BIOLOGY AND TAXONOMY OF THREE GALL FORMING SPECIES OF *EPIBLEMA* (OLETHREUTIDAE)

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Epiblema Hübn. in North America comprises 39 species, mostly named over a half century ago (Brown, 1973). Natural history information is available for fewer than 10 species and consists chiefly of host and parasite records. Studies of several species received impetus during 1920–50 because of their superficial resemblance to introduced lepidopterans and their role as alternate hosts of parasites. These interests are exemplified respectively by Thompson (1928) and Bobb (1942), the latter citing related literature. As far as known, *Epiblema* feed on Compositae; the late instar larvae bore in the stems. The three species treated in this paper produce rudimentary galls.

Besides reviewing taxonomy, this paper augments natural history knowledge of *scudderianum* (Clem.) and gives new information about *desertanum* (Zell.) and *discretivanum* (Heinr.). It reports hosts, maps geographic records, describes feeding patterns and galls, outlines seasonal life histories, and integrates the literature on the genus.

Taxonomy

The following review identifies the species treated. It is abbreviated to primary citations. I examined all types.

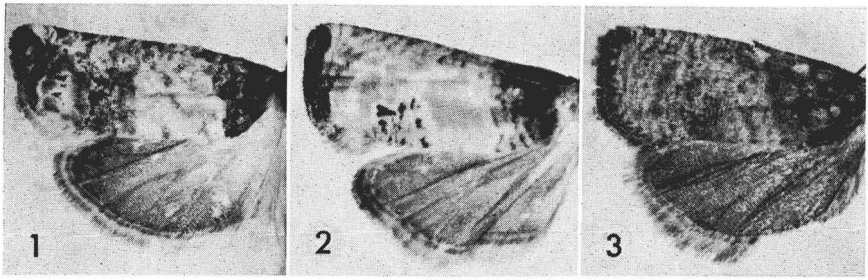
Epiblema scudderianum (Clemens) (Fig. 1)

Hedya scudderiana Clemens (1860, p. 358) (Type in Academy of Natural Sciences of Philadelphia, illustrated by Miller (1973)).

Euryptychia saligneana Clemens (1865, p. 141) (Possible type in British Museum (Natural History) (Miller, 1973)). *Paedisca affusana* Zeller (1876, p. 307) (Lectotype designated here, "Zeller Coll. Walsingham Collection . . .; *Paedisca affusana* Z. III, 307 fig. 38 Am. Sept. Rssl . . .; Type; B. M. ♀ Genitalia slide No. 5738," British Museum (Natural History), left forewing and distal part of right forewing missing, hindwing length 8.0 mm).

Epiblema desertanum (Zeller) (Fig. 2)

Paedisca desertana Zeller (1876, p. 306) (Lectotype designated here, "Dallas, Tex. Boll; Type 14338; *Paedisca desertana* Z.; . . . Lectotype des. W. E. Miller," Museum of Comparative Zoology, ♂, forewing length 8.0 mm).



Figs. 1–3. Wings of *Epiblema*. 1, *scudderianum* ♂, Ottawa Co., Michigan, forewing 8.0 mm; 2, *desertanum* ♂, Ingham Co., Michigan, forewing 8.0 mm; 3, *discretivanum* ♀, Chatham Co., Georgia, forewing 6.5 mm.

Epiblema discretivanum (Heinrich) (Fig. 3)

Eucosma discretivana Heinrich (1921, p. 823) (Type No. 23743, National Museum of Natural History).

Forewing patterns of *scudderianum* (Fig. 1) and *desertanum* (Fig. 2) scarcely vary while that of *discretivanum* (Fig. 3) varies without regard to sex in degree of shading, particularly in basal and mid-dorsal areas. Size of adults is shown by the following forewing length ranges: *scudderianum*, 7.0–10.5 mm (136 examples not sexed); *desertanum* 7.0–8.5 mm (25); and *discretivanum*, 5.5–7.5 mm (37). Male genitalia are illustrated by Heinrich (1923) and female genitalia and wings by Brown (1973).

