NOTES ON THE BIOLOGY AND DISTRIBUTION OF FLORIDA LEAF-MINING FLIES OF THE GENUS *PHYTOBIA* LIOY, SUBGENUS *CALYCOMYZA* HENDEL (DIPTERA: AGROMYZIDAE)[1]

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Little published information is available concerning the subgenus *Calycomyza* of the genus *Phytobia* in Florida; moreover, the subgenus is virtually unknown in the neotropical area of South Florida. The author and other Florida entomologists collected certain ecological data regarding the larval host plants, parasites, and other aspects of the life history of the subgenus *Calycomyza*. The Florida research yielded several new species of *Calycomyza* currently being described by Kenneth A. Spencer of London, England.

The larvae of certain *Calycomyza* species are known from the literature to produce distinct leaf mine forms on the leaves of their respective host plants. Frick (1956) reported numerous leaf mine forms concerning the *Calycomyza* species. Certain *Calycomyza* species may be recognized in the field, occurring as immature stages within the leaves of their host plants, by various types of leaf-mine forms. This information provides a means of correct identifications of the immature stage of the leaf miner species without rearing the adults in the majority of cases.

The subgenus *Calycomyza* is found throughout the world in Europe, Asia, Africa, North, Central, and South America, the Caribbean Islands, and Mexico. The subgenus is especially well represented in North and South America. More research and data are especially needed from the neotropical region; many new species remain undiscovered. The host plants of many described *Calycomyza* species remain to be reported. Parasites and other biological data concerning the *Calycomyza* are incomplete in this neotropical area.

Frick (1956) stated that 21 species are described and mentioned that the adults of all but 4 species have been reared from larvae mining in leaves of specific host plants. Frick also provided keys to 14 species of the subgenus *Calycomyza*. Spencer (1963) added to the information on the subgenus from the Caribbean Islands and South America. He described 8 new species of *Calycomyza* and discussed an addittional 19 species.

Frick (1956) reported that known larvae of *Calycomyza* species produce mines in the form of a blotch, linear blotch, or an extremely twisted linear mine that becomes a blotch. The author illustrates as an exception a mine of *Calycomyza malvae* (Burgess) (Fig. 2, A and B) that resembles a linear mine of a *Liriomyza* species. When *C. malvae* mines smaller leaves of a malvaceous host, it produces a linear-blotch mine. Frick also reported that some of the *Calycomyza* species pupate within their leaf

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mines while others leave the mine channels to pupate. He stated that larvae which pupate in the leaf mines attach the puparium to the lower epidermis with a mass of frass. Frick observed that before pupating, the larva cuts a curved slit in the upper epidermis through which the adult can escape. The frass may be deposited in various patterns, but usually was found to be concentrated about the pupation site or exit.

Phytobia (*Calycomyza*) *ambrosiae* Frick

Frick (1956) described the species; the holotype was reared by G. G. Ainslie from *Ambrosia artemisiifolia* L. in Tennessee. The species was also collected from *A. artemisiifolia* by J. M. Aldrich in Indiana. L. D. Beamer collected *P. ambrosiae* from *Ambrosia trifida* L., Royal Palm, Florida, while S. D. Frost reared the species from both species of ragweed in Pennsylvania. Frick reported that the species forms large blotch mines in the leaves of ragweed and larvae leave the mine before pupating.

I have observed large oval or irregular blotch mines of larvae in leaves of ragweed in south Florida. Fig. 1A, illustrates mature and immature mines of *P. ambrosiae* in *artemisiifolia*. Irregular blotch mines are produced by larval feeding in all directions with one larva per mine on the upper surface of the leaves. I have never observed mines on the lower leaf surfaces in south Florida. Many mines may occur on a single ragweed leaf when a severe infestation is present as shown in Fig. 1A. Frequent and severe infestations on ragweed have been observed throughout the growing season in south Florida.

