep contrasting brown. The females usually have black and white antennae.

Male. Head with vertex yellowish brown; front brown; palpi grayish brown. Thorax above yellowish brown.

Upper Surface of Wings: Forewings yellowish brown, pale brown, or pale ochraceous salmon, unicolorous or with brown bands basad of t. a. and distad of t. p. lines; cross lines absent,

obsolescent or present. Hind wings pale grayish white, more or less evenly covered with widely spaced pale grayish brown scales.

Under Surface of Wings: See species description.

Length of Forewing: 17 to 25 mm.

Female. Head with black and white antennae. Abdomen above tending to have two irregular longitudinal bands, with lateral spotting smaller than on dorsal bands.

Male Genitalia. As described for the genus.

Female Genitalia. As described for the genus.

Early Stages. No attempt has been made to compile a complete bibliography of the early stages, as this is listed in Tietz (1972, p. 638). A few of the descriptions can be found in Lugger (1898, p. 247), Dyar (1903b, p. 116), Mosher (1917, p. 57, fig. 3A, B [pupa]), and W. T. M. Forbes (1948, p. 67).

Food Plants. Polyphagous on shrubs and deciduous trees. For lists of food plants, see Prentice (1963, p. 464; 31 listed) and Tietz (1972, p. 639; 23 listed).

Types. Harris did not designate any types when describing *tiliaria*; he had both sexes before him when drawing up the species description. The Harris collection is now in the Museum of Comparative Zoology, and it is maintained as a separate entity. The following specimens of *tiliaria* are in it: male, bearing Harris's handwritten label 354; male, 354v; male, 236 ♂ N. H.; male 236 ?; female, 236; female, 236 ♀ N. H.; pupa, 236 N. H. Harris kept a holographic notebook; the entries after the appropriate numbers are as follows: 236: "Dublin, N. H. Mr. Leonard. ♂ and ♀." 236?: "Camb. [Cambridge, Massachusetts] on window, Nov. 10, 1837." 254: [no locality] "Nov. 1, 1832. – Oct. 25, 1838, var. – Nov. 1-8, 1838 – ♂ Nov. 1, 1841." As the species was described in an article entitled "Report on the insects of Massachusetts injurious to vegetation," I think the New Hampshire specimens, bearing number 236, should not be primary candidates for lectotype selection. The moths with number 254 are apparently without locality data. This leaves a single male, bearing number 236 ?, that has a locality (as well as a date). This last specimen is hereby designated, and has been labeled, as the lectotype of *Hybernia tiliaria* Harris. It is MCZ 26397; this number is on all the Harris specimens of this name.

Hulst did not specify either the number or sex of the specimens he had before him when describing *coloradata.* The description is obviously based on a male; it is possible that he only had a single one, as only one wing expanse is given. The specimen from the Hulst collection, now in the American Museum of Natural History (Rindge, 1955, p. 139), is the holotype. Its genitalia are mounted on slide FHR 17464.

Type Localities. Cambridge, Massachusetts (*tiliaria*); Colorado Springs, Garfield County, Colorado (*coloradata*).

Distribution. Eastern North America, extending to the Rocky Mountains. In Canada this species occurs from Newfoundland and Nova Scotia to Alberta (Prentice, 1963, fig. 292). In the United States it occurs north of about latitude 37° N, from Maine to New Jersey and Pennsylvania, west to North Dakota, eastern Nebraska and eastern Kansas; it is also known from Colorado and Utah. (See fig. 110.)

Flight Period. From late August into early December. Most specimens have been caught during October and November.

Remarks. Seven hundred sixty-seven specimens (654 males, 113 females) and 19 genitalic dissections (14 males, five females) have been studied.

The upper surface of the forewings of the males displays considerable variability in color and degree of maculation. The subspecies is easily recognized, nevertheless, as no other in eastern North America can be confused with it. The wings tend to be rather softly colored and not to be strongly contrasting in color; no examples have been seen that could be confused with the following subspecies. The female's body tends to be rather variable in the size and number of the black spots.