Hosts

Except as noted, host records refer to identified adults that developed naturally on the indicated plant species. Plant specimens were diagnosed or verified by E. C. Leonard, National Herbarium; J. H. Beaman, Michigan State University; and Harmon Runnels, Ohio Agricultural Research and Development Center.

Hosts of *scudderianum* in decreasing order of observation frequency were the Canada goldenrod complex, *Solidago altissima* L.-*canadensis* L.; tall goldenrod, S. *gigantea* Ait.; early blooming goldenrod, S. *juncea* Ait.; elm leaved goldenrod, S. *ulmifolia* Muhl.; and prairie goldenrod, S. *nemoralis* Ait. I reared moths from an unidentified host in Florida which was likely camphor weed, *Heterotheca subaxillaris* (Lam.) Britt. & Rusby, a host noted on museum specimens from Florida and Texas. I observed typical galls on *Aster ericoides* L. in northern Ohio but did not succeed in rearing adults.

I found *desertanum* only on the grass leaved goldenrod, *Solidago*

graminifolia (L.) Salisb. This goldenrod often occurred on the same sites as one or more of those above; both *scudderianum* and *desertanum* sometimes occurred at such sites. *Epiblema discretivanum* occurred mostly on groundsel-tree, *Baccharis halimifolia* L., but I reared adults also from narrow leaved groundsel, *B. angustifolia* Michx., and *B. glomeruliflora* Pers.

Geographic Distribution

Three types of locality records appear in Fig. 4: (1) where I reared adults that were subsequently identified, (2) where museum specimens that I verified were collected (museums included National Museum of Natural History, Canadian National Collection, and American Museum of Natural History), and (3) where I observed galls only. The map shows gall-only records where there were gaps in the first two types of records. Only one map symbol appears where two or more for the same species were close enough to overlap.

Records for *scudderianum* occur from Maine south to Florida and west to North Dakota and Texas. Those for *desertanum* occur through practically the same area while those for *discretivanum* are confined to the coastal plain from Georgia and Florida to Texas (Fig. 4).

Larval Feeding Pattern

Between hatching and entering stems, *scudderianum* larvae evidently fed at host tips. This was inferred from several series of observations typified by the following example. In mid-July, I examined 25 *Solidago altissima-canadensis* plants with incipient galls in a field in southern Michigan. The tip of every plant had been mined by a small insect no longer present. In the same field on the same date, I examined another 25 plants that had mined tips. Of this group, 16 had incipient *scudderianum* galls; larvae on the remaining nine plants probably did not survive to start galls. Limited observations suggest similar pre-gall feeding by *desertanum*. I did not observe *discretivanum* for pre-gall feeding.

A total of 85 incipient *scudderianum* galls which I examined in June and July in Ohio, Maryland, and Michigan had one and usually two small openings between the gall chamber and outside. One opening was gradually enlarged throughout the summer whereas the other usually was not. I assume the latter to be the passage by which the larva entered the stem. It was often located just above a leaf attachment. The enlarged opening served as a hatch through which the larva periodically ejected debris, mostly frass. The debris hatch was covered with silk when not in use. Some entry passages may have been converted to debris

