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BIOLOGICAL STUDIES ON MOTHS OF THE GENUS  
ETHMIA IN CALIFORNIA  
(Gelechioidea)

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## INTRODUCTION<sup>1</sup>

The family Ethmiidae is composed of small to moderate sized moths and is world-wide in distribution, with its greatest diversity occurring in the Neotropical Region. Consisting primarily of the one large genus *Ethmia* the group is distinct in many respects, without close relationship to other families. Ethmiids have in the past been considered as related to or members of the Oecophoridae. Probably they are most closely related to the Stenomidae, and the three groups are considered to be families in the Gelechioidea by present workers.

About 30 members of the genus *Ethmia* have been reared previously, primarily in the Palearctic and in the eastern United States. Nearly all feed externally on Boraginaceae or Hydrophyllaceae during the larval stage, but there have been few detailed studies. Habits of the few other Nearctic genera are equally poorly known: species in *Pyramidobela* feed on *Penstemon* (Scrophulariaceae) and *Buddleia* (Loganiaceae) (Braun, 1921; Keifer, 1936), while the biology of *Pseudethmia* is unknown. Two other species formerly considered to be ethmiids, *Eumeyrickia trimaculella* (Fitch) and "*Ethmia*" *coloradella* (Walsingham), are fungus feeders and have recently been transferred to the Oecophoridae, a group containing genera with similar morphological and biological traits (Lawrence and Powell, 1969).

In connection with a California Insect Survey project on Ethmiidae, I began to investigate the biologies of these moths in 1961. The study gradually developed into a comprehensive taxonomic one encompassing the New World fauna, some 135 species. Field efforts were particularly directed towards *Ethmia* in California, resulting in the present data on 14 species, which, however, represent only a few species groups in one section of the genus. Thus it seems appropriate to give this detailed biological information separately from the systematic treatment of the genus as a whole. A general review of biological knowledge for the family is given in that study (Powell, 1971).

It became evident early in this work that some species are diurnal and others nocturnal. It was one of the aims of the investigation to clearly define which are diurnal in order to assess the significance of this phase of the moths' biology in systematic relationships. Adults of both diurnal and nocturnal species are sometimes encountered in numbers during the daytime, and at times it is difficult to distinguish between active flight behavior and reactionary movement in response to disturbance by the observer. There-

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1 This study was in part made possible through assistance from National Science Foundation Grants GB-4014 and GB-6813x, "Comparative biology in relation to systematics of Microlepidoptera", 1965-1970.

fore, criteria I have used for defining natural activity rhythm in the diel cycle have been the timing of mating, oviposition, and the "quiescent posture" by moths in captivity.

The resting posture during periods of activity was distinguishable from that shown by moths in the "quiescent posture" assumed during the inactive phase of the diel cycle. In the "quiescent posture" the wings were tightly clasped against the abdomen and the antennae were held back alongside the body, under the costal edges of the wings. The insects crouched low, almost appressed to the substrate, with the legs widely outstretched. Moths temporarily not moving during activity periods held the wings somewhat loosely spread from the sides of the abdomen, and the antennae projected outward, at right angles to the body axis or somewhat forward, usually moving slowly. At the same time they stood up higher above the substrate with the legs less widely outstretched.

The "quiescent posture" was exhibited at night by all individuals of species which mate and oviposit in daytime. There was not a temperature correlation with darkness, since heating indoors kept the temperature above 18° C until midnight or so, while it often remained as low as 12° during the early daylight hours.

As a result of this study, it is now known that diurnal species possess small eyes and usually very dark integument and vestiture. Thus the behavior pattern can be predicted on the basis of preserved specimens. The eye size has been quantified and described elsewhere (Powell, 1971). In a few species the eyes are intermediate in size, and my observations on *Ethmia arctostaphylella* suggest that this is correlated with a tendency towards crepuscular behavior.

## TECHNIQUES

The present data originate from field collections of either late instar larvae or adults which were retained alive for oviposition. The moths were taken at lights or by netting them during daytime or at dusk. Adults were transported from the field in cotton-stoppered glass vials and were caged in one-gallon glass breeding jars. The housing methods and details of the container were essentially the same as used and described in studies of tortricine moths (Powell, 1964). The jars proved more satisfactory for ethmiids than for Tortricinae because oviposition by *Ethmia* usually occurred on the host plant or on the nylon mesh used as a ceiling on the cage (figs. 11, 12), rather than on the sides of the glass container. Insofar as possible the jars were placed adjacent to an open window, exposed to natural lighting, including direct, dappled sunlight (filtered through tree foliage) during part of the day. Observations after nightfall were made by means of a flashlight provided with a cover of red construction paper. This light source usually did not attract or otherwise disturb the moths.



In the field larvae were generally detected by hand-searching suspect plants. A few species could be effectively collected by beating (certain perennial plants) or sweeping, but most of the present species live in concealed shelters on low, herbaceous hosts. Larvae were transported from the field in polyethylene bags and generally were housed in closed containers with cut sprigs of host plant. Newly hatched larvae in the laboratory were usually housed in 25 x 100 mm salve tins on small bouquets of foodplant in water vials plugged by cotton. In few cases greenhouse plants were used for early instar establishment. Larger larvae were housed in plastic sandwich boxes or 85 x 100 mm jars with cuttings of foodplant.

To provide fresh plant material for species reared from eggs, plants from the collection site were transplanted to pots in a greenhouse, bouquets were placed in water, or cuttings of the same or a closely related plant were obtained from the University of California, Berkeley, Botanical Garden at the time of egg hatch. Transplanting (perennial *Phacelia*) or cuttings in water (annuals) proved satisfactory for early instars since these plants usually persisted well for 2-3 weeks. However they matured in advance of field conditions, and later instars were provided with plants from the Botanical Garden unless the original collection site could be revisited conveniently. For field collected late instar larvae, cuttings were either offered as bouquets in water or were refrigerated ( $\pm 4^{\circ}\text{C}$ ) and later offered without water. This required frequent replenishing of provisions.

Soft paper toweling, folded many times, and sometimes cut sections of dry *Yucca whipplei* floral stalks were provided as pupation substrates. A tendency to wander and burrow into soft bark and similar substances has been reported in the literature for several *Ethmia*.

Rearing was conducted at laboratory temperatures (usually varying about 12-20° daily). Pupae in diapause were in some cases housed in an outdoor screen cage at Berkeley or in an open shed at Russell Property, near Lafayette, California, an inland station where greater climatic extremes more approximate field conditions of inland parts of California.

The only previous biological information concerning the species discussed below is the report by Dyar (1902) that *E. semitenebrella* had been reared from *Cercocarpus* in Arizona. Hosts of three species must have been known to Keifer (1936) who described the pupa of *albitogata* and mentioned larval characters of two other species, but he gave no information on their biologies. Therefore I attempted to discover the host association through observing moths in the field. Adults of both diurnal and nocturnal species tend to stay close to the larval foodplants, and each of the present species has proven to be specific to members of one plant genus so far as known. Following field collection, I caged females with a small bouquet of the suspect host. If no clear association had been ascertained, a varied menu of

possible oviposition substrates was offered. Females exhibited only a poor oviposition response or none at all, if caged without the appropriate host. The fact that most previous recorded plants for *Ethmia* are Boraginaceae and Hydrophyllaceae helped to restrict my selection, during field searches. However, in one case this restricted thinking hindered the eventual discovery of an unrelated plant as the host.

Detailed comparison of eggs was not attempted. Photographs showing general habitus and placement on the plant were taken for most species. High magnification scanning electron micrographs were executed only for *scylla*. In scheduling for photography eggs were usually stored in a refrigerator (4° C) for several days, which delayed maturation of developing larvae for a period about equal to that in cold storage.

When sufficient numbers were available, larvae representing each instar were preserved, using KAAD for a few minutes, followed by storage in 95% ethyl alcohol. Head capsules representing previous instars of living individuals were recovered and were used in measurements for estimating the number of instars, along with the preserved larvae.

Detailed morphological descriptions of the larval stages have not been made. The larvae are briefly characterized, with special reference to instar differences, following the biological discussion of each species. Abbreviations are as follows (see fig. 7): HC = Head Capsule, a measurement of maximum width as seen from above is given; ThSh = Prothoracic Shield; Pin = Pinacula; D = Dorsal band a narrow color stripe in later instars of most species, from pro- or mesothorax to ninth abdominal segment; DL = Dorsolateral pigment bands lateral to D, above the spiracles; L = Lateral band, a broad area around and below spiracles; LV = Lateroventral band, a weakly developed pigment band below L, above the legs; AbdCr = Abdominal Crotchets, an extended mesoseries or mesopenellipse in all the present species; AnCr = Anal Crotchets. All measurements were made through a disc micrometer at 27x or 54x magnification and are given in mm, based on specimens distended in KAAD. Measurements are based on six or more specimens except where indicated otherwise, with the number in brackets [ ]. Color features were noted from living larvae. Integumental colors of *Ethmia* fade during preservation.

Morphological characteristics of the pupae are variable, and only limited comparison between species is attempted owing to inadequate series for most species. Most of the species examined here are quite similar.

## CONSTANT BIOLOGICAL CHARACTERS

Several features of the biology and behavior appear to be consistent among all species, and these are not discussed for each species. The eggs are deposited singly, cemented to the substrate by an affixed area nearly as long and wide as the egg. The egg is more or less rectangular in outline, nearly as thick as wide; it does not flatten out onto the substrate, but conforms to minor irregularities, sometimes altering its shape a little (e.g., fig. 12). At hatching larvae chew a round, ragged hole at the micropylar end, sometimes well off center. The hole is about one-half the diameter of the egg, and no further feeding is done on the eggshell by newly hatched larvae. When disturbed or dislodged, larvae of most species, especially in later instars, react by wriggling violently backward. A few species feign death and fall, immobile, to the substrate. Based on head capsule measurements, there appear to be five instars in several species, but data are too fragmentary to determine the number with certainty for most species. At least in *brevistriga* and *scylla*, and probably *plagiobothrae* and *albi-togata*, there are five, while large species such as *discos-trigella* and *arctostaphylella* probably undergo six, at least in some individuals (figs. 1-6). At maturity larvae of probably all species wander, often having been found to burrow into soft, woody substrates to pupate. Data on specimens I have examined, especially of several species reared by F.D. Parker at the University of California, Davis, from trap nests<sup>1</sup>, indicate this is a widespread habit. During my study larvae usually were confined in salve tins or 35mm pill boxes for pupation, and most did not burrow into yucca pith, using unnatural situations such as a corner of the container. At emergence the pupal shell remains inside the cocoon, held in place by the hooked setae of the anteriorly directed "anal legs" (figs. 8, 9) (in all species except *scylla*). The cremaster such as is normally developed in most Lepidoptera at the tip of the abdomen is vestigial. Eight frail setae are present in a constant arrangement for all species, but these do not aid in anchoring the pupa. The degree to which the "anal legs" of the pupa are appressed to the abdominal venter or angled outward varies within species, possibly affected by the shape of the cocoon.

## ACKNOWLEDGEMENTS

Grateful acknowledgement is made to Helen K. Sharsmith, formerly of the University of California, Berkeley, Herbarium, who provided many of the plant identifications associa-

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1 Sections of *Sambucus* stems, 45 cm in length, which had been stuck into the ground, with a 1.5-4 mm hole drilled in the exposed end (Parker and Bohart, 1966).

ted with this study. Through Mrs. Sharsmith, Lincoln Constance, University of California, Berkeley, determined most of the *Phacelia*, and Francia Chisaki Hommersand, Chapel Hill, North Carolina, identified some of the *Amsinckia* species. Thanks are due Anton Crist and other personnel of the University of California Botanical Garden, who have been cooperative in providing cuttings of native host plants many times during the past decade. Photographs of eggs *in situ* were executed by A.A. Blaker, Scientific Photographic Laboratory, University of California, Berkeley. Stereoscan Scanning Electron Microphotographs were executed through the cooperation of T.E. Everhart, Electronics Research Laboratory, University of California, Berkeley, through support from National Science Foundation Grant GB-6428 and Grant No. GM15536 from the National Institutes of Health. Assistance with field collections, particularly during early years of the study, was given by several persons, whose help is appreciated and acknowledged by mention in the text; but special thanks are due C. Don MacNeill, Oakland Museum, and Catharine Toschi Tauber, Ithaca, New York. Where not otherwise indicated, all collections and observations are my own.

### ETHMIA COQUILLETTELLA BUSCK

*Ethmia coquillettella* Busck, 1907, Proc. Ent. Soc. Wash., 8:95.

This species has been collected at only a few widely scattered sites in arid parts of California and interior British Columbia during the 70 years since the original specimens were taken in the vicinity of Los Angeles (Powell, 1959, 1971). Considerable interpopulational variation is exhibited, and study of more material will be necessary in order to confirm that just one species is involved. This and related species in the southwestern United States, which have the palpi clothed with stiff, erect bristles, are believed to be diurnal.

I have not been able to confirm the foodplant of *coquillettella* with certainty. The moths have been encountered only in small numbers, and not in close association with any plant. Larvae accept *Phacelia* and *Nemophila* in the laboratory, and on two occasions have been reared to the fifth instar but not to maturity. One larva was collected in the field on *Phacelia distans*.

Study areas: - 1) Pinyon Flat, 16 road miles southwest of Palm Desert, Riverside Co.; 1 male, 3 females taken in flight, 11:00 A.M. - 1:00 P.M., April 13, 1963 (C.A. Toschi and J. Powell), 3 females retained alive (63D19). 2) Railroad Canyon, 4 miles northeast of Elsinore, Riverside Co.; 1 male, 2 females at flowers of *Coreopsis californica* (Compositae), 11:45 A.M. - 2:00 P.M., April 13, 1965 (C.A. Toschi and J. Powell), 2 females retained alive (65D1). 3) Del Puerto Canyon, 23 road miles west of Patterson, Stan-

islaus Co.; 4 males, 1 female taken in flight, 12:30 - 3:00 P.M., March 25, 1969, 2 males, 1 female retained alive (69C94); 1 larva on *Phacelia distans*, April 27, 1969 (69D59). At Pinyon Flat the moths were taken near *Mentzelia* (Loasaceae), a possible nectar source, and immature *Phacelia distans* var. *australis*; at Railroad Canyon a mixed stand of *Phacelia cicutaria* var. *hispida*, *P. distans*, and *Nemophila menziesii* grew near the collection site; while at Del Puerto Canyon, *Phacelia distans* and *Amsinckia intermedia* were suspected hosts.

Adult behavior: - Collection records indicate a single flight period in early spring, in California from mid February to mid April, varying with conditions of locality and season. Laboratory observations have been sporadic but tend to confirm the diurnal behavior pattern indicated by adult morphology and field collections. In the breeding jar moths were active during the day and occasionally at night if direct lighting was on them. Mating was not observed.

Females from Pinyon Flat were caged with *Phacelia* and *Mentzelia* in a 85 x 100 mm jar, but on the day following collection the jar became water soaked during transport in a field ice box. Two of the females recovered and were transferred to a one-gallon jar; but probably they had been weakened as it appeared that neither left the floor of the container. Only 9 eggs were deposited, on the cardboard jar floor.

Females from Railroad Canyon were also housed in an 85 x 100 mm jar under field conditions. A bouquet of *Phacelia cicutaria*, *Nemophila*, and a *Coreopsis* flower was offered as possible oviposition substrate and nectar source. A natural photoperiod rhythm was not provided, and, with exposure to indirect and direct lighting late in the evenings, activity periods apparently were irregular. A total of 40 eggs was deposited by one or both females, in part during early hours of night (8:00 P.M. - 2:00 A.M.) and during early morning hours (2:00 A.M. - 8:00 A.M.). A few eggs were placed on leaves of *Nemophila* but most were deposited around corners of the container floor.

The adults from Del Puerto Canyon were caged in more suitable conditions, in a one-gallon breeding jar provided with a bouquet of immature *Phacelia distans*, *Amsinckia* in flower, and immature *Epilobium* sp. (Onagraceae), housed in natural photoperiod. Males lived only 1-3 days, but the females survived 10 days, depositing 70 eggs, nearly all during the first two days of confinement. Both sexes were inactive at night, remaining in quiescent posture until 10:00 - 11:00 A.M. The period of highest activity appeared to be 1:00 - 3:00 P.M., although individual movement occurred in dappled sunlight until 6:00 P.M. The moths displayed a stronger positive phototropic response than some other diurnal species. Oviposition was observed between 1:30 and 3:00 P.M., and a few eggs were deposited later in the day. The female selected roughened surfaces in the side of the

jar towards the light. She walked about on undersides of *Phacelia* leaves and on the nylon screen ceiling with the abdomen extended and curled downward, probing at the substrate. Usually she ran a few "steps", then probed two or three times, sometimes slightly to the side. A quiescent pause of several seconds followed each egg deposition.

Of the 70 eggs, about 75% were deposited around the side of the jar towards the light; and of the total, 60% were placed on the masking tape around the floor and 15% on the nylon. Only 8 eggs were deposited on the plants, all on the undersides of *Phacelia* leaves adjacent to the light side.

Egg. - Eggs were uniformly subrectangular, varying from 0.46 x 0.76 to 0.41 x 0.82 mm in outline. During development all turned pink by the third day, and a somewhat darker reddish by the 7th to 9th day. Incubation time varied from 10 days in April in the field (65D1) to 11-12 days in March at room temperatures (69C94). Emergence sometimes occurred well off center of the micropylar end.