The Colorado population is rather variable in color and maculation, as are most populations. The holotype of *coloradata* is a dark, smoothly colored individual. I do not believe that there is enough difference to retain this name as a subspecies, and so it is placed in the synonymy.

Erannis tiliaria vancouverensis Hulst, new combination
Figures 91, 108-110

Hybernia defoliaria: Smith, 1891, p. 73.

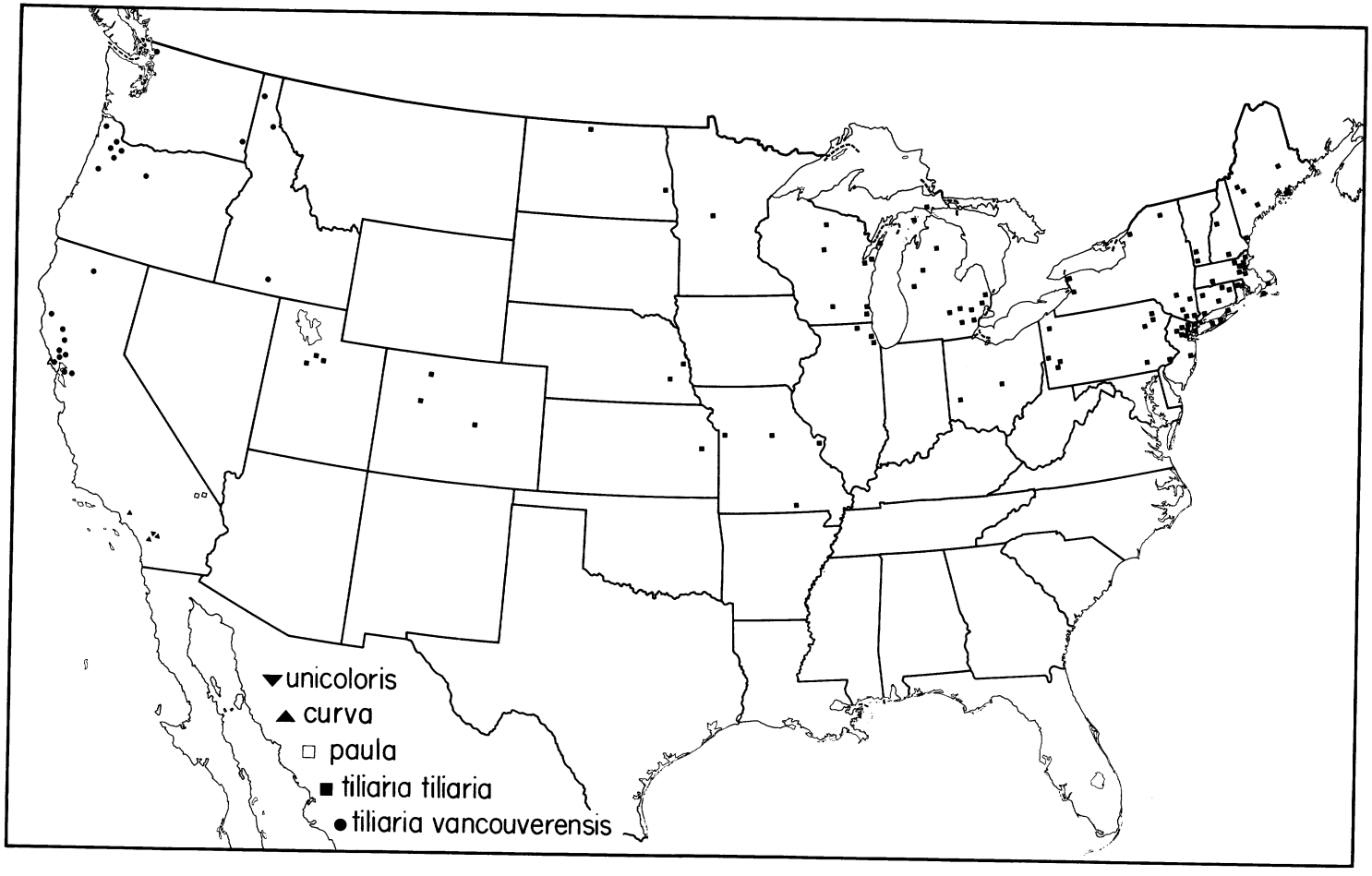


FIG. 110. Distribution of *Cochisea unicoloris*, new species, *C. curva*, new species, *C. paula*, new species, and *Erannis tiliaria* (Harris).

Hibernia (*sic*) *defoliaria*: Fletcher, 1894, p. 22 (*partim*, not fig.).
Erannis defoliaria: Essig, 1936, p. 701.
Erannis defoliaria vancouverensis Hulst, 1896a, p. 363. Dyar, "1902" [1903], p. 330. Smith, 1903, p. 78. Rindge, 1955, p. 155.
Erannis vancouverensis: Dyar, 1904, p. 911. Barnes and McDunnough, 1917, p. 119. McDunnough, 1938, p. 166. J. R. J. L. Jones, 1951, p. 132. Prentice, 1963, p. 464, fig. 291 (distribution in Canada). Sugden, 1968, p. 27. Evans, 1973, p. 605, figs. 1-6 (details of larvae), 7-9 (male and female genitalia), 10, 11 (larvae), 12 (pupa), 13, 14 (adult males), 15 (adult female), 16, 17 (defoliation).
Erannis vancouverensis melanic form *brunneata* Cassino and Swett, 1923, p. 21.
Erannis vancouverensis ab. *brunneata*: McDunnough, 1938, p. 166.

Diagnosis. The males can be recognized by the upper surface of the forewings having a grayish white median area sharply set off by the dark brown bands adjacent to the cross lines. The females usually have brownish black antennae.

Male. Head with vertex pale brown; front grayish brown; palpi dark brown. Thorax above pale brown.