REARING RECORD:

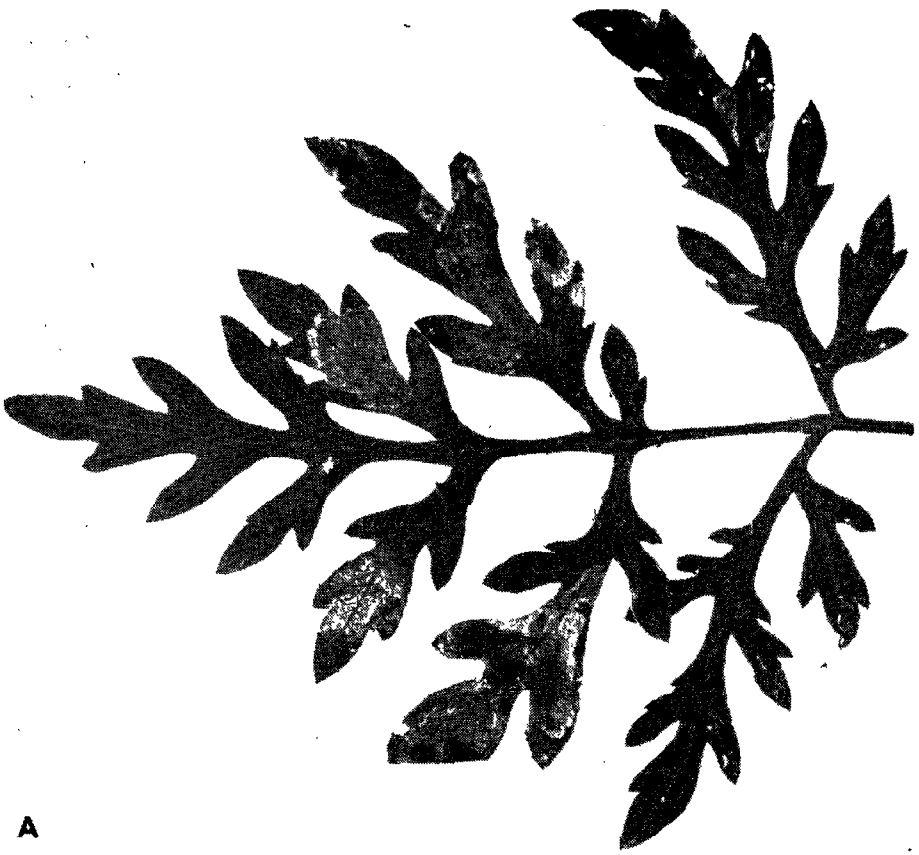
Ambrosia artemisiifolia L. Hialeah, 7 Mar. 1963 (C.E.S.).

Phytobia (*Calycomyza*) *jucunda* (Wulp)

The species was first described as *Agromyza jucunda* by van der Wulp (1867). Blanchard (1938) changed the generic designation to *Dizygomyza*. Frick (1952) stated, "Dr. Hering, in correspondence, has confirmed that this species does not occur in Europe. It is very closely related to *P. humeralis*, but the larvae make distinctive blotch mines in the leaves of numerous plants. Hendel believed that *A. platyptera* is a synonym of *P. jucunda*." Frick (1952), in his generic revision of the Agromyzidae, placed the species as *P.* (*C.*) *jucunda*. Frick (1956) listed the following as synonyms of *jucunda*: *Agromyza jucunda* Wulp, *Dizygomyza* (*Calycomyza*) *jucunda* (Wulp), *Agromyza platyptera* Thomson, *Agromyza coronata* Loew, and *Phytobia* (*Calycomyza*) *coronata* (Loew). Blanchard (1954) stated that his 1938 citation concerning the species in Argentina was an error, and he subsequently included it as a new species, *Dizygomyza jucundacea*. Spencer (1963) commented on *jucundacea* (Blanchard), "It has not been possible to examine this species nor to include it in my key." Spencer suggested that *jucundacea* may be identical to *malvae*

Fig. 1A. Mature and immature mines of *Calycomyza ambrosiae* on leaves of *Ambrosia artemisiifolia*.

Fig. 1B. A single blotch mine of *Calycomyza jucunda* on leaf of *Bidens pilosa*, spanish needle.