Larva. - Considerable difficulty was encountered in inducing young larvae to establish and feed, relative to my experience with other *Ethmia*. A distinct preference for flower buds was shown, and it appeared that leaves were unsuitable for development. A continuous supply of immature flowers was not provided, and this may have been a critical factor in the failure of larvae to reach maturity under laboratory conditions.

First instar larvae (63D10) placed on *Phacelia distans* from Pinyon Flat which had been in refrigeration 16 days failed to survive. Some fed a little at the base of buds, but none successfully established themselves.

One and two day old larvae (65D1) were placed on fresh buds of *Nemophila maculata* and *Phacelia tanacetifolia* from the Botanical Garden; larvae at first began feeding on both plants, either in the buds or in crotches of leaflets or sepals. All eight larvae placed on the immature, scorpioid spikes of the *Phacelia* established successfully and reached at least the second instar. The inflorescences were tightly curled, and by the second day frass was visible between the appressed, hirsute buds. Larvae continued to feed inside the buds during the first 12 days; on May 7, 10 day old plant material from the Botanical Garden was added when the larvae were 11-12 days old. Three days later only three larvae had moved to the more recently offered buds. On May 14, the 3rd and 4th instar larvae were moved to fresh *Phacelia tanacetifolia* from the Botanical Garden. By this time the plants had bloomed and subsequent feeding took place mainly on smaller leaflets, often those adjoining flowers.

The ephemeral character of the *Nemophila* flowers prevented establishment of all but one of the first instar larvae.

This larva succeeded in burrowing into an unopened bud, preventing it from further development, and fed on the pistil and stamens for 11 days; it then migrated to a new, less developed bud and began feeding. The 15 day, 3rd instar larva left the *Nemophila* (which was partially collapsing in the water vial) and was transferred to the *Phacelia*. At the Botanical Garden the *Nemophila* was drying by the time the larvae were 19-20 days old, which, together with the difficulties encountered in establishing on this plant, suggests that *Nemophila* is not a suitable host. Nutritionally the *Nemophila* flowers appeared to be adequate since the one larva was as mature as the most advanced of those feeding on *Phacelia* at each inspection.

On May 24, about 30 days after hatching, laboratory observations were interrupted by a vacation camping trip. The remaining larvae were carried in a salve tin and were subjected to greater temperature fluctuations than in the laboratory and to drying of the foodplant. Fresh *Phacelia* leaves were added from San Bernardino County, California, and Coconino County, Arizona, but the final larva died by June 4 while an early fifth instar.

Unfed first instar larvae (69C94) were placed on *Phacelia distans* from Del Puerto Canyon, which had been kept in water 12-13 days; establishment was affected by burrowing into unopened buds. After 4 days an accumulation of fine frass was noted in the dense hairs of the inflorescence. On April 19, the 10-12 day old 2nd and 3rd instar larvae were transferred within their shelters to vials with fresh *Nemophila menziesii* from Santa Clara County. Although the original *Phacelia* had become blackened and mouldy, after 3 days there were no signs of feeding on either flowers or leaves of the *Nemophila*. The 13-15 day old, 3rd instar larvae were then offered fresh *Phacelia tanacetifolia* from the Botanical Garden, and all established new shelters. Subsequent feeding occurred in buds on bouquets of this host. Fresh sprigs were added every few days, as it did not keep well in water, and two exposures to badly withered plants probably affected larval development. Owing to a field trip intervention, surveillance was terminated on May 9, and the 30-32 day old larvae were preserved. They apparently were penultimate and immature last instar individuals which had not grown during the preceding 4 days due to the condition of the plant.

Inspection of *Phacelia distans* at Del Puerto Canyon on April 27 (when laboratory larvae were about three weeks old) revealed only one larva of *coquilletella*. This individual was provided *P. distans* for 8 days, then *P. tanacetifolia*. However, foodplant conditions were intermittently poor, and the larva died on May 7 in the final instar.

Since feeding took place on buds of *Phacelia tanacetifolia* in water and the developmental rate was similar to

that of *Ethmia brevistriga*, it is assumed that *P. distans* and *P. cicutaria* might serve as suitable hosts at the study sites. However, as with other species in the diurnal group, a definite preference for feeding in unopened flowers was shown, and it may be that fresh buds are necessary to provide sufficient nourishment to complete development.

*First instar:* Length 1.6 mm; HC 0.20-0.22 mm, brown, ocellar area black; ThSh brownish; integument and setae unpigmented.

*Second instar:* Length [1] 4.0 mm; HC [4] 0.30-0.35 mm, brown, frontal area slightly paler; ThSh, thoracic legs, lateral spots on prolegs, and anal shield, brown; Pin minute, dark, integument otherwise unpigmented. AbdCr 8-10; AnCr 7-8.

*Third instar:* none preserved; HC and ThSh dark brown, integument pattern pale purplish.

*Fourth instar:* Length [2] 8.2-8.5 mm; HC [3] 0.67-0.74 mm, brown, mottled with pale areas; ThSh mottled, brown with darker spots; Pin blackish; D white (not unpigmented) with thin, median deep ochreous streaks; DL mottled, pale purplish to brownish olive, large, distinct white rings encircling pinacula; AbdCr 7-10 (usually 8-9); AnCr 7-8.

*Fifth instar:* [5] Length 8.0-12.0 mm (none mature); HC 0.74-0.82 mm, markings strongly contrasted; integument colors similar to penultimate, ThSh brown with darker spots; D and pinacula rings of DL more contrastingly white, DL, DV darker purplish or olive, L slightly whitish or unpigmented, with or without faint ochreous streak; AbdCr 9-14 (usually 12-14); AnCr 11-12.

### ETHMIA SCYLLA POWELL

*Ethmia scylla* Powell, 1971, U. Calif. Publ. Ent., in press.

Three localities along the inner Coast Range of central California comprise the known range of *scylla*. I collected the first specimen on March 18, 1959, at about the time my review of the poor state of knowledge of *Ethmia* in California had gone to press (Powell, 1959). However, exactly ten years were to elapse before I was able to solve the mystery of *scylla*'s biology, the search having been hampered by a preconceived notion that some Borage or Hydrophyll must be the hostplant. Although the adults resemble *Ethmia brevistriga*, and thus might be expected to feed on a *Phacelia*, this species proves to be unique as the only member of the genus known to use Scrophulariaceae and further the only member of a Nearctic or Holarctic species group which does not possess the peculiar "anal legs" of the pupa.

Study areas. - 1) Russelmann Park, north slope of Mt.



Diablo, 1100 feet, Contra Costa Co.; adults numerous, April 2, 1960 (J.M. Burns and J. Powell); adults sparse, April 6, 1962, 3 males, 2 females retained alive (62D2). 2) Raines Park, Del Puerto Canyon, Stanislaus Co.; adults sparse, March 5, 1963, (R. Langston and J. Powell), 4 males, 2 females retained alive (63C1); negative results checking *Amsinckia intermedia*, April 30, 1963; adults abundant, March 19, 1969, 4 males, 3 females retained alive (69C90); adults common, March 25, 1969, 2 females retained alive (69C90); larvae abundant in flowers *Collinsia heterophylla* April 27, 1969 (69D60). 3) Three miles northwest of Rumsey, Yolo Co.; adults sparse, March 8, 1964.

**Adult behavior.** - The species has a single annual flight, in moderately early spring, from late February to early April, varying two to three weeks with seasonal conditions. This is well ahead of the bloom period of the foodplant. All three localities are deciduous oak-digger pine scrub forest situations. At Russelmann Park the moths appeared to fly around poison oak, *Rhus diversiloba*, in the manner of *Ethmia albitogata* at the San Bruno Mountains, where *Amsinckia* grows in close association with the poison oak clumps. Adults of *scylla* sometimes perched on poison oak foliage where they resemble bird droppings. The association at Raines Park proved to be a general one; the *Collinsia* is abundant in semi-shaded spots on north slopes around various shrub growth including *Juniperus*, *Arctostaphylos*, and *Ceanothus*.

Adults were observed in the field between 11:00 A.M. and 4:00 P.M. Two mating pairs were taken, one at 3:40 P.M. on April 2, 1960. Mating did not occur in the laboratory.

In captivity moths intermittently abandoned the quiescent posture between 8:30 and 10:30 A.M., but continuous activity did not begin before 11:00. It lasted until about 4:00 P.M., after which movement gradually subsided, ceasing by 5:45 or 6:00 P.M., at about sunset. As indicated by oviposition, the height of activity was not concentrated into a brief period and did not strongly vary between cloudy and clear days, extending from 12:00 or 1:00 P.M. to about 4:00. Generally adults were strongly positively phototropic, and oviposition by the 1962 females seemed to corroborate this. However, when *Collinsia* was offered (69C90), eggs were more evenly distributed, with more than half of those deposited on plants having been placed on a *Collinsia* in the center of the jar, rather than on those nearer the light source.

In earlier collections various immature, low growing annual plants from the collection sites were included in the breeding jars. The 1962 lot was also provided with a few small *Plagiobothrys nothofulvus* from Lake County. Several small *Amsinckia intermedia* in bloom were included in the 1963 trial. One or more of the 62D2 females deposited 5 eggs on the nylon ceiling and 30 on the cardboard floor (which was roughened, with fibres protruding, the result of

removal of masking tape), 80% concentrated on the side of the jar towards the light. In experiments with other *Ethmia* the cardboard floor was sometimes used by old, weak females, but in this case it was selected on the first day of confinement, judging from the incubation period.

The 1969 moths were offered an array of *Amsinckia* in early bloom, and immature plants of both *Phacelia distans* and *Collinsia heterophylla*. The latter had been observed in high numerical density in the vicinity of female moth concentration. In the breeding jar females complied by displaying a distinct selection not only for *Collinsia*, but for the leaf axils. A total of 124 eggs was deposited by 4 females; exactly half were placed on the nylon screen, while nearly all the remainder (60) were laid in leaf axils of *Collinsia*. Most were on the upperside of the petioles, but some were placed in axils where secondary leaves originated, so that they were sometimes affixed to undersides of secondary petioles when tucked into the primary axils. They were distributed along the height of the plant, but tended to be concentrated (60%) on the middle axils, which bore the secondary leaf growth. One egg was deposited on the upperside of a leaf blade. One was deposited on each of the *Amsinckia* and *Phacelia*.

Females tended to concentrate on the screen ceiling towards the light source, but wandered during oviposition. The probing action of the extended ovipositor was more or less continuous at about 30/minute. One female was observed in this behavior on the nylon, traveling some 7 cm during 2.5 minutes; finally after 4 minutes she extruded an egg onto the apparently uniform nylon mesh. Deposition of an egg required 1-2 seconds, after which the female usually quickly moved several cm without probing the ovipositor, then stopped in a stationary pause, sometimes moving to the light side to do so. Results of individual female's efforts were not tabulated, but 3 females deposited a combined total of about 100 eggs in 2 days.

The moths did not survive long under cage conditions, males living 3-7 days, and the females only 3-5 days.

Egg. - (figs. 13-17) The egg is characteristically elongate, cylindrical, with the chorion strongly reticulated with ridges which bear no microstructural modifications. Eggs varied from 0.30 x 0.59 mm to 0.27 x 0.61 mm.

During development the eggs changed color, to pale orange by the 2nd day, bright pink by the 3rd day, and gradually darker reddish before the larvae became visible prior to emergence. Incubation required 10 days (62D2) and 8-9 days (69C90) at laboratory temperatures.

Larva. - In order to confirm the host selection displayed in oviposition behavior, separate lots of newly hatched larvae (69C90) were segregated in 32 x 90 mm shell vials and were offered cut terminals including flower buds,

of four menus: a) *Collinsia heterophylla* alone, b) *Phacelia distans* and *Amsinckia intermedia*, c) *Collinsia* and *Phacelia* d) *Collinsia* and *Amsinckia*. Six larvae were isolated in each vial, and three additional larvae were added to c) and d) after three days. In each case the only successful establishment occurred in flower buds of *Collinsia*, with about 33% of the individuals successful. The *Amsinckia* did not fare well under the conditions and was essentially wilted within three days, while the *Phacelia* remained in good condition for at least five days. All plants were in poor condition by eight days, and the a) vial became diseased by the 11th day. There was no evidence that feeding occurred on either *Collinsia* leaves or any part of the *Phacelia* or *Amsinckia*. Surviving larvae, along with others established in separate containers with *Collinsia* bouquets were fed subsequently on flowers of *Collinsia heterophylla* which had been taken in immature condition on March 25 at Raines Park and kept in water, where the plants developed to full bloom. Additional *C. heterophylla* from the Botanical Garden was provided to nearly mature, 24-26 day old larvae.

Larvae of all instars fed within developing flowers. If a bud was entered, no feeding occurred on sepals except in excavating an entrance hole; ovaries, stamens, and corolla parts were fed upon, preventing the bud from opening. Usually partially or fully opened flowers were used, and ovaries were consumed, along with basal portions of the corolla, but no feeding occurred on the sepals. After a few days young larvae migrated to new flowers, leaving the wilted corolla *in situ*. In the field this resulted in several withered and abandoned flowers on a given plant, indicating the presence of one larva. Normally only one or two flowers on any given tier were affected. The larva moved upward as the inflorescence elongated, rather than working around the inflorescence until all available flowers at one tier level were exhausted.

In contrast to some species of *Ethmia*, the larvae curled and feigned death at the slightest disturbance. They were thus difficult to manipulate during transfer from one flower to another, as they could not be induced to spin silk onto the probe, and even if transferred with a damp brush or forceps and balanced in an immobile posture on a new flower, would almost always drop off upon moving again. However, they showed a strong tendency to wander up vertical objects, and usually migrated back up flower stems and reestablished on their own when a given flower became exhausted.

Development proceeded rapidly relative to other *Ethmia*. Individuals provided with *Collinsia* buds in good condition reached the second instar by 8-10 days, and the third instar by 11-13 days. The fourth instar was not preserved, but all larvae had passed through it by 25-27 days. Final instar, 25-29 day old larvae were preserved on April 25 and 27, and the last mature larva prepared for pupation on April 29, 31 days following beginning of egg hatch.

On April 27 the Raines Park site was revisited and larvae were found abundantly in *Collinsia* flowers (69D60). Development was retarded relative to that in the laboratory. No larvae were preserved on this date, but after six days storage at outdoor temperatures, a larval sample showed three instars, 3rd, 4th, 5th, in a 2: 4: 5: ratio. At eight days all three were still present, in the ratio 1: 3: 10. Only full grown larvae remained on May 9 (12 days after collection), 51 days following the original collection of females in the field. Thus height of oviposition probably occurred March 19-26, and most larvae reached maturity in the field about May 3-9, an average lapse of 45 days.

There are five clear-cut larval instars, according to unsexed head capsule measurements (fig 4).

*First instar:* Length 1.2-1.4 mm; HC 0.16-0.18 mm, light brown; ThSh narrowly light brown, well defined; body yellowish, integument unpigmented.

*Second instar:* Length 2.0-2.5 mm; HC 0.25-0.27 mm, dark brown; ThSh well defined, brown; integument with pale DL color, faintly defined paler D and rings around Pin which are barely visible; AbCr 8-9, essentially a complete circle; AnCr 7-8.

*Third instar:* Length 3.2-4.8 mm; HC 0.38-0.43 mm, dark brown, slightly mottled paler; ThSh brown, slightly mottled darker posteriorly; D well defined; unpigmented except slight median pink line; DL pink, weakly defined; LV pinkish, scarcely defined; Pin dark, well defined; AbdCr 9-11; AnCr 8-9.

*Fourth instar:* Length 5.5-7.2 mm; HC 0.51-0.68 mm, light brownish mottled with darker brown; integument pattern as in final instar, paler; D well defined, unpigmented except median pinkish line; DL fairly well defined; Pin black, surrounded by unpigmented circles; AbdCr 10-14 (mostly 10-11); AnCr 8-9.

*Fifth instar:* Length 8.8-12.0 mm; HC 0.82-0.98 mm, orange with faint brown mottling; ThSh sclerotized as median lateral spot and posterolateral blackish patch; integument pattern well defined pink on whitish-unpigmented or purplish on pinkish-unpigmented (probably varying with petal colors consumed), D well defined with median pink streak; DL well defined, dark, defining unpigmented circles around the black Pin, L unpigmented; LV fairly well defined; AbdCr 14-18, rarely 20, usually nearly uniordinal; AnCr 16-17; one or two secondary setae in LV group on abdominal segments 1, 2, 7, sometimes 8.

*Pupa.* - Small blocks of dry *Yucca whipplei* floral stalks were provided and were used by all successfully pupating individuals. Each spun the cocoon in a narrow gallery running parallel with the grain of the wood. It

appeared that abandoned *Cossonus* galleries were appropriated and at times somewhat enlarged. Emergence trackways led out to split ends of the substrate and each was divided into two chambers by silken caps, one near the surface and one recessed several mm, which was of slightly less diameter than the pupation chamber, located at the anterior end of the cocoon. Cocoons ranged about 5.4-5.7 x 1.3-1.7 mm and were simple, without any interior meshwork.

Pupae (fig. 10) ranged 4.7-5.2 mm in length and were simple, without functional cremaster, anal legs, or other setation. The ninth segment was unmodified and fused to the eighth at mid venter. The spiracles were small, simple, 0.35 mm in diameter. Evidently the cocoon shape retains the pupa at emergence.

Pupae formed by larvae in May, 1969, failed to emerge, although housed at Russell shed, where conditions stimulated emergence of *plagiobothrae* (69D58) in the same winter. Pupae were still viable appearing when extracted from cocoons after 17 months.

### ETHMIA BREVISTRIGA BREVISTRIGA CLARKE

*Ethmia brevistriga* Clarke, 1950, Jour. Wash. Acad. Sci., 40:163.