Upper Surface of Wings: Forewings with basal, median, and terminal areas grayish white, with variable number of orange-brown and dark brown scales; cross lines prominent, broadly shaded with dark brown or blackish brown bands; fringe tending to be dark brown opposite veins. Hind wings pale grayish white, more or less evenly covered with widely spaced grayish brown scales.

Under Surface of Wings: See species description.

Length of Forewing: 20 to 25 mm.

Female. Head with shiny brownish black antennae, some specimens with pale gray scaling, less than in nominate *tiliaria*. Abdomen above tending to have numerous small black spots, with longitudinal bands reduced or obsolescent.

Male Genitalia. As described for the genus.

Female Genitalia. As described for the genus.

Early Stages. Descriptions may be found in Fletcher (1894, p. 22), Essig (1936, p. 701), Sugden (1968, p. 27), and Evans (1973, p. 605).

Food Plants. Polyphagous on shrubs and deciduous trees; rarely on conifers (*Tsuga*, *Pinus*; Evans, 1973, p. 605). Lists of food plants were given by Essig (1936, p. 701), J. R. J. L. Jones (1951, p. 132), Prentice (1963, p. 464), Sugden (1968, p. 27), and Evans (1973, p. 10).

Types. Hulst did not mention how many specimens he had before him when describing *vancouverensis*, although he did both a male and a female. The male from the Hulst collection, now in the American Museum of Natural History (Rindge, 1955, p. 155) is hereby designated as the lectotype. Its genitalia are mounted on slide FHR 17468. Additional specimens bearing type labels are in the National Museum of Natural History.

The holotype male of "brunneata" is MCZ 16863.

Type Localities. Victoria, Vancouver Island, British Columbia (*vancouverensis*); Wallace, Shoshone County, Idaho ("brunneata").

Distribution. Coastal and interior British Columbia (Prentice, 1963, fig. 291), Idaho, Washington, Oregon, and the northern half of coastal California (see fig. 110).