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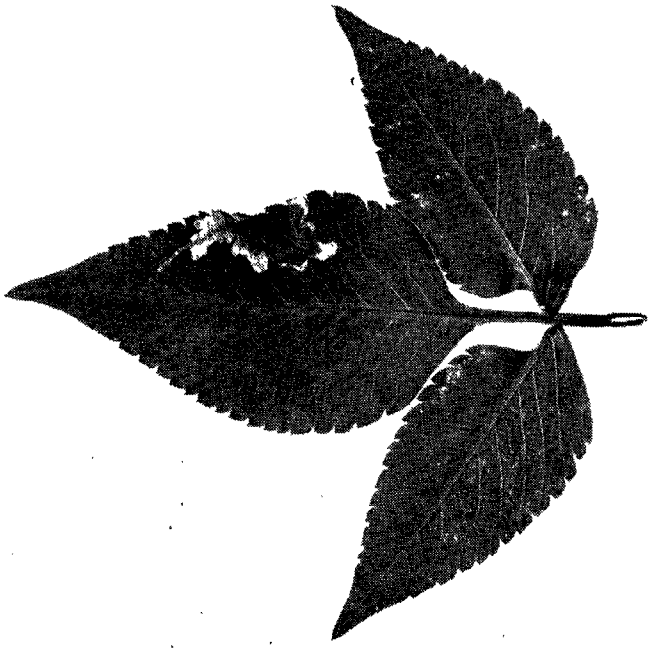


B

(a specimen bred from *Gossypium* at Tucuman, Panama) and indicated that its true status can be clarified only by examination of male genitalia of further specimens bred from *Papaver*.

Frick (1956) reported *P. jucunda* as a *Nearctic* species recorded from many states in the United States, Hawaii, and Canada. He cited host plants of *jucunda* as: *Ambrosia trifida* L., *Arctium* sp., *Artemisia douglasiana* Bess., *A. vulgaris* L., globe artichoke, *Baccharis viminea* DC. *Erigeron canadensis* L. *Erigeron* sp., *Grinidella squarrosa* (Pursh.) *Helianthus annuus* L., *Heterotheca grandiflora* Nutt., *Solidago* sp., *Xanthinum* sp., and *Zinnia* sp.

Frick reported the mines of *jucunda* as large white blotches turning brown with age. The larva pupates in the leaf mine channel and frass is deposited in a mass of small pellets around the pupation site. Frick noted a short linear portion at the beginning of the mine which developed into a blotch; the blotch usually obliterated the short linear mine. *C. jucunda* may have up to six mines centrally located on the midribs of 1 leaf of *Helianthus* according to Frick.

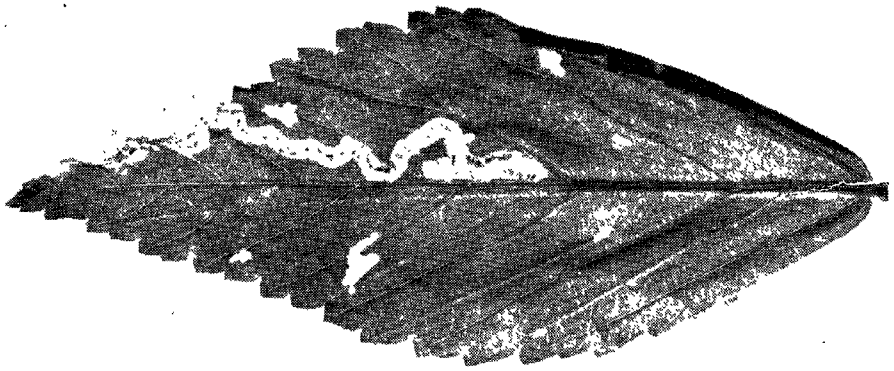
C. jucunda is quite common in south Florida infesting many plants in the family Compositae. A preferred host seems to be the wild spanish needle, *Bidens pilosa* L. Infestations on the leaves of spanish needle have been observed to occur throughout most of the year in south Florida. The leaves usually assume a distorted or wrinkled appearance largely as a result of the mines placed on the midrib or lateral leaf veins. The mature mine of *jucunda* (Fig. 1B), on the lateral edge of a *Bidens* leaf has necrotic or brown tissue surrounded by white on the outside of the mine. The short linear mine of which Frick speaks is also well defined and in this case is not obliterated by the blotch. The short linear mine leads into the blotch mine sometimes called a phyllonome.