The nominotypic subspecies is known only from localities along the immediate coast of California.

Study areas. - 1) Laguna Puerca, San Francisco; adults common in association with *Phacelia distans*, April 7, 1961; 5 males, 5 females retained alive (C.D. MacNeill and J. Powell) (61D2); larvae on *P. distans*, May 6, 1961 (61D2); larvae on *P. distans*, May 24, 1961 (61E21). 2) Lobos Creek, San Francisco; adults in association with *P. distans*, April 7, 1961; 1 male, 1 female retained alive (61D2).

Adult behavior. - A single, well defined flight was shown in 1960 and 1961 at San Francisco, from mid March to mid April, prior to beginning of flowering of *Phacelia distans*. Six pairs were caged with a bouquet of *P. distans*. These moths showed a slightly later diurnal activity period than *albitogata*, housed under similar conditions. Individuals of *brevistriga* were not active before noon, and even by 1:30 P.M. only limited movement and no oviposition was occurring. The height of activity appeared around 3:30 to 4:30, continuing until about sunset, around 6:00 P.M. By 7:00 they had become sluggish and only flew straight down if dislodged. None moved at night. This species showed a greater tendency to perch on the host plant than any of the others studied. About 60-80% of the individuals rested on the plant, even at night.

Mating was witnessed twice. A pair was swept *in copulo*

at Lobos Creek at 3:00 P.M. They had been flying or were perched on the tip of a *Phacelia* branch. They were still in coition at 7:00 P.M. following transport from the field. Housed in darkness, they remained *in copulo* until at least 11:00 P.M. The second pair mated sometime between 1:00 and 5:30 P.M. on the first day after confinement; after 5:30 they remained inactive, clinging to an upright pin all night. Separation occurred between 9:30 and 10:10 A.M.

Oviposition by several females was observed, between 3:30 and 4:00 P.M. It probably took place earlier, and one female exhibited apparent oviposition behavior at 5:15 P.M. Characteristically females crawled over the uppermost foliage or moved spirally up a stem, with the abdomen distended, moving rather slowly and vibrating their antennae. The substrate was tapped 4 or 5 times with the papillae anales prior to deposition of an egg. A period of quiescence (18 to 45 seconds) usually followed each egg after which the moth resumed its crawling or flew to a new spot. Periods of crawling on the screen were sometimes interspersed with those of oviposition.

About 80 eggs were deposited by the females during the first two days of confinement. It appeared that none were laid on the plant after the third day. Nearly all were concentrated in the upper 5 cm of foliage, mostly around the buds. The eggs on the inflorescences were not nested deeply into crevices, but were placed between the plant hairs (figs. 21-23). The uppersides of upper, young leaves and the main stem were also used as oviposition sites. Eggs placed below the upper 5 cm of foliage were on the stem. None were placed on the undersides of the leaves except on the main midrib. Some oviposition after the third or fourth day of confinement took place on the cardboard floor of the jar.

Egg. - The eggs ranged 0.31 x 0.53 mm to 0.30 x 0.60 mm and as thick as wide (fig. 23). When first deposited they were pearly white; after about 48 hours they turned yellow. Prior to hatching the dark larval head capsule became visible. Eggs hatched April 19-20, after about 11 days at room temperature.

Larva. - Several *Phacelia distans* plants from Laguna Puerca were planted in pots in a greenhouse prior to emergence of the first instar larvae. These plants, which matured sooner than those in the field, were used for observations on behavior of young larvae.

First instar larvae migrated upward and commenced feeding at bases of flower buds. In one instance a one day old larva had bored through the sepals of a small unopened bud. The first external evidence of established larvae appeared by 4-6 days in the form of small frass accumulations in the flower heads.

By the 14th day the insectary plants had bloomed com-

pletely, but the larvae, in the third and fourth instars, had prevented development of some buds in which they fed. In each case the larva had formed a well concealed shelter between the rows of flowers on the scorpioid spike, hidden primarily by the dense plant hairs. The shelters were held together by a weak network of silk. Feeding occurred in the currently opened flowers and unopened buds, usually all the way out to the terminal end of the inflorescence. Not all of every flower was consumed, and some were still in apparent bloom. Damage to the inflorescence was not evident externally, and the frass accumulations were the only visible evidence of the larvae.

On May 5, 17 days after commencement of hatching in the laboratory, the Laguna Puerca site was investigated. Three third instar larvae were found, in shelters similar to, but less extensive than, those in the greenhouse. Field plants had bloomed only about half way along the inflorescence. Larvae were located just basad of the current bloom, feeding on the flowers with developing seed. Frass from these shelters was not visible from the exterior, evidently having been dispersed by factors such as wind. All larvae were moved to newly potted plants at this time, but the plants did not survive. The remaining larvae were transferred to salve tins with cut inflorescences two days later.

By the 24th or 25th day following hatching some larvae had reached the last instar. One larva on one of the original potted plants reached the last instar by the 28th day, when it was preserved.

A third examination of the field colony was made on May 24, 36 days after laboratory eggs began hatching and 6 days after the first cocoon was spun in the greenhouse. Larvae were found to be fairly common in areas where the *Phacelia* was more sparse, although the shelters were as inconspicuous as they had been three weeks earlier. By this time field larvae were mostly penultimate instar; a few were antepenultimate, and only one was in the final instar.

All larvae reached the final instar by the eighth day after the second larval collection, and the final larvae which had not spun cocoons were preserved June 6, 60 days after the original adult collection.

There appeared to be five instars, on the basis of unsexed head capsule measurements (fig. 3).

*First instar:* Length 1.5-1.7 mm; HC 0.18-0.20 mm, brown; ThSh and anal shield pale brown; integument and setae unpigmented.

*Second instar:* None preserved; HC 0.27-0.36 mm [5], brown.

*Third instar:* Length 4.3-6.0 mm [3]; HC 0.42-0.47 mm, dark brown; ThSh brown; Pin minute, dark; DL sometimes with a trace of pale brownish; AbdCr 8-11; AnCr 9.

*Fourth instar:* Length 5.3-9.3 mm; HC 0.66-0.77 mm, usually slightly to considerably paler brown than third instar, lightly mottled; ThSh paler brown; Pin small; integumental pigment well developed, D white, DL brownish, broad, extending below spiracle; L narrow, whitish; LV with little pigment; AbdCr 9-13; AnCr 9-10.

*Fifth instar:* Length 9.0-13.2 mm; HC 0.86-0.95 mm, orange brown, mottled; ThSh pale brown with dark spots; D white (not unpigmented), DL broad, as in fourth instar, darker, purplish; Pin small, in DL surrounded by whitish circles; L white; AbdCr 15-18; AnCr 16-17. Segment A9 with 6-8 tiny secondary setae on LV.

*Pupa.* - Pupation and successful development took place in small beetle galleries in split sections of *Yucca whipplei* inflorescence stalk, in one instance about 15 mm into the yucca, although not much excavation of the matrix by the *Ethmia* larvae was involved. Pupation also occurred in a corner of a salve tin, in flower heads, and in folds of paper toweling. The only successful emergence occurred from one of the latter. Those in the flowers and salve tin desiccated prior to development.

The cocoon surface was papyrus-like, without much loose internal silken mesh. The pupae ranged 5.4 to 5.6 mm in length. The anal legs were short, the free portion only 0.22-0.23 mm long, appressed to abdomen, with 16-20 setae situated broadly over the distal end.

### ETHMIA BREVISTRIGA ARDICOLA POWELL

*Ethmia brevistriga ardicola* Powell, 1971, U. Calif. Publ. Ent., in press.

This race occurs at inland stations, mostly in the mountains marginal to the deserts. From the following fragmentary data and larval morphology, *ardicola* appears to have essentially the same biological characteristics as the nominate subspecies.

*Study areas.* - 1) Hills two miles northeast of Lake-side, San Diego Co.; adults taken in flight without definite plant association, March 13, 1963 (J.A. Chemsak and J. Powell); 5 males, 1 female retained alive (63C2). 2) Pinyon Flat, 16 road miles southwest of Palm Desert, Riverside Co.; adults abundant at flowers of *Cryptantha ?circumcissa* and flying in association with *Phacelia distans* subsp. *australis* April 7, 1963 (R.L. Langston, C.A. Toschi and J. Powell); 3 females retained alive (63D6); April 12, 1963, 4 males 5 fe-



males retained alive (63D17); young larvae on *P. distans* var. *australis*, April 13, 1963 (63D20).

Adult behavior. - This subspecies has about the same seasonal flight period as its coastal counterpart, despite the higher elevation of the inland sites (up to 5000 ft.). Moths of 63C2 were caged in a gallon breeding jar in the field with a bouquet of *Cryptantha* and kept under variable conditions until the fourth day. They did not begin activity until about 12:20-1:00 P.M. with the room temperature at about 18° C, even though an *Ethmia minuta* male in the same jar had been active for two hours. As with *b. brevistriga*, the greatest activity seemed to be about 4:00-4:30 P.M. The last individual ceased activity and entered the quiescent posture at 5:40 on one afternoon, but several were active until 6:10 (dusk) on another; and moths were observed with the antennae in active position as late as 7:00 P.M. on the tenth day after collection.

Males lived 8-13 days and the female 13 days, but only 2 eggs were deposited, those on the glass side of the container. Presumably absence of *Phacelia* resulted in failure to initiate oviposition. Moths of 63D17 were caged in an 85 x 100 mm jar with a bouquet of *Phacelia* and *Cryptantha* but became water soaked in transit in an icebox from the field laboratory April 14; several recovered and two females lived until the sixth day following collection. Eggs were deposited April 14-17 on both upper and lower surfaces of *Phacelia* leaves, not on buds, and on *Cryptantha* foliage, dry *Cryptantha* flowers, and on a dead *Ethmia* male.

The three 63D6 females deposited 1, 6, and 10 eggs in their individual, dry vials during the 2-3 days they lived.

Egg. - Eggs deposited in dry vials were evenly oval, tapering slightly towards both ends, not as rectangulate as in related species. The width and length ranged 0.33 x 0.63 to 0.36 x 0.63 mm.

Eggs of 63D6 were stored in dry vials in warm conditions of a field laboratory and hatched in 8 to 9 days; those of 63D17 were stored under moist conditions and variable, cooler temperatures (including one to two days in a field icebox) and hatched in 8 to 13 days.

Larva. - First instar larvae hatching from eggs on the plant material, *Phacelia distans* subsp. *australis* and *Cryptantha circumcissa* were left *in situ* in the inflorescences. Most established feeding sites successfully on *Phacelia* buds, although leaf material was eaten by two individuals. None fed on the *Cryptantha*. Those from dry vials were placed on flowers of *Phacelia*, and the flower parts served as food throughout their growth.

The second instar was reached by about the sixth day by most larvae; thereafter developmental rates varied, owing

to variation in condition of the plant material.

The *Phacelia* stems in one of two 63D17 lots began to rot a week after the larvae hatched, and these larvae were transferred to fresh, although mature, *Phacelia distans* from Stanislaus County. They continued development, using mature flowers; both the flower parts and developing ovules were eaten. One larva reached the final instar by the 30th day.

A second lot was retained on the original *Phacelia* material from Riverside County, which remained in good condition for about 27 days after the larvae hatched. However, all flower parts were eaten by this time. Larvae fed entirely on the half of the flowers towards the center of the spike, or by cutting a hole through this side and eating the center portions out, taking whole developing seed or only their inner half. By the 33rd day the plant had dried excepting the stems, and larvae starved in the final three instars.

Laboratory reared larvae averaged somewhat smaller and were considerably paler than *b. brevistriga*.

*First instar:* Length 1.3-1.4 mm, HC 0.19-0.20 mm, almost colorless except ocellar area black.

*Second instar:* None preserved; HC 0.27-0.36 mm [3], pale brownish.

*Third instar:* Length 3.6 mm [1]; HC 0.46-0.49 mm, dark orange-brown; ThSh pale tan; integument, setae and crotchets unpigmented.

*Fourth instar:* Length 6.4 mm [1]; HC 0.63-0.68 mm [4], orange-brown, mottled; ThSh orange-brown; integument, setae and crotchets unpigmented; AbdCr 10-11; AnCr 10.

*Fifth instar* [2]: Length 7.5-8.0 mm; HC 0.79-0.85 mm, orange, mottled; ThSh orange-brown; integument pattern similar to *b. brevistriga* but much paler and reduced; D whitish (not as distinctly white); DL dark pinkish or rosaceous; setae and crotchets unpigmented; AbdCr 14-16; AnCr 14-16.

### ETHMIA ALBITOGATA WALSINGHAM

*Ethmia albitogata* Walsingham, 1907, Proc. U. S. Natl. Mus., 33:109.

This species is known from only a few localities in central California. It is closely related to *E. plagiobothrae*, and it was not until differences in hostplants and larvae were discovered that distinguishing morphological characters in the adults of the two species were recognized.

Study areas. - 1) San Bruno Mountains, San Mateo, Co.;

adults common, Feb. 28 - March 1, 1963 (C.D. MacNeill and J. Powell); 5 males, 2 females retained alive (63B9); larvae on *Amsinckia lunaris*, May 3, 1963 (63E1). 2) Pt. Reyes, Marin Co.; larvae on *Amsinckia spectabilis*, April 31, 1967 (G.A. Gorelick) (67D149). 3) Arroyo Mocho, 15 miles southeast of Livermore, Alameda Co.; adults common, Feb. 22-24, 1968 (C. D. MacNeill and J. Powell); 5 males, 4 females retained alive (68B178); negative results checking *Amsinckia* and *Plagiobothrys*, April 27, 1969; adults sparse, Feb. 21, 1970.

Adult behavior. - The moths fly in early spring, late January to early March. Presumably germination of the host plant has begun, but I have been unable to locate young *Amsinckia* when the moths are flying. Adults (63B9) were caged with a bouquet of *Phacelia californica*, a suspect host; while 1968 adults were provided with young *Plagiobothrys nothofulvus*, owing to a misidentification of the moth. The correct foodplant was never offered as an oviposition substrate and stimulus.

The moths exhibited a definite diurnal activity rhythm, but neither mating nor oviposition was observed. Individuals from the San Bruno Mountains commenced activity earlier, beginning to abandon the quiescent posture by about 9:30 A.M., three hours after daybreak, with the outside temperature at 9-11° C. During the following two hours all adults engaged in some movement. One female was observed to take water in this matinal "pre-activity" period. Continuous activity, with moths mostly crawling at the side of the jar towards the sunlight, took place between 12:00 and 4:00 P.M. By 4:30 some moths ceased movement, and by 5:30, with the last rays of sunlight on the jar, most individuals had assumed the quiescent posture. Adults from Arroyo Mocho, by contrast remained inactive until 10:30-11:30 A.M., even when the container was transported by car 15 miles to Berkeley. However, they remained active later, till 6:00-7:00 P.M., through the dusk period. Outside air temperatures were warmer during the 1968 observations, ranging to 24° C maximum compared to 15-17° in 1963. Moths in both groups generally displayed a longer activity period than some of the other diurnal *Ethmia*, and they became active quickly if exposed to direct light at night.

Males lived 2-6 days, females 6-9 days, following collection in the field.

In 1963 no eggs were deposited by captive *albitogata*. Presumably the *Phacelia* did not provide adequate stimulus, since cage conditions were comparable to those extant during successful oviposition by other diurnal *Ethmia*. The 1968 females laid only 35 eggs; again absence of *Amsinckia* probably adversely affected oviposition behavior. Of the total, 28 eggs were placed on the helical, ribbed portion of a horizontal, screw-cap vial which held a moisture wick and *Plagiobothrys* bouquet. The remaining eggs were deposited on *Plagiobothrys* leaves (5 upperside, 2 underside).

Egg. - The eggs did not differ superficially from those of *plagiobothrae*. No measurements or photographs were executed. Incubation required 11-11.5 days.

Larva. - First instar larvae were placed on *Plagiothrys nothofulvus* from Arroyo Mocho. Uprooted young plants had been placed in water vials 12 days previously, and after initial die back of lateral leaves, survived well for the duration of the experiment and were sending up floral stalks by the time of larval hatch. Most larvae did not establish on this host. It appeared that those situated on new terminal leaves were unable to penetrate the thick pubescence; when transferred to the undersides of basal green leaves, where pubescence was less dense, most still did not feed successfully. Two individuals accepted the *Plagiobothrys* and fed about 7-9 days, reaching the second and third instar. Feeding occurred in the form of small skeletonized areas, with a thin silk envelope between the new leaves of the terminal growth. Although the plants remained in good condition more than three weeks after transferral to the water vials, no flowers had begun to open by the time the larvae succumbed in what appeared to be starved condition. The unavailability of flower parts rather than the wrong host genus may have been the critical factor in the failure of the larvae to mature.

At San Bruno Mountains in 1963 close association of adult flight with several clumps of poison oak (*Rhus diversiloba*) on rocky outcroppings, enabled discovery of larvae on *Amsinckia lunaris* there in early May. At this time, about 60 days after the height of observed adult activity, the plants were in full bloom, and larvae of the final three instars were present. There was variation between *Amsinckia* colonies from 75% penultimate and none full grown to 50% mature final instar and the remainder young final instar.

All larvae were found inside inconspicuous shelters formed in the flower spikes, similar to those of *E. brevistriga*. Larvae moved along the upper side of the scorpioid spike, webbing the flower parts together above the larval galleries. Feeding took place on the whole inner side of the flowers. Developing ovules and ovaries of unopened flowers were consumed, and even sepals were eaten by larger larvae. Portions of the flowers on the outer half, visible from the exterior of the inflorescence, were untouched. Petals were mostly above the area of feeding and remained intact, without discoloration or wilting. Some feeding occurred on the inflorescence stem; in one instance it was cut entirely through.