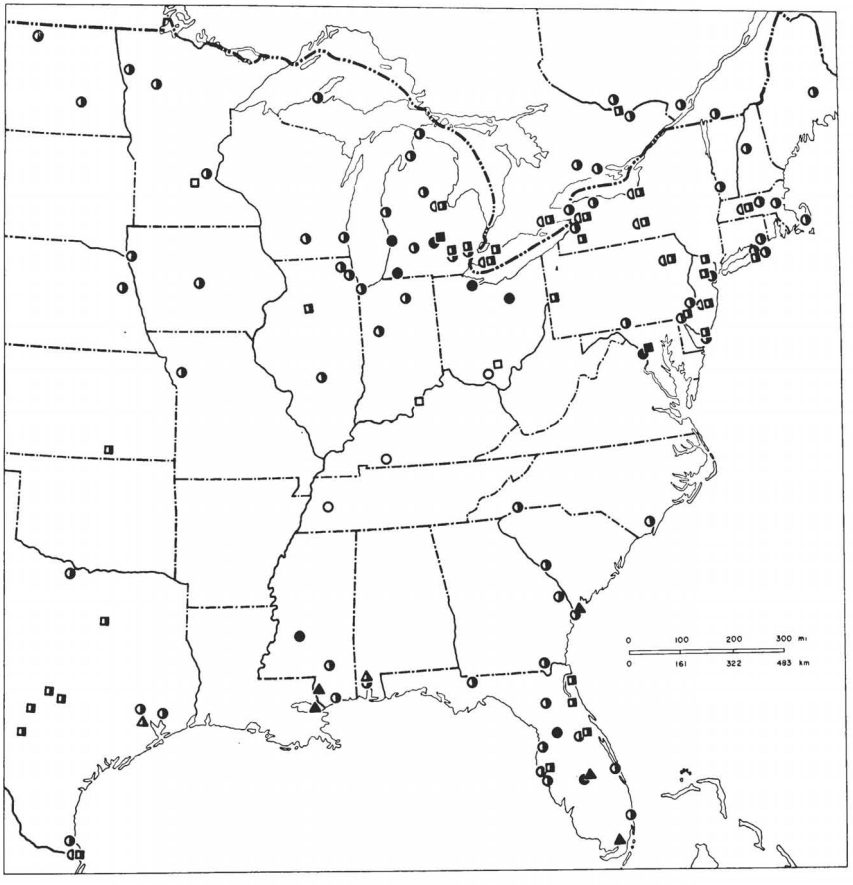


Fig. 4. Distribution of records for *Epiblema scudderianum* (circles), *desertanum* (squares), and *discretivanum* (triangles). Solid symbols signify reared adults; half open symbols, museum specimens; full-open, galls.

hatches. I observed ejection of debris from galls brought indoors; frass intercepted by leaves beneath galls is a common sight in the field. Kellicott (1878) also reported ejection of debris by *scudderianum*. Debris hatches were usually located in the lower half of *scudderianum* galls. After larvae became full-grown and ceased to feed and excrete, they permanently sealed debris hatches with a dark brown noncellular material probably of larval origin. Such plugs were closely fitted and when removed looked somewhat like train wheels.

Debris hatches and plugs occurred in *desertanum* and *discretivanum* galls but were located in the upper half of galls. No entry passages

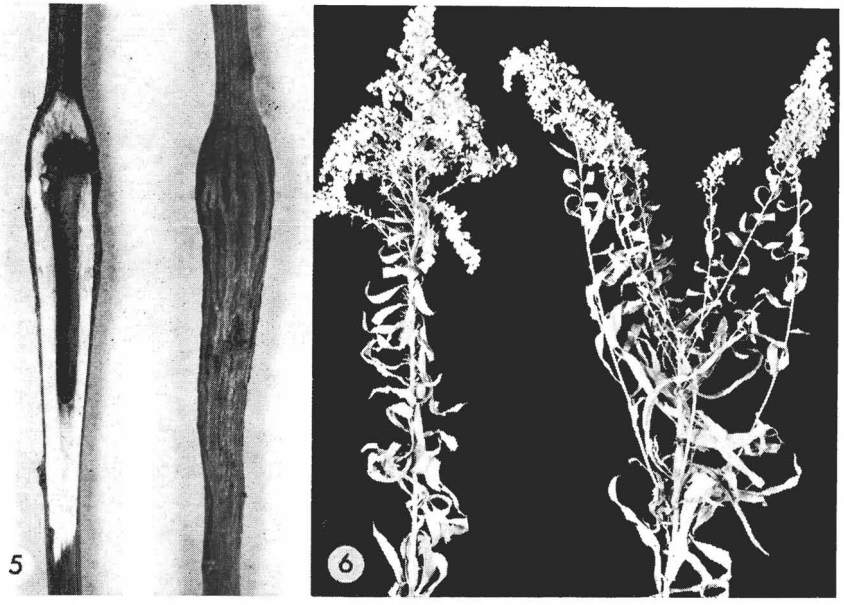


Fig. 5. Galls of *Epiblema discretivanum* on *Baccharis halimifolia.* Left, sectioned to show larval tunnel and moth exit. Right, intact.