The color of many previously observed immature mines on such plants as *Aster* sp., and *Solidago* sp. (cited in the rearing records) are light green. The larvae sometimes produce a central blotch mine with many characteristic finger-like processes which resemble a green star on thicker leaves of some composites. Hering (1951) (a noted authority on all orders of leaf miners in Germany) described this particular type of mine when he stated, "Finally, there are a whole series of mines in which the larva, setting out from a central patch, drives short tracks or galleries into the leaf in all directions, forming in this way a star-shaped pattern. These are therefore known as digitate or star mines or asteronomes." Hering observed that this peculiar type mine construction seemed to be associated with avoidance of strong leaf veins by the larva while feeding.

I have not investigated the host range within the family Compositae for *jucunda* in south Florida, but September through March seem to be ideal months for the study of host plant ranges of the species as severe infestations of *jucunda* are common.

Fig. 2 (A and B). Linear leaf mines of *Calycomyza malvae* on leaves of *Sida* species.

Fig. 2 (C and D). Blotch mines of *Calycomyza lantanae* on leaves of *Lantana camara*.



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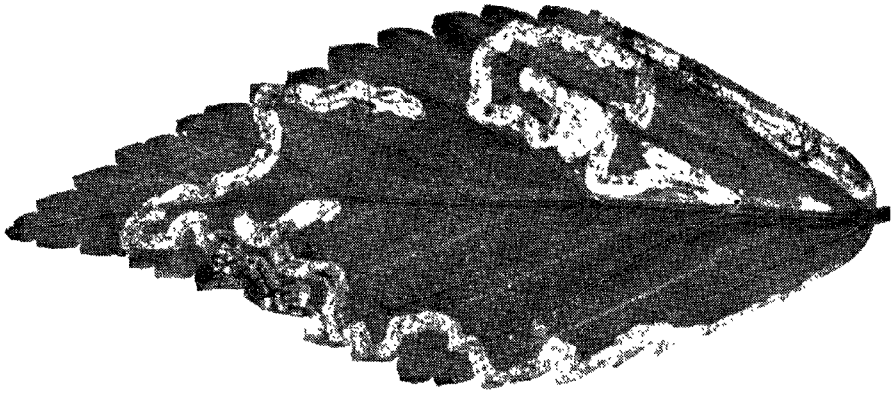

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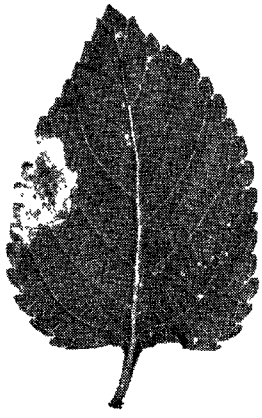

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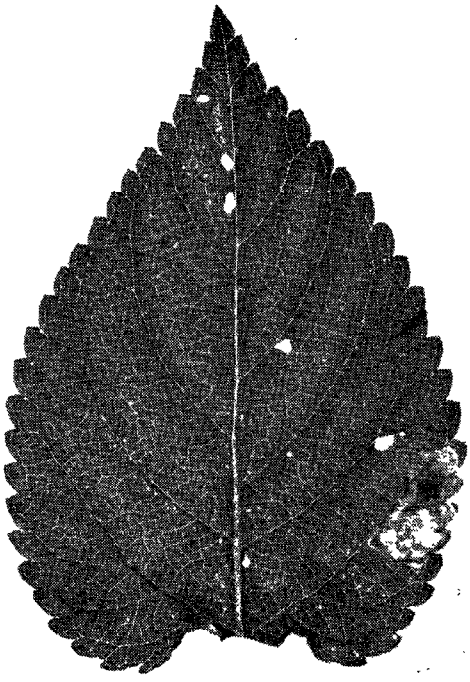

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REARING RECORDS:

Aster simmondsii Small: Hialeah, 24 and 29 Jan. 1966 (leaf mines only) (C.E.S.).

Ambrosia artemisiifolia L.: Sanford, 21 Jan. 1964 (G. W. Desin); Quincy, 13 May 1964 (D. H. Habeck).

Bidens pilosa L.: Hialeah, 16 Apr. 1963 (C. E. S.); Hialeah, 4 July 1966 (leaf mines only) (C.E.S.).