Shelters were not evident from the exterior, but affected inflorescences could be detected by frass clinging to the older, unoccupied portion of the spike where elongation of the stem caused separation of the partially eaten flowers, exposing silk. Frass apparently was entirely retained within active parts of the shelter, not visible from the exterior.

Larvae were placed in plastic sandwich boxes with small bouquets of *Amsinckia*. However, the viscid plant did not keep well and mould developed within three days. *Yucca* pith was added as a pupation site, but the colonies became affected with disease and no larvae pupated.

As in *plagiobothrae*, head capsule measurements did not enable definition of all instars (fig. 2). In both species either the second instar head capsules were not recovered or a greater relative size increment occurred between the first and second than in other *Ethmia*. Moreover, these two species exhibited two color phases in the final instar, a characteristic not observed in related species. Head capsule measurements showed only a very slightly larger average in the paler of the two phases.

*First instar:* (None preserved in healthy condition) HC 0.18-0.22 mm, dark brown; integument, including pinacula, unpigmented.

*Second instar(?)*: [1] (Not preserved in distended condition) HC 0.33 mm; dark brown; integument unpigmented, Pin slightly darker; AbdCr 9-10; AnCr 9.

*Third instar (?)*: [1] (Not preserved in distended condition) HC 0.50 mm; brown, unmottled; ThSh brown laterally, unpigmented mesally; D whitish, DL brownish gray, L unpigmented, LV pale grayish, Pin dark, not defined by pale areas; AbdCr 9-10; AnCr 8.

*Penultimate instar:* [4] Length 7.5-7.8 mm; HC 0.57-0.60 mm, dark brown, paler above labrum, not mottled; D scarcely distinguishable, whitish, DL pale grayish (not distinct as in fourth instar *plagiobothrae*), L unpigmented; AbdCr 6-9 (usually 8-9); AnCr 6-7.

*Final instar:* Length 10.2-13.0 mm (rarely, teneral?, 7.7 mm with integumental pigment reduced); HC 0.83-0.96 mm, strongly mottled; similar to *plagiobothrae* but paler, with the two color forms not as distinguished: (a) (HC avg. 0.88 mm) D pale without yellow-orange spots, DL well defined, dark to pale gray; (b) (HC avg. 0.90 mm) D pale with segmental yellow-orange spots, DL and LV pale gray; Pin small, well defined, dark; AbdCr 10-20 (usually 12-16); AnCr 12-16.

### ETHMIA PLAGIOBOTHRAE POWELL

*Ethmia plagiobothrae* Powell, 1971, U. Calif. Publ. Ent.; in press.

Although discovered only about ten years ago, this species has been collected many times. The larvae are often encountered in large numbers, but in the laboratory they are extremely susceptible to disease. Those which pupate frequently do not metamorphose. Only a few adults have been

taken in the field. *Ethmia plagiobothrae* is closely allied to *albitogata*, but the two exhibit marked biological differences.

Study areas. - 1) Cool, El Dorado Co.; larvae abundant on *Plagiobothrys nothofulvus*, April 24, 1961 (C.D. MacNeill and J. Powell) (61D4, 61D5); 1 male, 1 female, March 21, 1962, female retained alive (62C2); investigated for adults, March 29, 1964 and March 23, 1965, negative results. 2) Six miles west of Whiskeytown, Shasta Co.; larvae on *Plagiobothrys* probably *nothofulvus*, May 10, 1961 (R.L. Langston and J. Powell) (61E10). 3) Eight miles south of Leesville, Colusa Co.; larvae on *P. nothofulvus* April 12, 1962 (J.A. Chemsak and J. Powell) (62D5); investigated for adults, March 8, 1963, negative. 4) Elk Mountain, 2800-3000 feet, 11-12 miles north of Upper Lake, Lake Co.; 3 females flying in association with, 1 egg, 2 young larvae on *P. nothofulvus*, April 4, 1962 (62D12); investigated for adults, April 9, 1964, negative (penultimate instar larvae on *P. nothofulvus* at 2200 feet, one mile south on the same road); adults sparse, March 18, 1965 (R.L. Langston and J. Powell). 5) Ten miles south of Creston, San Luis Obispo Co.; 3 larvae on *P. nothofulvus*, April 30, 1962. 6) Arroyo Mocho, 18 miles south of Livermore, Alameda Co.; larvae on *P. nothofulvus*, April 30, 1963; investigated for adults, February 23, 1964, March 14, 1965, Feb. 24, 1968, March 4, 1969, Feb. 21, 1970, negative. 7) San Antonio Valley Ranger Station, Santa Clara Co.; mature larvae on *P. nothofulvus*, April 30, 1963; investigated for adults, Feb. 9, 1964, negative; 3 young larvae on *P. nothofulvus*, March 14, 1965; investigated Feb. 24, 1968, negative; 1 male, 1 female, March 4, 1969 (P.A. Opler and J. Powell); larvae common on *P. nothofulvus*, April 27, 1969 (69D58). 8) One mile north of Posey, Tulare Co.; larvae common on *P. nothofulvus*, May 14, 1963 (C.A. Toschi and J. Powell) (63E2). 9) Three miles north of Havilah, Kern Co.; 4 larvae on *P. tenellus*, May 15, 1963 (63E10). 10) Fifteen miles southwest of Havilah, Kern Co.; larvae on *P. nothofulvus*, May 15, 1963. 11) Havilah, Kern Co.; larvae common on *P. nothofulvus*, April 28, 1964 (C.A. Toschi and J. Powell) (64D10). 12) One mile east of Woody, Kern Co.; larvae on *Plagiobothrys*, April 25, 1964 (C.A. Toschi), May 3, 1964 (64D16). 13) Three miles northwest of Mariposa, Mariposa Co.; 3 young larvae on *Plagiobothrys*, March 25, 1965.

Adult behavior. - This species has a single annual flight period, in early spring. The few field collections indicate the moths fly in March and early April, ahead of or at about the time the blossom period of the host begins. The development of *Plagiobothrys* is highly variable from one season to another at a given locality, possibly correlated with early spring rainfall, and occurrence of young larvae in mid March, 1965, suggests that the moths are sometimes flying by mid February.

Only one female was observed in captivity (62C2). This field collected individual was caged in a one-gallon

jar with a flat of planted herbs from Cool, and a bouquet of *Phacelia californica* from San Mateo County. The female showed the same activity periods and quiescent posture at night as described above for *E. albitogata*. On one occasion, the female did not move when lights were intermittently on from dusk until 8:00 A.M. In this instance she began activity about 10:30 A.M.

Oviposition behavior, with the abdomen distended and curled towards the leaf substrate, was observed at 12:15, 2:00 and 4:55 P.M. one day, and deposition of eggs was witnessed at 2:30 on another afternoon. On one occasion two eggs were deposited in rapid succession, (a few seconds interval) without apparent probing of the ovipositor, followed by a third egg nearby a few minutes later. A total of 62 eggs was recorded. About two-thirds (44) were deposited on the *Phacelia* (figs. 24-25) and 5 more on grass blades and the glass side of the container adjacent to the *Phacelia*. The remainder were located on what was presumed to be basal rosettes of young *Plagiobothrys*. All but one of the latter group and 90% of those on the *Phacelia* were placed on the undersides of the leaves, which were more hirsute in both cases.

The moth lived nine days after its capture, but probably no oviposition took place after the fourth or fifth day.

Egg. - (Figs. 24-25) The eggs were more variable in shape than most other *Ethmia* studied, ranging in outline from rectangular-oval to ovoid, tapering at both ends; width and length varied accordingly, from 0.22 x 0.47 mm to 0.28 x 0.42 mm.

Development at laboratory temperature required 10-11 days, hatching April 2-4, 11 to 13 days after the female was first caged. Some of the eggs were stored in a refrigerator for 72 hours, and emergence of these was delayed about 3 days beyond the last of the non-refrigerated ones.

Emergence frequently took place off center from the micropyle, by means of an irregular slot contrasted to the more or less evenly oval hole in the middle of the micropylar end, which is usually cut by larvae of other *Ethmia*.

Larva. - Newly hatched larvae were placed on *Phacelia californica*, but none successfully established themselves. A few small spots of skeletonizing represented the only feeding and none of these larvae reached the second instar.

Two young larvae were collected at Elk Mtn., in the basal rosettes of *Plagiobothrys*, but their shelter and feeding were not observed. When preserved, they were in the second and third instar.

Larvae of at least the final two instars fed entirely exposed, on the flowering stalks of *Plagiobothrys*. No visible silk nor other shelter was employed. Larvae could be

found curled around the uppermost flower, feeding on the inflorescences.

Frass was flipped free of the flower parts, appearing on the sides of the container.

In the following larval diagnosis, specimens from Cool and Havilah are mixed in the final two instars. Those from Havilah average smaller, but the ranges of variation are similar.

Evidently this species has five instars (fig. 1), with two well defined color phases in the final instar. It was originally assumed that two instars were involved, but head capsule measurements do not show an appreciable separation. Form (a) has dark gray, almost black integumental markings with yellowish spots in the dorsal band, while (b) has much paler gray integumental bands and conspicuous orange blotches on each segment except the prothoracic. The pale form (b), larvae seemed bulkier and apparently were more mature, but I had no evidence that an ecdysis occurred in development of (a) to (b).

*First instar*[4]: Length 1.0-1.2 mm; HC 0.20-0.22 mm, pale orange with ocellar area black; integument and setae colorless.

*Second instar*[1]: Length 3.0 mm; HC 0.36 mm, dark brown; ThSh, Pin small, and setae dark, integument unpigmented; AbdCr 6-7; AnCr 7-8.

*Third instar*[1]: Length 3.3 mm; HC 0.49 mm, lighter brownish; ThSh not defined; Pin brown, as small as in 2nd instar; integument unpigmented; AbdCr 9-10; AnCr 11.

*Fourth instar*: Length 6.3-8.8 mm; HC 0.53-0.60 mm, dark brown, poorly defined pale area above labrum; Pin small, dark; DL pale gray, D well defined, LV scarcely pigmented; AbdCr 9-11 (Cool) or 7-8 (Havilah); AnCr 9-11.

*Fifth instar*: Length, form (a) 10.0-13.0 mm, form (b) 12.9-15.8 mm; HC 0.75-0.85 mm (Havilah, (a) average 0.77, (b) average 0.79 mm), 0.77-0.88 mm (Cool, both forms average 0.83 mm), orange-brown, strongly mottled; ThSh darkened laterally only; Pin black; D white, well defined, each segment except prothoracic with a bright orange blotch as broad as D; DL gray, narrow; L pale with dull, irregular blotch above spiracle; LV pale gray, irregularly mottled; AbdCr 16-20 (usually 17-19), biordinal mesally; AnCr 19-21, biordinal.

*Pupa*. - Successful pupation occurred in folds of paper toweling or tissue paper, and in yucca pith. Under laboratory conditions most individuals either died as prepupae or young pupae or remained in diapause and did not emerge. On two occasions (61D4, 63E2) single moths emerged early the following year and twice pupae were still healthy appearing



during the second winter: two pupae of 61E10 in December 1962 (19 months after pupating), and one of 64D10 in February 1966 (after 21 months). The latter was placed in an outdoor cage at Berkeley through the spring, 1966, but still did not emerge. Larvae from several lots constructed cocoons in corners of salve tins, and in one case between a cotton plug and glass side of a vial. In all these cases prepupal larvae or pupae became dessicated and collapsed prior to development.

Full grown larvae from San Antonio Valley (69D58) were placed in 35 mm square pill boxes or small salve tins, two or three individuals per container, with a block of yucca cortex in each. After storage at laboratory temperature for 10 weeks they were transferred to the outdoor shed in July. Successful emergence occurred by late February in over 60% of the individuals, suggesting that temperature and moisture rather than photoperiod are stimuli which are important to development during the pupal stage. Cocoons were formed in cracks in the yucca or between the yucca and paper liner.

Pupae from Cool ranged 5.0-5.6 mm in length. The anal legs were dorsoventrally flattened more than in other *Ethmia* studied. In addition they showed a definite tendency for greater lateral expansion distally (appearing boot-shaped in outline rather than evenly expanded laterad and mesad). The free portion was about 0.24-0.27 mm long, with a lateral projection of 0.09 mm. The legs had 32-36 (rarely 38) hooked setae which are about 0.05 mm in length. The setae of the cremaster area were 0.12 mm long and relatively strong, remaining intact during emergence of the moth.

Natural enemies. - About 40% of the groups of larvae in various types of containers became diseased and nearly all larvae in these lots succumbed prior to pupation. Representatives from two affected collections (64D10, 64D16) were submitted to the Division of Invertebrate Pathology at the University of California, Berkeley. G.M. Thomas responded (*in litt.*), indicating that media inoculated directly from titrated specimens produced pure cultures of a *Pseudomonas* sp. and that observations indicated this bacterium was the cause of the disease.

It is assumed that the epidemics were brought on by conditions in rearing, since similarly affected larvae were not commonly seen in the field, and in at least two cases (61D4, 64D10) containers with few larvae did not show the symptoms while those with larger groups did. However, the high incidence of these epidemics and the fact that such symptoms occurred only in this species, *albitogata*, and *charybdis*, indicate that the body flora of these larvae differs from that of most *Ethmia*, causing them to be more subject to disease. This may help account for the fact that larvae of these three species are more easily found in high numerical density in the field than the adults, whereas the reverse is true with other *Ethmia* I have studied.

## ETHMIA MINUTA POWELL

*Ethmia minuta* Powell, 1971, U. Calif. Publ. Ent., in press.

This species was collected in southern California as early as 1916, but probably it was not recognized as an *Ethmia* owing to the small size. The elongated, strongly sclerotized ovipositor and smooth egg are features unique to this species among known New World *Ethmia*.

Study areas. - 1) Hills 2 miles northeast of Lakeside, San Diego Co.; adults at midday flying and on flowers of *Cryptantha intermedia*, March 30, 1961 and March 13, 1963. 2) Two miles northeast of Moreno, Riverside Co.; males flying in midafternoon, April 5, 1963 (C.A. Toschi and J. Powell); both sexes flying in association with *Cryptantha intermedia*, April 12, 2:00-4:00 P.M., 4 males, 4 females were retained alive (63D18).

Adult behavior. - *Ethmia minuta* has a single, early spring flight, from mid March to late April. The moths are diurnal. The four pairs from Moreno were caged in an 85 x 100 mm jar with a bouquet of *Cryptantha* April 13-14 under field laboratory conditions. About 20 eggs were deposited during this time, but no observations on behavior were made. On the following day the moths became water soaked during transport from the field in an ice box. Three females partially or fully recovered, and one lived until April 17. It was observed on the *Cryptantha* once, but no oviposition occurred after April 14.

Eggs on April 13 were all deposited between bases of flower buds (figs. 18-20). These were located only in inflorescences with partially developed flowers. Those with larger green seed and no blossoms left were not used for oviposition. Evidently the elongated ovipositor of *E. minuta* is an adaptation for use of the densely bristled inflorescences of *Cryptantha intermedia*.

Egg. - (Figs. 18-20) In contrast to all other species for which eggs were studied, those of *minuta* had a smooth chorion, without visible network of structural ridges under 54x magnification. The shape was roughly oval, circular in cross section, measuring 0.30 x 0.43 mm to 0.25 x 0.47 mm; variation resulted from the situation of placement. Upon dissection of the flowers most eggs were found to be wedged between a sepal and upper portion of a carpel. Emergence of larvae invariably occurred from the inward end of the egg, adjacent to the carpel. Hatching occurred April 22 ( $\pm$  10 days incubation).

Larvae. - Some of the buds on which the eggs were deposited had dried by the time the larvae began emerging, and they were placed on the exterior of green buds. They seemed unable to crawl on or penetrate the densely bristled vestiture, and several died. None attempted to feed on stems;

no leaves were available.

By opening buds slightly with forceps and inserting two day old larvae, I was able to provide conditions which enabled feeding. Whether the few larvae which successfully established included any of these, or were only those which entered directly from the eggs, was not determined. Feeding by first instar larvae took place at the sides of developing ovules. There was no feeding on petals or sepals, and larvae placed in buds which were too young to have developing ovules did not feed. Most died without establishing successfully, even after some feeding.

Those surviving hollowed out developing ovaries. Second instar larvae were transferred on the fourth day from the drying buds to buds which had been refrigerated two weeks. Again larvae had to be placed into forced open buds and not all succeeded in feeding.

On the twelfth day two third instar larvae were placed on new *Cryptantha* from the refrigerator (originally taken with the moths 21 days earlier). These larvae experienced considerable difficulty and were unable to penetrate the bristled buds after one hour. The two were then placed on flowers which I broke open, but they were still unable to establish easily. After another hour one larva succeeded in beginning feeding on the inner side of the ovary wall. This larva lived until the 17th day after hatching. By this time, however, the 26 day old *Cryptantha* failed to take up water when removed from the refrigerator and no additional food-plant was provided.

*First instar:* Length 1.0-1.25 mm, HC 0.16-0.17 mm, pale tan, almost colorless, ocellar area black; integument and setae colorless.

*Second instar:* None preserved; HC 0.27-0.29 mm [2]; integumental markings evident as pale yellow-orange or ochreous-tan blotches surrounding the DL pinacula.

*Third instar*[2]: Length 3.7-4.2 mm; HC 0.36-0.41 mm, pale to dark brown; DL mottled pale olive-brown; Pin not differentiated, setae and crotchets colorless; AbdCr ±8; AnCr ±8.