Fig. 6. Upper stem of flowering *Solidago altissima-canadensis.* Left, normal plant. Right, branched plant infested by *Epiblema scudderianum.* Gall is visible near center of the segment of stem shown.

separate from debris hatches were identified in either species, the entry passages probably having been converted to debris hatches.

Apparently due to host reaction, *scudderianum* and *desertanum* galls occasionally ruptured, exposing the larval feeding chamber. Counts in Maryland in mid-July showed 7 of 25 *scudderianum* and 9 of 48 *desertanum* galls in various stages of rupture. Several larvae were continuing their feeding in adjacent parts of the same stems.

Stem tunnels of larvae that pupated ranged in length as follows: *scudderianum,* 3.2–5.0 cm (16 observations); *desertanum,* 4.5–4.7 cm (2); and *discretivanum,* 2.1–3.3 cm (24).

Mature larvae excavated moth exit tunnels in the upper half of galls, leaving only a thin layer of plant tissue. They spun silken funnels that guided the emerging insect into the exit. Moth exits were completed by all three species before winter. The gall of *discretivanum* (Fig. 5) is similar in appearance and gross structure to the other two galls; that of *scudderianum* has been illustrated often and is shown together with *desertanum* galls by Miller (1963).

Infestation by *scudderianum* was often accompanied by branching of host plants late in the summer (Fig. 6).

Seasonal History

Scudderianum flew in May and June in northern localities. At a light near an old field in southern Michigan, I caught 30 moths between May 25 and June 21 during two years of observations. In northern Ohio during one year of observation, 6 moths emerged within the above dates from galls held in an outdoor insectary. In Maryland during one year of observation, 4 moths emerged between April 30 and May 12 from galls in an outdoor insectary. In studying galls of *Gnorimoschema gallaesolidaginis* (Riley) (Miller, 1963), I obtained one moth of *Epiblema scudderianum* during the above periods.

I made one observation concerning the flight period of *desertanum*: on June 26 in Maryland, 13 galls had protruding empty pupal cases and two had live pupae. I made no comparable observations on *discretivanum*.

The earliest dates I observed incipient *scudderianum* galls were June 20 in Maryland and June 24 in northern Ohio; *desertanum* galls, July 19 in Maryland. All three species overwinter in galls as mature larvae.

The earliest dates I observed *scudderianum* pupae were April 11 in Maryland, May 7 in northern Ohio, and May 22 in southern Michigan; *desertanum* pupae, May 24 in southern Michigan.

Discussion and Conclusions

Type examination and fixation confirms and formalizes identities and synonymies of the three species. The synonyms were proposed by Fernald (1882) as well as Heinrich (1923); it is uncertain whether Fernald saw all types but certain that Heinrich did not. Adults of the three species are recognizable from forewing pattern despite the variability in *discretivanum*. Larvae of some *Epiblema* are characterized by MacKay (1959) and pupae of two are included in Mosher's (1916) classification. Eggs of *Epiblema strenuanum* (Wlkr.) *E. carolinanum* (Wlshm.), and *E. otiosanum* (Clem.) are known (Peterson, 1965; Thompson, 1928; Decker, 1932).

Scudderianum, associated with four genera of hosts, has more known hosts than any North American *Epiblema*. It has often been reported from the Canada goldenrod complex. The five host species reported here, representing two genera, appear to be new records. Ellis (1925) listed *Bidens frondosa* as a frequent host, and two other genera observed once by him as hosts, referring to *scudderianum* as the bidens borer. One

wonders if he confused *scudderianum* with the true bidens borer, *otiosanum*, but he stated correctly that his insect was univoltine whereas *otiosanum* is multivoltine (Decker, 1932). *Desertanum* has only one known host in the North; its host or hosts in the South, where *Solidago graminifolia* does not occur (Fernald, 1950), are unknown. Thus far, *discretivanum* is known only from the three species of *Baccharis* listed in this paper. Heinrich (1921) said it formed a gall on "wild myrtle" which Bottimer (1926) identified as *B. halimifolia.*

All three *Epiblema* studied appear confined to eastern North America. Distributions of *scudderianum* and *discretivanum* and their most frequent hosts closely coincide; the same is true for *desertanum* in the North. *Discretivanum* likely occurs in the West Indies and other Caribbean areas because its hosts are there (Small, 1933).