Flight Period. Specimens from California have been taken from November into March; northern examples from late August into December, with a few continuing to emerge until March.

Remarks. Three hundred forty-nine specimens (335 males, 14 females) and 10 genitalic dissections (eight males, two females) have been studied.

There appears to be less individual variation in the maculation of the upper surface of the forewings in *vancouverensis* than in nominate *tiliaria*. Specimens from the coastal areas of Oregon and California tend to have darker markings than those from Idaho and British Columbia. This may be due to the cooler and damper maritime climate that is found west of the Cascade Mountains.

Essig claimed that this moth "is a European species which has been introduced into Vancouver Island, British Columbia" (1936, p. 701). I do not know any actual basis in fact for that statement; Essig may have assumed this from reading Fletcher's article (1894, p. 22).

LIST OF SPECIES WITH THEIR KNOWN DISTRIBUTION

Genus *Biston* Leach, 1815
Amphidasis Treitschke, 1827

1. *betularia* (Linnaeus), 1758	Holarctic
a. *cognataria* (Guenée), 1857	Transcontinental; south into Chihuahua, Mexico
fortitaria (Barnes and McDunnough), 1917	
"swettaria" (Barnes and McDunnough), 1917	
"mesle" (W. T. M. Forbes), 1928	
b. *contrasta* (Barnes and Benjamin), 1923	Utah, Nevada
2. *multidentata* (Guedet), 1941	Arizona

Genus *Cochisea* Barnes and McDunnough, 1916

1. *rigidaria* Barnes and McDunnough, 1916	Arizona, New Mexico, Utah
2. *barnesi* Cassino and Swett, 1922	New Mexico, Utah
3. *undulata*, new species	Arizona
4. *paula*, new species	California
5. *unicoloris*, new species	California
6. *sonomensis* McDunnough, 1941	California
"abrunnea" McDunnough, 1941	
7. *recisa*, new species	California, Nevada
8. *curva*, new species	California
9. *sinuaria* Barnes and McDunnough, 1916	Arizona, California

Genus *Lycia* Hübner, [1825]
Poecilopsis Harrison, 1913

1. *ursaria* (Walker), 1860	Transcontinental
2. *ypsilon* (S. A. Forbes), 1885	
a. *ypsilon* (S. A. Forbes), 1885	Eastern United States
b. *carlotta* (Hulst), 1896	Peninsular Florida
3. *rachelae* (Hulst), 1896	Massachusetts, Pennsylvania, west to Colorado, British Columbia, Alaska

Genus *Phigalia* Duponchel, 1829
Coniodes Hulst, 1896
Rhaphidodemas Hulst, 1896

Group I

1. *titea* (Cramer), 1782	Eastern North America
titearia (Hübner), [1825]	
revocata Walker, 1862	
cinctaria French, 1878	
nevadaria (Hulst), 1896	
"mephistaria" Reiff, 1913	
"deplorans" Franclemont, 1938	

Group II

2. *denticulata* Hulst, 1900 — Eastern United States
3. *strigataria* (Minot), 1869 — Eastern North America
   olivacearia (Morrison), 1874
4. *plumigeraria* (Hulst), 1888 [emendation for *plumogeraria* (Hulst)] — Western North America

Genus *Paleacrita* Riley, 1876

1. *vernata* (Peck), 1795 — Eastern North America, Colorado, California
   sericeiferata (Walker), 1862
   speciosa Hulst, 1893
2. *merriccata* Dyar, "1902" [1903] — Eastern North America
3. *longiciliata* Hulst, 1898 — California

Genus *Erannis* Hübner, [1825]

1. *tiliaria* (Harris), 1841
   a. *tiliaria* (Harris), 1841 — Eastern North America, Colorado, Utah
      coloradata Hulst, 1896
   b. *vancouverensis* Hulst, 1896 — Western North America
      "brunneata" Cassino and Swett, 1923

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