### ETHMIA CHARYBDIS POWELL

*Ethmia charybdis* Powell, 1971, U. Calif. Publ. Ent.; in press.

This bizarre species is known from only three localities, having been discovered when we reared a male from larvae collected in 1967. The moth is unique among all *Ethmia* by possession of extremely elongate and peculiarly thin legs, as well as by markedly reduced mouthparts. Primarily on the basis of male genital characters *charybdis* had been placed

as a monobasic species group related to the diurnal group. However, with the discovery, in 1970, of the female which is brachypterous, reevaluation of the species' assignment to *Ethmia* is anticipated.

According to the geographical distributions of the hostplant and of other insects which occur at the type locality, we expected colonies of *charybdis* along the western edge of the San Joaquin Valley and in the Mojave Desert. This has proven to be the case, with collection of larvae in the Mojave in 1970 and recognition of apparently conspecific larvae in the U.S. National Museum collection which had been taken in the southeast corner of San Luis Obispo County<sup>1</sup>, in April 1956, "sweeping wheat and various flowers", by G. Beevor of the California State Department of Agriculture. Examination of *Amsinckia tessellata* in a similar habitat to the type locality, at Jocalitos Canyon near Coalinga, Fresno County, in early February and late March proved negative.

Study areas. - 1) Big Panoche Creek, near Fresno-San Benito County line; larvae on *Amsinckia tessellata*, April 20-21, 1967 (J. Powell and P.A. Rude) (67D87); 1 young larva on *Amsinckia*, March, 1968; negative results checking *Amsinckia intermedia* and *A. gloriosa*, March 5, 1969, and *A. tessellata*, April 23, 1969, and with *Amsinckia* not yet germinated, Feb. 5, 1970. 2) Ryan Mountain, Joshua Tree National Monument; larvae on *Amsinckia intermedia*, March 31, 1970 (R.E. Dietz and J. Powell) (70C13).

Adult behavior. - Only two adults, from Ryan Mountain, have been observed alive, serving as indicators of the seasonal and diel activity periods. Emergence occurred at the end of November and beginning of December, after pupal aestivation in closed containers which were housed under laboratory conditions through the summer and in a modified outdoor situation during fall. Field surveys have not been carried out during the fall months, but the normal flight period is presumed to be late fall or winter, in part through comparison with the life cycle of *E. timberlakei*, discussed below, and in part owing to the brachypterous condition of the female in *charybdis*, a characteristic of certain winter moths in other taxa.

As is true in other fall flying *Ethmia*, adults of *charybdis* possess large eyes and nocturnal habits despite the fact that activity, in November in desert habitats, must take place in cold temperatures. Moreover, there was an indication in laboratory *charybdis* that activity is restricted to early morning hours rather than at dusk or early darkness, when it was warmer. No crepuscular movement occurred, and on several evenings activity by one or both individuals did

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<sup>1</sup> Probably in the vicinity of Cuyama according to M.E. Gardner, Bureau of Entomology, Sacramento, California.

not begin prior to 4-6 hours after nightfall. In every observed nocturnal cycle both moths moved after 11:00 P.M. This behavior may have been artificially induced, because the moths were housed at about 16-18° C during daylight and early evening, and in temperatures declining to about 12-14° C between 11:00 P.M. and 8:00 A.M. It may be that optimal temperatures for *charybdis* are well below 16-18°, and in the field that might occur in early evening. It is not unreasonable to suppose that this species is active at colder temperatures than any other known *Ethmia*. By comparison, the geometrid winter moth, *Operophtera brumata* (L.), in which the female is brachypterous, has been observed to mate and oviposit at temperatures just under 0° C (Cuming, 1961), whereas most other Geometridae, even species which fly only in early spring, are rarely active below a temperature range around 4-5° C, and not at all below 2-3° C according to light attraction records (Powell, 1962).

As in the case of *timberlakei*, *Ethmia charybdis* was able to survive without water. The proboscis is short and may not be functional. No moisture was provided during the first 7-9 days the male was alive or the first 3-4 days following emergence of the female. Whereas a shorter period would have been lethal to most *Ethmia*, there was no evidence of weakening of the *charybdis* adults, and mating took place during this time. Ultimately the male was killed when 10 or 11 days old, while the female, after an oviposition period during which she was provided with water, died 6-7 days after emergence.

Mating occurred during the second or third night following emergence of the female, when the male was 6-8 days old. Copulation was initiated after 11:30 P.M., on an evening when both individuals had been active between 6:30 and 11:30. The pair remained in coition approximately 22-26 hours, showing no signs of activity during this time (even when exposed to electronic flash and direct sunlight for several minutes during photography). Separation occurred, with both male and female moving away, between 4:00 A.M. and 8:00 A.M.

Oviposition behavior was not observed, but it occurred between 12-72 hours after completion of mating and could have begun immediately in the matinal period following mating. Although no protein was provided, the single female deposited 75 eggs, the highest total I recorded for an individual *Ethmia*. The eggs were placed in depressions and holes in yucca pith and under and between layers of tissue paper. The female selected cracks and open beetle galleries in the yucca piece for 11 eggs, which were recessed up to 0.6 mm below the surface. Most of the oviposition (58 eggs) occurred in creases, between layers, and onto the underside of tissue paper liners of the original larval containers and fresh paper provided in the breeding cage. Three eggs were nested adjacent to mouldy frass on the tissue, suggesting that larval evidences on old foodplant may

elicit oviposition stimulus. Dry flower and leaf fragments of *Amsinckia tessellata* from a herbarium sheet were provided but were not selected by the female.

Egg. - The eggs were characteristic of other *Ethmia* in shape and chorion sculpture but were smaller than those of other nocturnal species with forewing length comparable to that of male *charybdis*. Eggs ranged 0.37 x 0.62 mm to 0.30 x 0.67 mm in outline, about the size of those of diurnal species, which the female approximates in body size. Stored at laboratory temperatures, all but a few apparently infertile ones turned yellowish within 3 days, to a peach color by 7-9 days, and later gradually reddish. They showed no signs of maturation by the 15th day, suggesting diapause, but they did not rapidly change to a tomato red color characteristic of eggs in diapause in *Ethmia timberlakei* and in tortricine moths (Powell, 1964). However, color transition in *timberlakei* was not observed and may be a gradual, slower process as in the present species.

Larva. - Younger instars were not observed; individuals thought to be antepenultimate and penultimate were taken by net sweeping. Mature larvae lived exposed on the inflorescences, usually perching on one side, below the highest part of the plant, without any visible webbing. In the laboratory those of the last two instars housed in 32 x 90 mm plastic vials proved to be susceptible to disease epidemics, even though individuals were separated, a few in each container. Others placed in 25 x 75 mm salve tins were less susceptible, and several matured successfully. Shelters were spun among flowers, but these may have been constructed only in preparation for pupation. Feeding probably occurs primarily on developing seed and flower parts under natural conditions.

At maturity larvae spun opaque cocoons in corners of the rearing containers or in foliage (67D87). No soft, woody substrates were provided. The 1970 larvae were offered yucca blocks bearing galleries of cossonid beetles, but the three larvae which successfully completed cocoons all selected folds of tissue paper.

Penultimate instar (?) [2]: Length 9.7-10.0 mm. HC 0.58-0.71 mm; orange, indistinctly mottled with brownish; ThSh brownish, fairly well defined; integument color as in final instar, paler than most but not all individuals; AbdCr 7-10; AnCr 9-15.

Final instar: (Fig. 7) Length 10.0-16.0 mm. HC 0.85-0.97 mm; orange, distinctly mottled with brown; ThSh not well defined, sclerotized areas restricted to posterior margin; integument pale to distinctly colored, D white with a median rust-orange streak (sometimes reduced to a trace), DL fairly uniform dark to pale gray, mottled, defining distinct white circles around pinacula; L white, well defined, with variable elongate blotch of pale to bright rust-orange, LV as in DL,

usually slightly paler; Pin large, black, distinct; AbdCr 15-21; AnCr 21-22. Segment A9 with 0 or 1 very small secondary seta at LV, anal leg with small patch of usually 3 tiny secondary setae.

Pupa. - Pupation occurred in various cocoon situations, but lack of suitable substrates may have ultimately resulted in dessication of several prior to development. The only successful emergences occurred from a cocoon tightly spun in old foliage and flower parts in 1967 and in tight folds of tissue paper in 1970.

Preserved pupae measured 6.0-6.8 mm in length, were smooth, pale orange, without specialized spiracle structures. The anal legs were rather short with slight to no lateral extension distally, with 20-22 anchoring setae. The frail cremaster homologue setae were located on a roughened, but not depressed area.

### ETHMIA ALBISTRIGELLA (WALSINGHAM)

*Psecadia albistrigella* Walsingham, 1880, Proc. Zool. Soc. Lond., 1880:89.

Described from the Siskiyou Mountains on the northern border of California, *albistrigella* is widespread in western North America, occupying more boreal regions than the closely related *nadia*, discussed below. Both have small eyes, but according to phenetic assessment are more closely related to members of the semilugens group which are nocturnal, than they are to the foregoing diurnal species (Powell, 1971). It is possible that small eyes and diurnal habits in *albistrigella* are a secondary development as a result of adaptation to high elevations where temperatures early in the season deter night time activity.

Study areas. - 1) Chipmunk Flat, 3 miles west of Sonora Pass, 8800 feet, Tuolumne Co.; adults associated with *Phacelia ramosissima*, June 25, 1962 (C.D. MacNeill and J. Powell) 2 males, 3 females retained alive (62F11); and July 1, 1962, 1 male, 1 female retained alive (62G4). 2) Donner Pass, 7300 feet, Nevada Co.; 1 male, 1 female flying near *P. ramosissima*, July 4, 1962 (C.A. Toschi and J. Powell); larvae on *P. ramosissima*, August 3, 1962 (62H3).

Adult behavior. - *Ethmia albistrigella* has a single annual generation, flying early in the season, in California from mid June to mid July, after the snow in the vicinity has receded to patches and the *Phacelia* has not yet begun to bloom. Adults were apparently actively flying between 1:00 and 3:00 P.M., and I have seen no record of collection of this species at light. In the breeding jar, adults were caged with a bouquet of *Phacelia* from the collection site. They did not show a definite activity period, but laboratory conditions probably differed more (especially warmer in late afternoon, night and early morning) from field conditions with this

boreal species than for any other species studied. Most *albistrigella* moved occasionally or were actively crawling during morning hours, as early as 8:30. Most were active, crawling towards the daylight side of the container, feeding at water, etc. between noon and 5:00 P.M. However, many instances were noted in which moths moved after dark, both with and without lights in the room. They did not seem to be continuously active after dusk, but they were not consistently inactive as in the cases of the diurnal species discussed above.

One mating pair was observed at 8:00 P.M., just prior to sunset, having coupled after 6:30 P.M. Separation occurred in the dark, between 9:15 and 11:00 P.M.

Oviposition was not witnessed, but took place between 1:00 and 2:30 P.M., and at least once between 8:30 P.M. (dusk) and 8:30 A.M., after six days confinement of the female. Eggs were placed only on the *Phacelia* leaves, excepting one or two placed on the glass adjacent to the *Phacelia*. About 70 eggs were deposited by 3 females, almost exclusively on the undersides of the leaves; 2 each were placed on uppersides of leaves and on stems.

Egg. - The shape of eggs was more variable than any other species studied, ranging from oval to kidney shaped or constricted towards one end. The width and length ranged 0.38 x 0.84 to 0.44 x 0.94 mm. Hatching occurred after about 10 days at laboratory temperatures.

Larva. - First instar larvae emerged July 7 and were placed on an immature flowering spike of *Phacelia ramosissima* which had been taken at Chipmunk Flat six days earlier and kept in water. Within two hours, several had begun skeletonizing leaves. Usually the underside of the leaf was selected. Later emerging larvae were placed in plastic vials with leaves and began feeding successfully. By the fourth day successfully established larvae were still in the first instar, located either on the underside or in curled portions on the upperside and had skeletonized several small spots.

After the 9th day larvae were supplied with leaves from a greenhouse *Phacelia ramosissima* transplanted from Chipmunk Flat on June 24. The cut pieces were accepted but turned black after a day or two. A leaf of *Phacelia distans* from San Francisco was supplied to second instar, 11 day larvae, but little attempt was made to feed on it. Thereafter, the greenhouse *P. ramosissima* was used.

By the 16th day all larvae were third instar. Two days later some individuals had reached the fourth instar and were feeding on the full leaf thickness. Generally, very little silk was used in visible shelter preparation.

On the 24th day third and fourth instar larvae were transferred to a branch of *P. ramosissima* in water. All be-



gan feeding without any apparent shelter.

The four surviving larvae reached the fourth and fifth instars by the 28th day, and *Phacelia ramosissima* from Donner Pass was provided.

Some larvae were full grown by the 31st day, appearing blackish with a dull orange-brown dorsal median band. The final larva began its cocoon on the 39th day.

Larvae were observed in the field at Donner Pass 30 days after adults had been collected at this site. By this time the plants had reached full to late bloom in somewhat sheltered, east facing exposure. The larvae, in the third and fourth instars, lived in thin webbing shelters among the inflorescences, usually more or less on the underside of the flowering spike, rather than between the geminate flower rows. The silk was not easily visible, but presence of the larvae was evident by frass, retained by the hairy, viscid texture of *P. ramosissima*. Lower leaves were thoroughly investigated and neither larvae nor signs of larval feeding were found.

Two larvae reached the final instar one day after this field collection, and the first larvae spun cocoons on the 12th day following collection (42 days after adults were observed at the site).

There appeared to be five instars, based on unsexed head capsule measurement (fig. 5). However the size range in later instars suggests a possible sixth instar in occasional individuals.

*Second instar:* (None preserved) HC [5] 0.36-0.40 mm, pale orange with slightly darker mottling.

*Third instar:* Length 5.0-9.9 mm; HC 0.55-0.78 mm, orange-brown to dark brown, mottled paler; ThSh pale orange-brown; Pin dark but somewhat diffuse; D whitish, not well defined; DL scarcely evident, ochreous yellow; AbdCr 7-8; AnCr 6-9 (usually 8-9).

*Fourth instar:* Length 10.4-12.0 mm; HC 0.86-0.96 mm, white anteriorly with dark brown posterior markings; ThSh mottled laterally only; Pin dark, small; D unpigmented, not well defined; DL pale ochreous or olive-green with whitish encircling pinacula; AbdCr 9; AnCr 10.

*Fifth instar* [3]: Length 12.2-14.2 mm; HC 1.22-1.32 mm, white anteriorly with black posterior markings; ThSh mottling restricted to small areas at posterior margin; D well defined, unpigmented to dull orange-brown; DL, LV well defined, dark gray to blackish, mottled with unpigmented areas; L well defined, pale, unpigmented or tinged with orange; AbdCr 13-15; AnCr 15-17. Segment A9 with 3 tiny secondary setae just anterior of LV seta.

Pupa. - Full grown larvae were placed in a salve tin with pieces of dry *Phacelia* stems from Donner Pass. The stems were 2-4 mm in width and were hollow or had a soft, pithy context throughout. No larvae used these stems for pupation. Cocoons were spun in the upper and lower corners of the tin. Kept at room temperatures and humidity, the pupae desiccated prior to development. Cocoons were about 12 x 4.5 mm, with a dense, white papery cover and little internal silk mesh.

Pupae ranged 6.8-7.1 mm in length. The anal legs varied in divergence, with one individual having them nearly adjacent. The distal portion had no lateral development and bore about 18 hooked setae. The frail, posterior "cremaster" setae were all short, possibly broken, in the individuals examined. They originated from a depressed, smooth area subtending lateral humps.

### ETHMIA NADIA CLARKE

*Ethmia nadia* Clarke, 1950, J. Wash. Acad. Sci., 40:161.

A difficult taxonomic problem exists concerning relationships of *nadia* and *albistrigella*. The present species occupies generally warmer, drier (Upper Sonoran and Transition Zone) regions than the boreal sites (Canadian and Hudsonian Zone) observed for *albistrigella* in California. In addition, it appears that *nadia* is primarily crepuscular. Possibly it is not obligated to diurnal activity by low night time temperatures as is *albistrigella* at higher elevation stations.

Study areas. - 1) Fowler's Camp, 5 miles east of McCloud, Siskiyou Co.; 1 male at Coleman lantern July 7, 1957; 2 males, 1 female, net collected, apparently actively flying in late afternoon and at dusk, July 14, 1962; negative results in examination of *Phacelia mutabilis*, July 21, 1966. 2) Hills back of Citrus Experiment Station, University of California, Riverside, Riverside Co.; larvae on *Phacelia ramosissima* var. *suffrutescens*, May 13, 1962 (62E8). 3) Herbert Creek, 3 miles west of New Almaden, Santa Clara Co.; 1 female net collected between 1:00-2:00 P.M., April 20, 1966 (A.J. Slater and J. Powell); retained alive (66D21).

Adult behavior. - Although the moths have been collected in March and April in southern California and June and July in northern California, it seems likely that a single annual flight is involved. It occurs late in the season compared to other species with small eyes, and is correlated with flight later in the day, at least into a crepuscular phase. In addition to afternoon, dusk, and evening collections listed above, single adults have been taken in the daytime: at Riverside, on flowers of *Cryptantha intermedia* (P.H. Timberlake); at Fairview, Tulare County, at midday, April 27, 1964 (P.A. Rude); and 9 miles south of Fairview,

in late afternoon, April 29, 1964 (P.A. Rude).