Gnaphalium spathalium Lam.: Hialeah, 22 Apr. 1964 (first emergence of adults, 2 May 1964) (C.E.S.).

Helianthus annuus L.: Hialeah, 7 Mar. 1963 (C.E.S.); Hialeah 4 Apr. 1963 (first emergence of adults, 16 Apr. 1963) (C.E.S.).

Solidago caesia L.: Hialeah, 6 June 1966 (leaf mines only) (C.E.S.).

Solidago tortifolia Ell.: Hialeah, 17 Oct. 1965 (leaf mines only) (C.E.S.).

Solidago spp.: Hialeah, 10 Nov., 6, 12, and 17 Dec. 1965, 24 and 29 Jan. 1966 (leaf mines only) (C.E.S.).

Xanthium sp.: Quincy, 13 May 1964 (first emergence of adults, 18 May 1964) (D. H. Habeck).

Zinnia sp. cult.: Miami Beach, 10 Apr. 1964 (leaf mines only) (C.E.S.).

Phytobia (*Calycomyza*) *lantanae* Frick

Frick (1956) described and discussed this neotropical species and stated that larvae mine the leaves of the following host plants: *Lantana camara* L., *Lantana* species, and *Lippia helleri* Britt., recorded from Texas, Mexico, Puerto Rico, and Trinidad. Frick reported that Williston's syntype series of *allecta* in the British Museum belongs to this species and indicates collections of *C. lantanae* were reared by N. L. H. Krauss from blotch mines of *Lantana camara* in Trinidad. Krauss also collected *C. lantanae* from *L. camara* in Grenada, West Indies. Spencer (1963) cited personal collections of *C. lantanae* from blotch mines on *Verbena litoralis* H. B. and K. and *Lantana* from Caracas, Venezuela.

I have observed *C. lantanae* severely mining leaves of *Lantana camara* throughout the year in south Florida. Fig. 2, C and D, shows two leaves of *Lantana camara* with a single blotch mine or stigmatonome on each of two leaves. The blotch mine of *lantanae* contains a well defined dark area which is a characteristic accumulation of excretory deposits contained in a central mass. The dipterous leaf miners on *Lantana camara* found in south Florida to date are *C. lantanae* and *Ophiomyia camarae* Spencer. Mines of *O. camarae* follow the midrib and lateral veins only; therefore, the blotch mines of *C. lantanae* should not be confused with those of any other leaf miner on *L. camara* in Florida.

REARING RECORDS:

Lantana camara L.: Hialeah, 18 Apr. 1963 (C.E.S.); Miami Beach, 6 May 1964 (leaf mines only) (C.E.S.); South Miami, Sep. 1965 (C.E.S.).

Phytobia (*Calycomyza*) *malvae* (Burgess)

Burgess (1880) described this Nearctic species as *Oscinis malvae* mining the leaves of *Malva rotundifolia* L. Frick (1956) placed the species in

its present generic position and cited the following host plants: *Abutilon theophrasti* Medic., *Althea* sp., *Malvastrum coromandelianum* L., and *Sida spinosa* L. He cited the distribution of the species from the following areas: Arizona, California, New Mexico, New York, Florida, Washington, D. C., Indiana, Pennsylvania, and the Panama Canal Zone. Spencer (1963) reported *C. malvae* from *Sida* sp. from Brazil; however, personal correspondence from Spencer has disclosed that the Florida species and the Brazilian species may be distinct species. He illustrated a leaf mine of *C. malvae* which had been sent to him from my personal collection of *Sida rhombifolia* mined leaves. The leaf mine illustrated by Spencer (1963) appears as a blotch mine.

Spencer quoted a description of a leaf mine described by Burgess as follows: "an irregular linear mine, first above the under-, afterwards beneath the upper surface." Frost (1964) reported rearing *Phytobia (alycomyza) malvae* from linear mines of *Urena lobata* Vell. at the Archbold Biological Station at Lake Placid, Florida. He also recorded light trap collections of the species from the same locality.