Riley (1883) stated that *scudderianum*, in one of several alternate feeding patterns, fed first on tips and later formed galls. Kellicott (1882) confirmed gall forming but not tip feeding. Riley mixed species and even genera of goldenrod-feeding olethreutids in his observations. Whether he observed true *scudderianum* tip feeding is uncertain. Pregall tip mining by *scudderianum* and *desertanum* may represent an early feeding mode characteristic of other olethreutid larvae (MacKay, 1963). Similar feeding has been reported in *otiosanum* (Decker, 1932), *carolinanum* (Thompson, 1928) and *tripartitanum* (Zell.) (Bottimer, 1926).

Early debate about whether *scudderianum* induced gall formation arose in part by *scudderianum* moths apparently emerging from *Gnorimoschema* galls (Kellicott, 1882). Judd (1951) as well as I observed the same phenomenon. Old galls of these two gall makers can be confused. On the other hand, *scudderianum* larvae whose galls rupture might find their way into *Gnorimoschema* galls just as some *otiosanum* larvae wander to new sites before overwintering (Decker, 1932).

In contrast to linear stem boring, *scudderianum*, *desertanum* and *discretivanum* concentrate their feeding within a short length of stem. Maximum stem swelling seems to be associated with the point of maximum internal feeding. After *scudderianum* larvae form their chambers, cambial activity is greatly accelerated. Tissues internal to the cambium are grazed (Blum, 1953). Ejection of debris is essential where feeding is intensified in a small area. Branch proliferation due to *scudderianum* has counterparts in hosts of *strenuanum* (Crawford, 1933) and *carolinanum* (Thompson, 1928).

North American *Epiblema* with known biologies overwinter as mature larvae. *Scudderianum* and *desertanum* are apparently univoltine in the North. In Ontario over several years, Brodie (1909) observed *scudder-*

ianum moths flying between June 12 and July 1, two weeks later than I observed in southern Michigan. Moth flight, gall formation, and pupation appear to be earlier in Maryland than in the Midwest.

Galls of all three species observed in this study persist for a year or longer after their makers leave and many are used as homes by other arthropods (Miller, 1966).

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A POSSIBLE SOURCE OF MORTALITY IN *PAPILIO TROILUS* (PAPILIONIDAE) POPULATIONS IN EASTERN TEXAS

While collecting *Papilio troilus* (L.) eggs in the vicinity of the Hardin town dump in Hardin Co., Texas, on 21 March 1972, several trails of leaf-cutter worker ants were observed carrying pieces of leaves to their nests presumably for culture medium for their fungal "gardens" (Creighton, 1950, Bull. Mus. Comp. Zool. Harvard Univ. 104: 325–329). These ants were kindly determined by Dr. Wm. L. Brown, Jr. to be *Atta texana* (Buckley). One of the small shrubs which was rapidly being defoliated of its succulent spring growth of leaves was *Sassafras albidum* (Nutt.), which was also the main plant species being utilized for oviposition by *P. troilus*. While looking at one particular sassafras plant I was able to rescue a *troilus* egg on an excised leaf section that was actually being carted off down the stem by an ant and three more eggs on leaves certainly destined for the same outcome. The probable fate would have been death, but the proximate source of mortality could have been any of several, including desiccation, predation by ants, or fungal attack of either eggs or larvae. These eggs and the resulting larvae were instead reared through to *P. troilus* adults on *Sassafras albidum* in Ithaca, New York. Specimens of *P. troilus* and *Atta texana* from these Hardin County populations have been deposited in The Cornell University Collection: Lot 1023, sublot 13b.

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