A reared female was observed in January 1963, over a 16 day period. No males were available. At laboratory temperatures this individual was active, crawling and feeding at damp cotton, at dusk and each evening with lights on in the room. The moth was not active in morning hours and was not observed to move much during the afternoon. No eggs were laid. When prodded during evening activity periods, the moth would feign death, dropping to the substrate on its back, with the legs tightly clasped to the body. After a few minutes activity was resumed.

The female from Santa Clara County (66D21), caged in April, 1966, was observed only on the first night. It was not active between dusk and 9:30 P.M., or between 5:00 and 5:30 A.M., resting in the quiescent posture. Retained at outdoor temperatures in a 100 x 85 mm jar with a bouquet of *Phacelia distans*, (the only *Phacelia* discovered at the collection site), the moth lived only five days. At least two eggs were deposited between 5:30 P.M. and dusk on the first day and ultimately 24 eggs were laid. Oviposition sites varied in these conditions (crowding and unnatural orientation of the *Phacelia* branch may have been factors). Half the eggs were placed on leaves, both upper and lower surfaces, with the remainder on flower heads (4), stems (2) and the nylon screen over the jar (4).

Egg. - The eggs were nearly cylindrical, measuring 0.40 x 0.80 to 0.38 x 0.85 mm.

The eggs were placed in a refrigerator from April 25 to May 3, and were then stored at room temperature. Hatching occurred after about 17 days (including the 9 days in cold storage).

Larva. - Newly hatched larvae were placed on a cut sprig of *Phacelia tanacetifolia* from the Botanical Garden in a salve tin. Two day old larvae had established mostly on spots under leaves against the salve tin surface. Feeding occurred as skeletonized spots on either upper or lower surfaces of the leaves. However, as the plant material began drying, by the fifth day, all larvae dispersed and escaped owing to a faulty container.

Field collected larvae at Riverside in the final and penultimate instar differed markedly in appearance from *albistrigella*, appearing olive-green with a pale dorsal band. The plants were in full bloom and larvae spun a thin web which enclosed a terminal raceme or a leaflet or two.

Penultimate instar: Length 13.0 mm [1]; HC 0.95-1.07 mm [4]; ThSh not differentiated; Pin minute; no integumental pigment; AbdCr 11-12, uniordinal; AnCr 11.

Final instar: Length 16.5-17.5 mm; HC 1.22-1.28 mm,

orange, strongly mottled with whitish; Pin small, black; D, L fairly well defined, yellowish; DL pale olive-gray, mottled, with whitish encircling pinacula; AbdCr 17-19, biordinal mesally; AnCr 17. Segment A9 with about 12 tiny, unpigmented secondary setae in a row between LV and V setae.

Pupa. - Cocoons were spun in the leaf material and in folds of paper toweling. The outer layer was dense, white, tough, paper-like and could be torn when dry. Inside, cocoons had an ill-defined but strong mesh surrounding the pupa, making it difficult to extract pupal shells intact. Pupae were formed before early August. Successful emergence occurred from nearly all those which had pupated, although they were stored in laboratory conditions. Emergence took place in December and January, well ahead of that of field conditions.

One pupa measured 8.2 mm in length. The anal legs were irregularly to strongly divergent or curved, with a slight lateral development distally. About 30 setae were located in the anchoring group on each leg. The "cremaster" setae were short (possibly broken), in the individuals examined, and were borne in a shallow V-shaped, roughened depression.

### ETHMIA SEMILUGENS (ZELLER)

*Psecadia semilugens* Zeller, 1872, Verh. Zool.-Bot. Ges., Wien, 22:561.

This species is widespread in arid areas from Colorado to Chihuahua and southern California (Powell, 1959, 1971). Although there had been only a single record for California, we were fortunate in discovering larvae on two species of *Phacelia* at one locality at the northern end of the Panamint Valley in 1969.

Study area. - Darwin Wash, 1-3 miles west of Panamint Springs, Inyo Co.; larvae on *Phacelia calthifolia*, May 12, 1969 (P.A. Opler) (69E65); larvae on *P. calthifolia* and *P. crenulata*, May 14, 1969 (J. Powell and P.A. Rude) (69E78, E79).

Adult behavior. - Collection records indicate this species is facultatively double-brooded, with flight records for late February and March to September, but mostly in April and July. Records in California are for April and May, and individuals we reared either emerged in July or went into a prolonged diapause. The moths are nocturnal, judging from eye size and light attraction records. Adults were not observed in the laboratory.

Egg. - Unknown.

Larva. - Individuals of at least four instars were found on annual plants along a rocky roadside and wash bottom, a

site which had been heavily eroded during the preceding winter. The caterpillars lived externally on the undersides of leaves and stems without any visible webbing. Feeding evidently occurred entirely on leaves, although both host species were in bloom at the time. In the laboratory, larvae were housed in polyethylene bags or plastic freezer dishes and continued to feed more or less exposed. Foliage of the two plants became mouldy easily. However, larvae did not seem to be susceptible to disease outbreak and provided with refrigerated leaf material, larvae matured 7-14 days following collection.

Cocoons were formed in folds of paper toweling. No soft woody substrate was offered. Mature larvae took on a pinkish cast while wandering in search of pupation sites.

Head capsule measurements did not clearly define instars, and there may be six instars in this species. The following diagnosis represents a somewhat arbitrary instar division, based in part on crotch numbers and secondary setae.

*Second instar* (?): [4] Length 3.5-6.0 mm; HC 0.32-0.48 mm, unicolorous dark brown; integument unpigmented, body appearing more or less uniform pale green; ThSh brown, nearly unicolorous to blotched; Pin dark, conspicuous, but relatively smaller than in later instars; AbdCr 9-13, unioordinal, essentially a complete circle; AnCr 7-8.

*Antepenultimate instar*: Length 7.0-10.5 mm; HC 0.56-0.75 mm, color of HC, ThSh, and integument as in preceding instar; AbdCr 8-15 (usually 10-13), partially biordinal; AnCr 8-12.

*Penultimate instar*: Length 12.0-14.5 mm; HC 0.85-0.98 mm, whitish mottled with extensive blackish areas; integument color as in preceding instars, except D yellow, DL darker greenish, L with a yellow blotch on each segment; Pin darker, larger; AbdCr 13-16; AnCr 10-12.

*Final instar*: Length 15.5-23.0 mm; HC 1.07-1.36 mm, white with black markings posteriorly; ThSh unpigmented except two lateroposterior, variable black patches; D bright yellow, DL bright green with unpigmented areas around pinacula; L whitish with large yellow blotch on each segment; LV greenish; Pin large, black; AbdCr 15-28 (usually 20-24), biordinal; AnCr 20-24, biordinal; segment A9 with 3-6 small secondary setae between LV and V setal groups.

*Pupa*. - Cocoons spun in folds of paper toweling were flat, oval, with an opaque, white cover; pupation occurred within 10 days of cocoon construction. All pupae apparently entered diapause. A few emerged in early July, after 6-7 weeks at laboratory conditions. The remainder did not metamorphose; exposure to outdoor shed conditions through the following year failed to stimulate completion of development

and emergence. Some appeared to remain viable after 16 months.

Pupae (figs. 8-9) ranged 8.6-9.1 mm in length and were unusually dorso-ventrally flattened. Each spiracle was followed posteriorly by a raised area which was subtended ventrally by about 50 tiny spicules. The anal legs were moderately to strongly diverging, well separated at the base, distally without any enlargement. Each had 15-16 hooked setae. Caudally 4 "cremaster" setae were borne on each of 2 raised areas corresponding to the anal prolegs of the larva, and these setae were stronger than on other *Ethmia* examined, yet still non-functional.

### ETHMIA ARCTOSTAPHYLELLA (WALSINGHAM)

*Psecadia arctostaphylella* Walsingham, 1880, Proc. Zool. Soc. Lond., 1880:88.

Speculation that the name *arctostaphylella* is a misnomer and that *Eriodictyon* is the host of this species (Powell, 1959) has proven to be correct. *Ethmia arctostaphylella* has been found closely associated with *Eriodictyon* in various parts of California on many occasions, while no evidence that *Arctostaphylos* is a foodplant has been forthcoming. Adults fly in late afternoon and at dusk around *Eriodictyon* plants, and they can be found resting on the leaves or flushed from foliage during mid day. They have been taken on *E. californicum* at many stations in northern California, on *E. trichocolyx* var. *lanatum* in San Diego County, on *E. crassifolium* in the Santa Rosa Mountain foothills of Riverside County, and on *E. tomentosum* in San Luis Obispo and San Benito Counties. The study areas cited below are only those in which early stages have been involved, among the many records for the moth's occurrence on *Eriodictyon*.

Study areas. - 1) Carson Ridge near Woodacre, Marin Co.; 1 female, 2 larvae, on *Eriodictyon californicum* May 14, 1960 (60E1). 2) Hills north of Alpine Lake, Marin Co.; larvae on *E. californicum*, May 28, 1960 (J.M. Burns and J. Powell) (60E6); adults on *E. californicum*, April 17, 1961 (C.D. MacNeill and J. Powell), 5 males, 7 females retained alive (61D3). 3) Three miles west of Stoneyford, Colusa Co.; young larvae on *E. californicum*, May 11, 1961 (61E13). 4) Ten miles east of Clearlake Oaks, Lake Co.; 1 mature larva on *E. californicum*, May 11, 1961 (61E14). 5) Two miles east of Groveland, Tuolumne Co.; 1 larva on *E. californicum*, June 12, 1961. 6) Mt. Diablo, 3000 feet, Contra Costa Co.; 2 larvae on *E. californicum*, July 17, 1961 (61G2). 7) Eight miles north of Boulder Creek, Santa Cruz Co.; 1 male, 1 female, 1 cocoon on *E. californicum*, Aug. 11, 1962 (62H6). 8) Five miles east of Boulder Creek, Santa Cruz Co.; adults, cocoons, larvae on *E. californicum*, Aug. 11, 1962 (62H7).

Adult behavior. - In the foothills of central California the moths fly as early as February, commonly in April and in all subsequent months until September. Adults and larvae occur together during summer, suggesting overlapping generations. At higher elevation sites spring emergence occurs in May, and only two generations may obtain.

In the field the moths become active before sundown and fly into the night, according to light attraction records. In the laboratory activity began by 6:00 P.M., prior to sunset, and was highest during the next two hours. Some individuals remained active as late as 11:00 P.M., but they moved more slowly and activity generally appeared to diminish late at night, although temperature change was not occurring.

When at rest during the daytime, both in captivity and in the field, the moths assume the characteristic quiescent posture and often perch on the upperside of the elongate *Eriodictyon* leaves, oriented with the body axis along the mid vein. The white and grey color pattern causes the moths in this position to resemble bird droppings.

Mating pairs were observed four times. One pair was swept from *Eriodictyon californicum* at Mt. Tamalpais, Marin County, between 4:00 and 4:30 P.M. on a cool, windy day in mid March, 1964, by C.W. O'Brien. In the laboratory one pair was first seen at 8:30 P.M.; the couple moved at least once, but remained stationary from 9:45 to 11:30 P.M. Separation occurred between 11:30 P.M. and 7:30 A.M. The second pair apparently mated between 8:00 and 9:30 P.M. and remained in coition until after 10:30 P.M. The other copulation occurred five days after the adults were caged, when the moths had become very worn appearing. The pair was observed at 7:30 A.M., having mated sometime after 6:30 P.M.

Oviposition occurred at various times of night. One female was observed probing the nylon screen ceiling with the ovipositor at 6:00 P.M. Many eggs were deposited between 6:00 and 7:30 P.M. and between 7:30 and 10:30 P.M., and a few were deposited after 11:30 P.M.

About 200 eggs were produced by 7 females. More than 60% of these were placed on the *Eriodictyon*; 27% were deposited on the nylon screen. Of those on the plant 90% were on leaves, but there was no significant difference in preference for higher or lower leaves on the stem. Even a lower leaf which was black with sooty mould (as the lower leaves of *E. californicum* always are in the field) had 15 eggs. About two thirds of those on leaves were placed on the upperside, and all but 8 (of 80) on the uppersides were deposited along the mid vein (figs. 26-28).

In captivity, males lived 4 to 7 days, females 4 to 8 days, but water was not provided after the fifth day.

Egg. - (Figs. 26-28) The eggs were elongate, and slightly flattened (slightly wider than thick), measuring about 0.40 x 0.83 to 0.44 x 0.90 mm.

During development the eggs turned pink by the third day. Hatching occurred after 9 to 10 days at laboratory temperatures. Eggs of the fall generation were not observed, and the overwintering stage or stages are unknown.

The eggs proved to be impervious to water. Several deposited in a field collection vial were submerged when the vial was used as a water source in the breeding jar. After five days the vial was allowed to dry. These eggs all hatched on the 11th to 13th day after their deposition.

Larva. - First instar larvae were placed in salve tins with immature terminals of *Eriodictyon californicum*. Larvae tied two leaflets together or spun silk between a leaflet and the container. Feeding occurred as skeletonizing. By the sixth day most individuals were still in the first instar. Six and eight day old larvae were placed on *E. californicum* in water vials. The plant kept well in this condition and bloomed, but larvae did not establish well. Apparently they wander considerably even though fresh leaves are available. Leaves in salve tins did not keep well and larvae had to be transferred every few days.

By the 26th day larvae were in the third instar. Feeding at this stage occurred as skeletonizing on older leaves. Larvae constructed small silken trackways between leaves.

Some larvae had reached the fourth instar by the 32nd day. No attempt was made to rear these further owing to difficulties in keeping the plant, which resulted in frequent exposure of the larvae to mouldy leaves.

Larvae collected in the field were of various stages from about half grown to mature. Most of these were not preserved. Larger larvae typically constructed shelters by spinning silk across the upperside of one leaf, pulling its margins towards the center. In new foliage the leaf margins were often drawn completely together, forming a tubular shelter, open at both ends. On older leaves which had hardened, the margins were drawn in only partially, forming a hammock shaped shelter with a silken mat ceiling, under which the larva rested, oriented along the midrib. The amount of visible silk varied, possibly with age of occupancy, and sometimes only a thin layer of silk covered the larva which was visible from above. Even so, and despite the fact that the larvae are brightly marked with red and black, their general light green color rendered them inconspicuous under the silk. In searching, the silk was usually seen first, and probably the larvae are thus protected from visual detection by larger predators.

On one occasion (61E13) several larvae were feeding in



inflorescences and immature terminal leaves of *E. californicum*. None of these shelters resembled the characteristic single leaf type observed at other localities. Two or three young leaves, or sepals and flower parts were tied with silk. As in other situations, many abandoned shelters were present. In the laboratory these larvae seemed to prefer leaves, which were consumed before the flowers. *Eriodictyon* blooms only in spring; flower parts and developing seed are not available to summer feeding larvae.

Final instar larvae of *E. arctostaphylella* ranged from strongly marked, with black longitudinal bands and orange dorsal spotting, to virtually unpigmented, pale greenish with tiny dark pinacula. Some of the latter appeared to be full grown, and I had no evidence that any individual developed from one color phase to the other.

*First instar:* Length 1.8-2.0 mm; HC 0.27-0.30 mm, orange-brown, ocellar area black; ThSh pale brown; setae and integument unpigmented.

*Second instar:* None preserved.

*Third instar:* Length 6.8 mm [1]; HC 0.62-0.71 mm [2] brown; ThSh defined laterally only; D defined, pale; DL indistinct, dark gray; Pin small, not surrounded by pale areas; AbdCr 6-7; AnCr 8-9.

*Fourth instar:* Length 10.4 mm [1]; HC 0.84-0.89 mm (parasitized) [3], 0.87-1.0 mm [5], dark orange-brown with regular, posterior darkened areas laterad and mesad on each epicranial lobe; ThSh defined, mottled dark; Pin large, dark; D defined, unpigmented; DL distinct, dark to pale gray, Pin not defined by pale; L and LV not distinguished, pale and grayish mottled; AbdCr 9-12; AnCr 9-12.

*Fifth instar:* Length 14.3-19.4 mm [3]; HC 1.29-1.35 mm (starved) [3], 1.40-1.60 mm, orange-brown lateral and mesal markings not as well defined as in fourth instar; ThSh unpigmented except tiny black pinacula; integumental pigment lacking to well developed, when developed, D well defined, pale orange or orange-brown; DL black, well defined with little pale mottling; L well defined; LV pale, indistinct; AbdCr 15-16 to 19-20; AnCr 19-21. Segment A9 with about 8 secondary setae on LV.

One larva from Mt. Tamalpais (unnumbered collection) exceeds above limits, representing a possible 6th instar. Length 18.4 mm; HC 1.73 mm; AbdCr 21, strongly biordinal; AnCr 23, biordinal.

*Pupa.* - Pupation in captivity occurred in folds of paper toweling and in shelters in foliage similar to those occupied by larger larvae. Whether these were shelters previously used for feeding was not ascertained. The general behavioral tendency to wander and burrow into soft substrates, known

for many other *Ethmia*, does not seem to be consistently practiced by *E. arctostaphylella*. This is the only New World species which has been recorded as using foliage for pupation. Walsingham reared the original specimen from a cocoon in foliage of *Arctostaphylos*, suggesting the larvae wander. In field searches I discovered cocoons of this species on the *Eriodictyon* at two localities in August, 1962. Five cocoons with viable pupae were located in tightly folded leaves, these resembling the typical larval shelters except more closely closed over the occupant. The dense, opaque, white outer layer of silk, covered a thin, loose silken envelope, which was evident at the ends of the leaf fold.

One adult was reared from a dry flowering stalk of *Yucca whipplei*, collected near Cajon Pass, San Bernardino County, in December, 1962. The cocoon was located at the end of a tunnel several cm in length into the woody cortex, according to the collector, Eric Jessen.

Development by non-diapausing pupae required 11-13 days, including cocoon formation (60E6).

Cocoons measured about 14 mm in length and were tough with dense internal mesh. Pupae ranged 8.5-9.5 mm in length. The anal legs were broad with slight lateral enlargement, each distally bearing 27-30 hooked setae which were about 0.14 mm in length. The caudal "cremaster" setae were borne in a shallow, flattened trough; all were short, probably broken in the individuals observed.

Natural enemies. - Braconid wasps of the genera *Apanteles* and *Microgaster* were reared from larvae of *arctostaphylella* at four scattered localities. *Apanteles* (n. sp. #141 of W.R.M. Mason): Alpine Lake (60E6, 3 of the 7 larvae not preserved). *Microgaster* (n. sp. #22 of W.R.M. Mason): Stoneyford (61E3, 1 of 6 larvae); Mt. Diablo (61G2, 2 of 2 larvae); Groveland (unnumbered collection, 1 larva).

The three parasitized larvae at Alpine Lake were still living when discovered, although each already had a braconid cocoon alongside it. The mother larvae crawled slowly if prodded, but there appeared to be no recent feeding in the shelters. One of the three was retained alive, and it lived three days after collection. In each case the braconid larva had emerged from a hole in the side of the third abdominal segment just below the spiracle of the host.

### ETHMIA DISCOSTRIGELLA (CHAMBERS)

*Anesychia discostrigella* Chambers, 1877, Bull. Geol. Surv. Territories, 3:122.

This is the most commonly collected species of *Ethmia* in the New World. The adults are nocturnal and sometimes are

attracted to lights in great numbers. Despite its abundance over a wide range in western North America, until recently nothing was known of its life history (Powell, 1959). *E. discostrigella* and the closely related *semitenebrella* have diverged from the typical pattern of the genus and feed on species of *Cercocarpus* (Rosaceae). In Great Basin regions of eastern California, typical *discostrigella* is associated with *Cercocarpus ledifolius*. In cismontane parts of the state, where the moths are generally more bluish white in appearance and the name *subcaerulea* Walsingham is applicable, *C. montanus* (= *betuloides*) is the principle host. For purposes of the present discussion the two are treated together.

The moths have been flushed from foliage of *Cercocarpus* at a number of sites: from *C. minutiflorus* at San Diego, from *C. montanus* in the mountains of San Diego County, Kern County, and Lake County, from *C. alnifolia* on Santa Cruz Island, and from *C. ledifolius* in the Warner Mountains, Modoc County. The study areas listed below are those which have involved the early stages. In addition, M.M. Furniss of the U.S. Forest Service sent me a large series of larvae and reared adults from *Cercocarpus ledifolius* collected in Owyee County, Idaho.

Study areas. - 1) Crooked Creek, 10,150 feet, White Mountains, Mono Co.; young larvae on *Cercocarpus ledifolius*, July 4, 1961 (61G1); 2 females at light, July 22, 1961, retained alive (61G4). 2) Lee Vining Campground, Mono Co.; young larvae on *C. ledifolius*, July 19, 1961 (61G3). 3) Lake Pillsbury, Lake Co.; 1 female at light, April 3, 1962, retained alive (62D1). 4) miles east of Monitor Pass, Mono Co.; adults at light, June 30, 1962, 2 males, 4 females retained alive (62G3).

Adult behavior. - Collection records from a station in Monterey County, where a continuous sample of insects attracted to light was made throughout a season, indicated that three or more overlapping generations obtain (Powell, 1959). In Great Basin areas probably a single flight, in June and July, is normal. Under laboratory conditions pupae resulting from eggs laid in June and July in Mono County did not emerge the same season but underwent diapause, emerging the following spring.

Although the moths are easily startled into flight during the daytime, both in the field and laboratory, even in early morning, normal activity is nocturnal. Caged females became active at dusk and engaged in oviposition behavior then. Whether or not lights were directly on them seemed not to affect behavior of females except they tended to congregate in the portion of the jar towards the light. The moths are active all night under favorable temperature conditions, judging from light attraction records.

Mating was not seen in the laboratory, and field observations suggest that it may occur only late at night. One

pair was taken from a congregation of scores of individuals on a vertical sheet before a 15 watt blacklight, between 12:30-2:00 A.M., east of Monitor Pass, June 25, 1962. Numerous mating pairs were observed in tree foliage at Fandango Pass, Modoc County, in May, 1970, between 9:00-11:00 A.M. by P.A. Rude.

During oviposition females continuously walked slowly with the abdomen curled downward and prodded the substrate with the ovipositor. Females sometimes did this on the plants provided (*Cercocarpus ledifolius* for Mono County, *C. montanus* for Lake County moths), but more often used the nylon screen ceiling. In one case (62D1) nearly all 28 eggs were placed on the jar rim under the screen. In the 62G3 lot, four females deposited a total of 82 eggs; only 14 of these were on the *Cercocarpus*, 8 of those on the silk of an abandoned caterpillar shelter. Propensity for selection of other fibrous and roughened substrates was shown. About 30% of the eggs were placed on top of the rim of the jar, between the rim and the appressed nylon ceiling; another 25% were located on masking tape on the floor of the container (but only 4 eggs were placed on the smoother cardboard which was of greater area). Three were placed on a patch of cotton fibers which had stuck to the vial holding the plant. Of those on the *Cercocarpus* two eggs were placed on terminal stems, adjoining leaf bracts, etc., but none were laid on the larger, woody stems.

These oviposition sites suggest the possibility of use of the elongate, twisted, soft-hairy style of the fruit, which are persistent on the trees, for egg placement in the field.

Adults did not survive well in captivity, the Lake County female living 7-8 days, those from Mono County even fewer.

Egg. - The eggs were somewhat irregular in outline, evidently conforming somewhat to the substrate. Those from one 61G4 female were oval, flattened, tapering in outline toward one or both ends and measured 0.70 x 1.27 to 0.72 x 1.40 mm.

White when first deposited, the eggs turn bright pink on the second day, remaining so until just prior to hatching when the dark larval head capsule becomes visible and the eggshell looks whitish, semiopaque.

Hatching occurred in 9 days in July, in 10 days in April at laboratory temperatures.

Larva. - First instar larvae (62G3) were placed on *Cercocarpus ledifolius* from Monitor Pass, which had been in water 10 days. Nine days later some had reached the second instar. Larvae at this stage were inconspicuous, living in crotches of twigs and sessile leaves, with little visible silk. Feeding occurred as small round skeletonized spots,

mostly on undersides and on apical half of leaves. Young larvae were easily disturbed and quickly dropped down on silken threads at the slightest stimulus.

*Cercocarpus ledifolius* from the collection site was provided at 9, 19, and 35 days, after refrigeration, and seemed to take up water and serve adequately as larval food.

By the 16th day larvae had reached the third instar. By this time, and thereafter, the larvae were extremely reactive to external stimuli - prodding caused them to wriggle backwards extremely quickly, so as to appear to jump, often going 10 to 20 cm on a flat surface.

At 20 days most individuals were in the fourth instar, and all larvae had reached the penultimate instar by the 25th day.

By the 35th day all larvae had reached the last instar. As in the case of *E. plagiobothrae*, two distinct color phases were shown: a paler one showing bluish dorsolateral bands and a lighter orange dorsal band, and a dark form, which was more common, with the dorsal band yellow-orange to rust-orange, the dorsolateral bands black.

The final full grown larvae, in the pale state, were preserved on the 41st day.

Larvae collected as second instar at Crooked Creek required a longer period to mature, probably owing to poorer food conditions. These larvae were provided with cut twigs of *C. ledifolius* in salve tins. After 13 days fresh *C. montanus* from Contra Costa County was provided. All subsequent feeding took place on this plant. Intermittently the plant material dried, leaves frozen for 14 days were provided, and fresh *C. montanus* was provided again on the 36th day.

The first cocoon was formed 48 days after collection of second instar larvae, and the last larva died after the 58th day when additional foodplant from the freezer was added.

There appear to be five instars (fig. 6). The rather wide spread in head capsule measurements in the final two instars may have been caused by differential laboratory conditions, since field collected larvae were taken in young instars.

*First instar* (62D1): Length 2.3-3.0 mm; HC 0.31-0.30 mm, pale tan, slight brownish spots; Pin visible on thorax. (61G4): Length 3.1-3.3 mm; HC 0.34-0.38 mm, pale tan with brown dorsolateral and venterolateral spots; ThSh brownish laterally; Pin brownish, diminishing on posterior half of abdomen. (62G3): Length 2.7-3.1 (one day) to 4.2 mm (9 days); HC 0.36-0.39 mm, pale tan becoming darker at 9 days; Pin pale brownish, becoming darker and well defined on whole abdomen.

Later instars are characterized on the basis of 61G1 and 62G3 specimens.

*Second instar:* Length 4.7 (Teneral) - 6.0 mm; HC 0.50-0.55 mm, dark brown without appreciable mottling; Pin dark brown, those of ThSh larger; integument otherwise without pigment, setae dark; AbdCr 6; AnCr 8.

*Third instar:* Length 6.7-8.0 mm; HC 0.60-0.91 mm, yellow-tan with faint brownish mottling and dark and frontal spots; Pin dark, large; D well defined, pale orange; DL heavily mottled, gray to blackish with a paler (less densely mottled) median streak; L not well defined, LV with almost no pigment; AbdCr 10-11 (rarely 14); AnCr 11-13.

*Fourth instar:* Length 9.1-15.1 mm; HC 0.96-1.24 mm, yellowish with black adfrontal spots; Pin dark; D well defined, orange with blackish spots; DL well defined, blackish, darker than 3rd instar, obscuring pinacula; L well defined, pale; LV almost as dark as DL, Pin only slightly darker; AbdCr 13-17; AnCr 18-22, biordinal.

*Fifth instar:* Length 15.9-21.5 mm; HC 1.46-1.68 mm, orange, mottled darker orange along posterior margins; Pin dark, relatively smaller than preceding instars; D well defined, dark orange (dark phase) or yellow-orange (pale phase); DL pale gray or blackish, less densely mottled than 4th instar, densest at D and L margins; L pale, not well defined; LV mottled gray, pale to dark, not well defined; AbdCr 23-30 (usually 28-30), biordinal mesally; AnCr 26-30, biordinal. Segments A1, A2, A9 with 1-3 small secondary setae on LV.

*Pupa.* - Cocoons were constructed in the corners of salve tins, incorporating a few plant parts. One individual used a rolled leaf. Pupation occurred within ten days after starting construction of the cocoon. Those pupating in mid and late August went into diapause and were housed in the dark salve tins at laboratory temperatures overwinter. Emergence occurred in late April and early May, probably about a month ahead of the flight period in Mono County.

Pupae ranged 7.7-8.7 mm in length (61G3). The anal legs protruded ventrally more strongly than in most other species and were relatively smaller, widely spaced, and strongly diverging, sometimes extending almost directly ventrad and laterad. There were 17-18 (rarely 12) hooked setae on each anal leg. The caudal "cremaster" setae were extremely long and frail, up to 1.4 mm long (twice as long as the hooked setae of the anal legs), borne on weakly to well developed lateral humps. Usually they were broken off in the cocoon.

## ETHMIA SEMITENEURELLA DYAR

*Ethmia semiteneurella* Dyar, 1902, Jour. N. Y. Ent. Soc., 10:204.

As discussed elsewhere (Powell, 1959) this and the preceding species, *discostrigella* are closely related. Subsequent studies have shown that the two share similar biologies, using species of *Cercocarpus* as hosts. In the original description Dyar mentioned that *E. semiteneurella* was reared from *C. parviflorus* in Arizona.

Study area. - Four miles east of Monitor Pass, Mono Co.; adults at light, June 24 and 30, 1962, 2 males, 6 females retained alive on latter date (62G2).

Adult behavior. - This species is geographically and ecologically restricted compared to *discostrigella*, and *semiteneurella* appears to have only a single annual flight.

The moths are nocturnal. Adults were caged after 36 hours storage in a field ice box. They became active at dusk and showed a similar activity pattern to *discostrigella* from the same locality. Neither oviposition nor mating was observed. Females behaved similarly to those of *discostrigella* in prodding the ovipositor through the nylon screen. All the *semiteneurella* died 5-6 days after collection.

Only 44 eggs were deposited by the 6 females. As in the case of *discostrigella*, a preference for roughened surfaces was shown, but 30 of the 44 were deposited on the floor of the jar, possibly in part a function of age or weakening of the females. All but 3 of these were laid on masking tape or in a crease in the cardboard. Only 3 eggs were deposited on the *Cercocarpus*. Seven eggs were placed on the nylon screen, but none were at the rim of the jar adjacent to or under the appressed nylon, a site used for 30% of *discostrigella* eggs.

Egg. - As in *discostrigella*, eggs of the present species were not regularly rectangulate or ovate, but varied to some extent with the substrate, often tapering towards one end. Those deposited on the nylon screen measured 0.66 x 1.40 to 0.70 x 1.32 mm.

All turned uniform dull reddish prior to the fifth day, darkening only shortly before eclosion. Eggs began hatching July 13, about 10.5-11 days after oviposition. Most were transported on a field trip July 13-15; and those remaining unhatched survived transit in an uncooled car at 40° C air temperature, conditions which were lethal to young larvae, hatching between 8:00 and 11:00 A.M. the following day, about 11 days incubation.

Larva. - First instar larvae were placed on terminals of *Cercocarpus ledifolius* which had been in refrigeration 12

days. Those emerging prior to July 15 did not survive automobile transport in 40° C air temperature. The remaining first instars hatched July 16 and were placed on 15 day old refrigerated *C. ledifolius*. They showed a marked tendency for positive phototropism during daylight hours, crawling to the top of a vial, away from leaves or to the side of a branch toward the light.

Larvae established in small webs in crotches of leaves and twigs or between leaves. Larvae had reached the second instar before the 14th day. Additional *C. ledifolius* from Monitor Pass was provided on the 14th day, after 30 days in refrigeration.

The third instar was reached on the 15th to 16th day, and the fourth by the 20th day. Although the original branch had become covered with fine mold by 10-14 days, larvae had not left it and were transferred to the fresher foliage which had been added to the bouquet 6 days previously. At this time evidence of larvae had become quite noticeable, with considerable webbing which at times collected frass on the uppersides of leaves.

The final instar was reached by the 29th day and the last full grown larva was preserved on the 35th day. To the unaided eye mature larvae appeared steel blue-gray with bright yellow dorsal and lateral bands. The venter was bright pink, differing from *discostrigella* which had a pale venter.

Too few specimens were preserved to enable precise determination of the number of instars.

*First instar:* Length 3.3-3.5 mm; HC 0.45-0.47 mm, pale tan with black ocellar area, becoming entirely dark brown at maturity. No integumental pigment.

*Second instar:* Length 8.2 mm [1]; HC 0.64-0.66 mm [5], pale brown, mottled darker; Pin brown, rather large; integument otherwise unpigmented, setae black; AbdCr 8-11; AnCr 11.

*Penultimate instar* (none preserved): Length 9-10 mm; HC 1.04-1.28 mm [2], pale orange, shaded brownish, not strongly mottled; D yellowish; DL pale bluish.

*Final instar* [3]: Length 15.9-23.0 mm; HC 1.70-1.87 mm, orange, mottled with white laterally; Pin dark brown, scarcely differentiated from integumental dark areas, strongly contrasting in pale areas; D and L distinct yellow; DL dark steel gray to blue-gray, irregularly mottled with small white spots; LV only lightly mottled; V bright pink, a subintegumental color; AbdCr 28-30 or 32-34; AnCr 30-34. Segment A9 with 12-14 small secondary setae on a sclerotized patch extending 1/2 the distance to V seta.



## ETHMIA TIMBERLAKEI POWELL

*Ethmia timberlakei* Powell, 1971, U. Calif. Publ. Ent.; in press.

This species is closely related to *geranella* Barnes and Busck, and may prove to represent a segregate of that species when more is known of both. These and related species differ from most other *Ethmia* in life cycle, feeding as larvae in spring, aestivating as pupae, and flying in fall. The biology of *E. macelthosiella* Busck, a member of the group in eastern United States, was studied by Busck and Heinrich (1922).

Study area. - Hill back of Citrus Experiment Station, University of California, Riverside; larvae on *Phacelia ramosissima* var. *suffrutescens*, March 21 and 24, 1961 (P.H. Timberlake, R.L. Langston and J. Powell) (61C12, C13); larvae on *P. ramosissima*, May 13, 1962 (62E7).

Adult Behavior. - Only a single individual has been field collected, at light between 8:30 and 10:00 P.M. on October 17, 1960, near Desert Springs, San Bernardino County. Closely related species have been taken at lights between mid September (8000 feet elevation) and November (1000 feet). Adults of *E. timberlakei* emerged prior to November 8 (61C12) and between November 1 and 19 (62E7).

Reared moths were observed in late November, 1962. One male and two females already in worn condition were caged in a dry jar with debris and cocoons from the original rearing container. The moths were inactive during daylight and appeared reluctant to move at night with lights on in the room. At this time they moved only by short, quick "jumps" when disturbed by the observer. They were active at night with the lights off.

Fertile eggs were deposited prior to November 19, but not after that date. Although no water was available, the moths lived 11-14 days after first observed, when already in worn condition.

Numerous eggs were deposited, primarily in aggregated groups, not in any systematic arrangement, around the glass side of the jar near the upper rim. A few scattered eggs were laid on the dry *Phacelia* foliage and paper toweling. Most had turned reddish by November 19 and apparently entered diapause.

Although kept in a dry container at laboratory temperatures, about half of the eggs hatched at sporadic intervals during the following spring.

Larva. - In late March, 1961, larvae of at least the final three instars were present on *Phacelia ramosissima*. Most were in the last instar. In mid May, 1962, only full

grown larvae were present, and evidences of feeding indicated that most had already left the plants.

Larvae of *E. timberlakei* differed in habits from most other species studied (including *nadia* at the same site) by living exposed on the leaves, without any shelter. During the daytime most were concentrated towards the lower portions of the dense foodplant clumps, rather than exposed in direct sunlight. In several cases the bushes grew adjacent to large boulders on a southerly exposure. The caterpillars rested toward the back of the clump, in the shade, where the foliage was most dense. Almost all perched on the undersides of stems or main midrib of the compound leaves.

Presence of larvae was evidenced by scattered frass toward the distal end of the branch, evidently held by the viscid hairiness of the plant. Probably larvae moved outward at night to feed, and rested under the stems inactively during the day.

A few small webs were found on undersides of leaves, with associated head capsules. It is assumed these were moulting webs, but it may be that early instars, which were not observed, construct weak shelters.

In rearing, larvae were housed in 85 x 100 mm jars in field conditions for 7 to 10 days and severe moisture condensation and moulding of foodplant resulted. However, no disease symptoms developed. Fresh *Phacelia*, presumed to be *ramosissima*, from San Diego County, was provided on the 5th day, but little or no feeding occurred on it.

Most of the larvae successfully formed cocoons by the 12th day after collection.

*Second instar* (?) [2]: Length 6.0 mm; HC 0.47 mm, entirely dark brown; Pin tiny, dark; almost no other integumental color; D, L weakly white, Abder 8-10; AnCr 7.

*Third instar* (?): Length 6.0-7.8 mm (teneral), 9.5-11.0 mm; HC 0.61-0.68 mm (teneral and parasitized), 0.73-0.83 mm, dark brown with pale mottling anteriorly; D defined, whitish; DL pale gray; Pin black, small; integument otherwise unpigmented; AbdCr 8-11; AnCr 7-11 (usually 10-11).

*Penultimate instar*: Length 10.4-12.0 mm; HC 0.87-0.97 mm, dark brown posteriorly, whitish anteriorly; D well defined, yellowish; DL mottled grayish (appearing bluish green in life); L distinct, yellowish; Pin dark, small; AbdCr 14-16; AnCr 15-16.

*Final instar*: Length 9.5 mm (unfed?), 15.6-17.2 mm; HC 1.0-1.23 mm, white, mottled with brownish black posteriorly; ThSh defined by small blackish mottling; Pin small, black; D yellow; almost no other integumental color, DL pale grayish, lightly mottled (appearing pale bluish green in life), leav-

ing irregular unpigmented areas around pinacula; AbdCr 14-20 (usually 17-20); AnCr 16-21.

Pupa. - Cocoon formation occurred mainly in folds of paper toweling in the rearing container; a few were formed in mouldy foliage. Pupae were formed soon after cocoon construction. At least one pupa was present by April 5, 12 days after the larvae were collected.

In the field no cocoons were located on the foliage, even in late season condition, in May, 1962. The closely related *E. macelhosiella* was reported to burrow into bark of trees and logs for pupation (Busck and Heinrich, 1922). At Riverside, the dry chaparral association contains no plants with large woody trunks and appreciable thickness of bark. The pithy, dry stems of previous years' *Phacelia* growth was the only likely site evident in which larvae might burrow, but search of a large random sample of preceding years' stems revealed no abandoned cocoons.

The cocoons were about 11-12 mm long and exteriorly were papyrus-like in consistency, not translucent and could be torn like paper. Inside there was little loose mesh, and pupal shells could be easily extracted without breakage.

Pupae measured 7.5-8.2 mm in length. The cremaster setae were observed intact on several individuals, about 0.11 mm in length, very frail, curving towards the tip. The anal legs were widely spaced (0.33 mm apart at base), not diverging, and short, the free part only about 0.23 mm in length. The distal end bore 18-20 anchor setae in several examples.

Cocoons were stored in dry jars at room temperature and successful emergence occurred from nearly all, during a three week period in late October and the beginning of November.

Natural enemies. - The colony at Riverside was affected by a braconid, an undescribed species of *Microgaster* (n. sp. #8 of W.R.M. Mason). In the laboratory *Ethmia* larvae reached the final instar prior to emergence of the braconid larvae. Numerous wasps were reared, and it is assumed that each affected the host solitarily. However, no estimate of the proportion of the sample which was parasitized was made. Under laboratory conditions *Microgaster* adults emerged in May, apparently out of phase with any available stage of the ethmiid.

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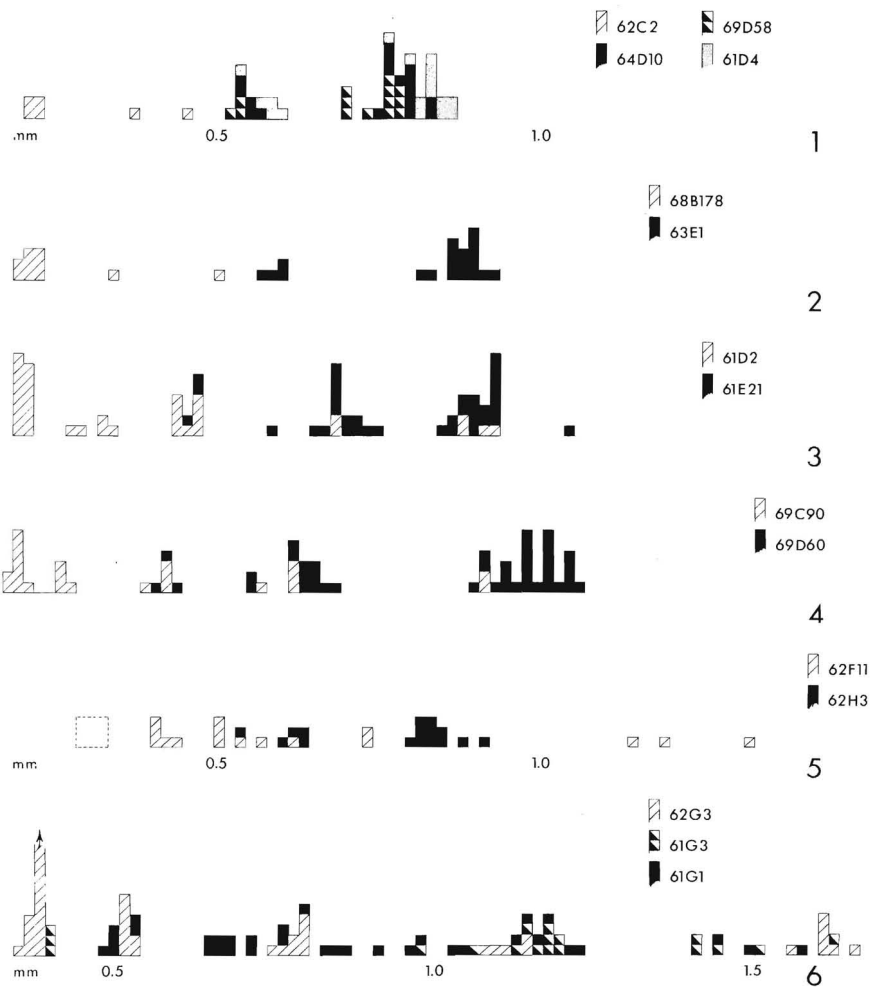
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## EXPLANATION OF FIGURES

Figs. 1-6, larval head capsule measurements in six species of *Ethmia*. Each square represents one individual. Diagonal-lined squares represent larvae reared from eggs in lab; solid, half-solid, and shaded squares represent field collected larvae. Rearing lot numbers refer to data given in text. Size scale (mm) is the same in figures 1-5.

1. *E. plagiobothrae* Powell
2. *E. albitogata* Walsingham
3. *E. b. brevistriga* Clarke
4. *E. scylla* Powell
5. *E. a. albistrigella* (Walsingham); dotted line indicates hypothetical size of first instar.
6. *E. discostrigella* (Chambers)



## EXPLANATION OF FIGURES

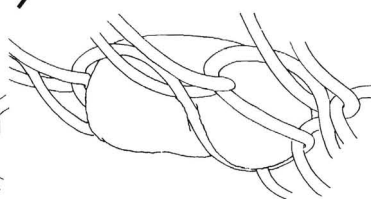
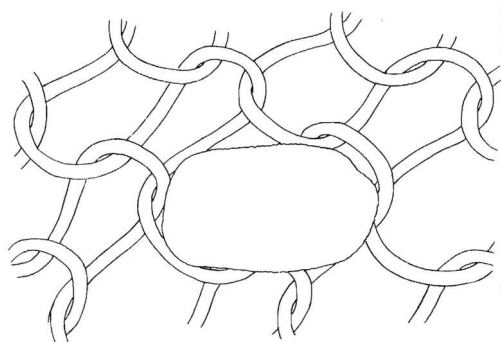
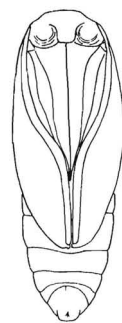
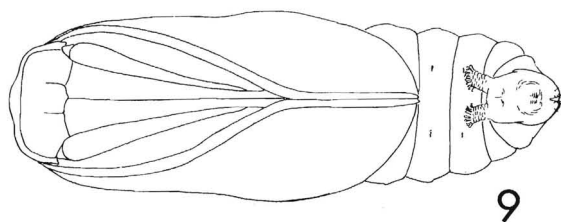
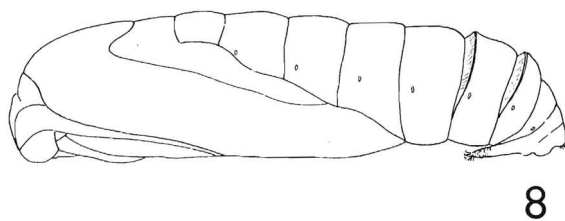
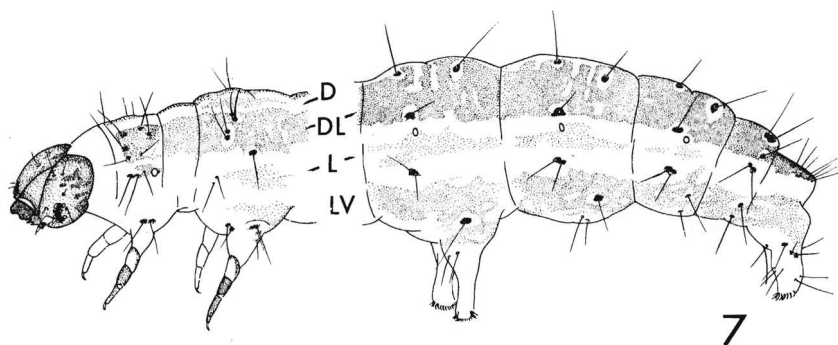
Fig. 7, final instar larva of *Ethmia charybdis* Powell; head and thoracic segments I-II, dorsolateral aspect; abdominal segments 6-10, lateral aspect. Body regions: D = dorsal, DL = dorsolateral, L = lateral, LV = lateroventral.

Figs. 8, 9, pupa of *E. semilugens* (Zeller); 8, ventral aspect; 9, lateral aspect.

Fig. 10, pupa of *E. scylla* Powell, ventral aspect.

Figs. 11, 12, egg of *E. coquilletella* Busck, illustrating placement on nylon mesh, a substrate commonly selected by females of various species under cage conditions; 11, ventral aspect; 12, lateral aspect. Length of egg = approximately 0.80 mm.





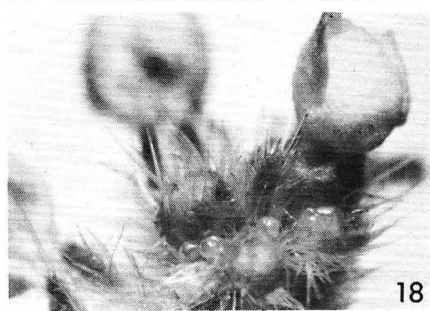
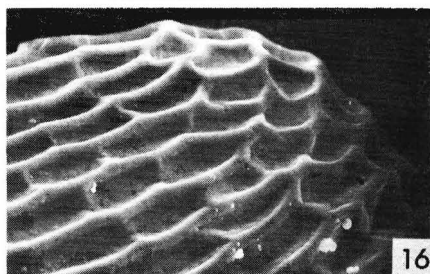
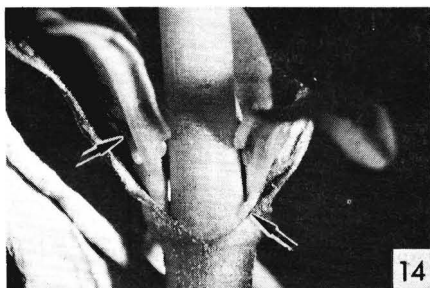
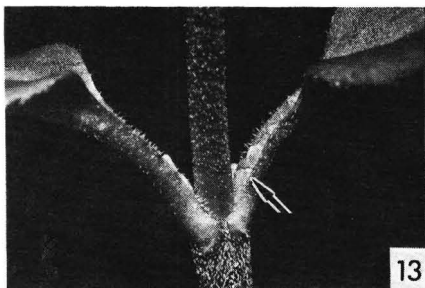
## EXPLANATION OF FIGURES

Figs. 13-20, eggs of *Ethmia* (approximate magnification indicated in parentheses).

13, 14, eggs of *E. scylla* Powell (69C90) in petiole axils of *Collinsia heterophylla* (4x).

15-17, scanning electron micrographs of *E. scylla* eggs and detail of chorion structure (69C90); 15, (60x); 16, (300x); 17, (1200x).

18-20, eggs of *E. minuta* Powell (63D18) in unopened, hispid inflorescences of *Cryptantha intermedia*; 18, (12.5x); 19, (7x); 20, (7x).

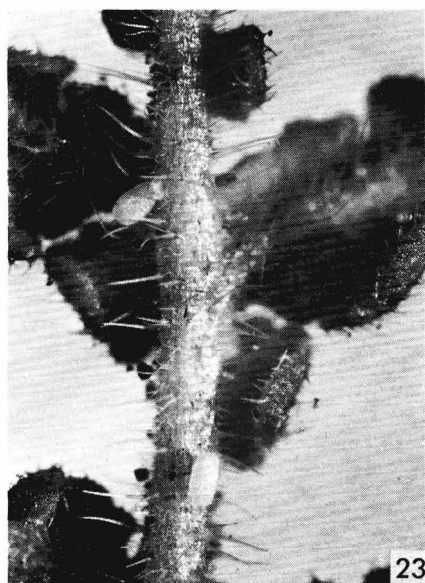
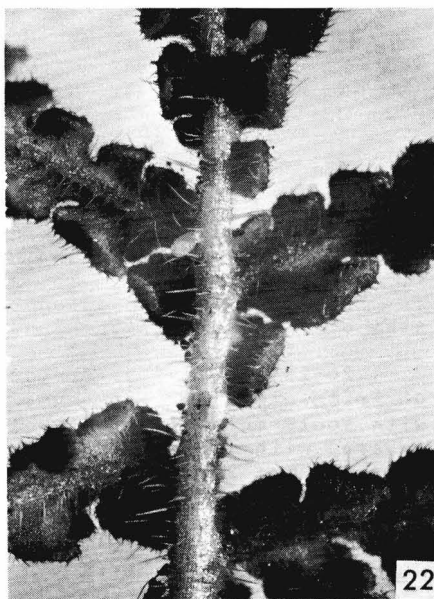
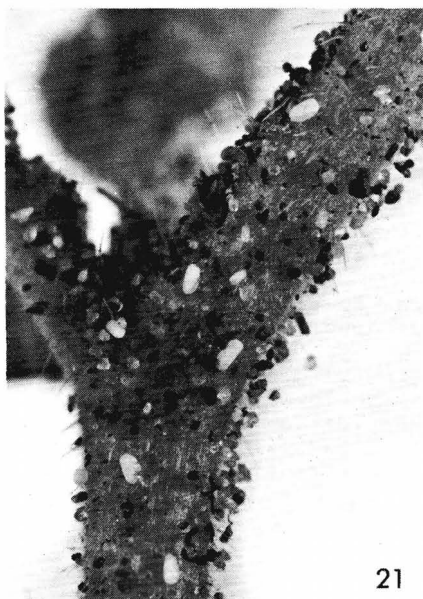


## EXPLANATION OF FIGURES

Figs. 21-24, eggs of *Ethmia* on natural plant substrates (approximate magnification indicated in parentheses).

21-23, eggs of *E. b. brevistriga* Clarke (61D2); 21 on sand-encrusted lower branch of *Phacelia distans* (7x); 22, on underside of mid-vein of *P. distans* compound leaf (7x); 23, same eggs (12.5x).

24, eggs of *E. plagiobothrae* Powell (62C2) on underside of *Phacelia californica* leaf, an abnormal host which was partially accepted by females but not accepted by larvae (7.5x).



## EXPLANATION OF FIGURES

Figs. 25-29, eggs of *Ethmia* on natural plant substrates (approximate magnification indicated in parentheses).

25, eggs of *E. plagiobothrae* Powell (62C2) on setose stem of *Phacelia californica*, an abnormal host (13.5x).

26-28, eggs of *E. arctostaphylella* (Walsingham) (61D3) on *Eriodictyon californicum*; 26, on lower branch encrusted with sooty-mold (7.5x) (the lower foliage commonly becomes covered with sooty-mold owing to glandular secretions of this plant); 27, on mid-vein, upperside of leaf (7.5x); 28, same eggs (12x).