C. malvae has also been reared from several malvaceous host plants by the author in south Florida since 1962. Numerous leaf mines, especially on *Sida* spp., have been noted continuously throughout the year in south Florida. Fig. 2A and B, illustrate typical linear mines on leaves of *Sida* spp. Fig. 2A illustrates a single linear mine of *malvae.* Although the mine is distinct and clear, the excretory trail is irregular and rather diffuse. The excretory pellets and trail show an alteration first on one side and then on another, after which the excretory trail seems to be centered in the mine channel. Fig. 2B illustrates a leaf containing multiple mines of *malvae.* The species does not cross the midrib of *Sida* in its larval stage except near the outer edge of the leaf; the species seems to prefer the lateral edges of the leaves. A possible explanation for this aspect of mining by the larvae may be the lack of strong mouthparts and the inability to feed on the strong vascular bundles of the larger leaf veins. Spencer's (1963) illustration of the mines of *malvae* show most of the blotch type mines between two leaf veins of *Sida rhombifolia* L.

REARING RECORDS:

Abutilon sp.: Hialeah, 21 Aug. 1962 (C.E.S.).

Althea rosea Cav.: Gainesville, 22 Apr. 1964 (first emergence of adults, 3 May 1964) (D. H. Habeck).

Malvastrum corchorifolium (Desr.) Britton: Hialeah, 15 Sep. 1963 (first emergence of adults, 23 Sept. 1963) (C.E.S.).

Malvastrum coromandelianum (L.) Gareke: Hialeah, Sep. 1964 (leaf mines only) (C.E.S.).

Sida acuta Burm.: Hialeah, 18 Aug. 1962 (C.E.S.).

Sida cordifolia L.: Hialeah, 3 Aug. 1963 (C.E.S.).

Sida rhombifolia L.: Hialeah, 4 Feb. 1963 (C.E.S.).

Sida spp.: Hialeah, 22 Sep. 1963 (C.E.S.). Many unidentified species of *Sida* have been observed to be mined by *C. malvae* in various areas of Florida, and mines have been seen by the author throughout the sea-

sons in south Florida. *Sida* seems to be a preferred host plant as it is severely infested during the cooler months in Neotropical Florida.

Phytobia (*Calycomyza*) *verbenae* (Hering)

Hering (1951) described the species as *Dizygomyza* (*Calycomyza*) *verbenae*, and Frick (1953) placed the species in its present generic position. Frick stated that the larvae form blotch mines in the leaves of cultivated varieties of *Verbena hybrida* Voss. Frick commented that type specimens were reared by J. R. Eyer, at Las Cruces, New Mexico. Frick (1956) recorded the following distribution of *C. verbenae*: Arizona, New Mexico, Texas, Missouri, Illinois, Ohio, Indiana, New York, Pennsylvania, New Jersey, Washington, D. C., Maryland, Georgia, Florida, and Mississippi. Frick (1956) cited the host plants of *verbenae* as: *Verbena neomexicana* (Grey) Small, *V. wrightii* Grey, and *V. hybrida* Voss, cultivated varieties.

Frost (1964) cited collections of *C. verbenae* from light traps stationed at the Archbold Biological Station at Lake Placid, Florida. Spencer (1963) stated that *C. verbenae* is not a true neotropical species since it occurs so far north; however, he suggested that the species may be found in the West Indies or Central America. No one knows the southern limit of its distribution at the present date.

I have not yet recorded the species from south Florida.

Phytobia (*Calycomyza*) *ipomaeae* (Frost)

Frost (1931) described the species as *Agromyza ipomaeae*, a leaf miner on sweet potato leaves in Puerto Rico. Frick (1952) placed *Phytobia* (*Calycomyza*) *ipomaeae* (Frost) in its present generic position. Frick (1957) emended the name *ipomaeae*, the specific name assigned by Frost in his original description, to *ipomoeae*; Spencer (1963) stated that Frick's reason for the emendation was to bring the specific name of the fly in line with the current botanical spelling of the host plant, "*Ipomoea*". Spencer reported that the specific name assigned by Frost was correct as the original spelling used by Linnaeus was *Ipomaea* and he did not accept Frick's emendation. Spencer also reported the distribution of *P. ipomaeae* as Jamaica, Puerto Rico, Dominican Republica, and Brazil.

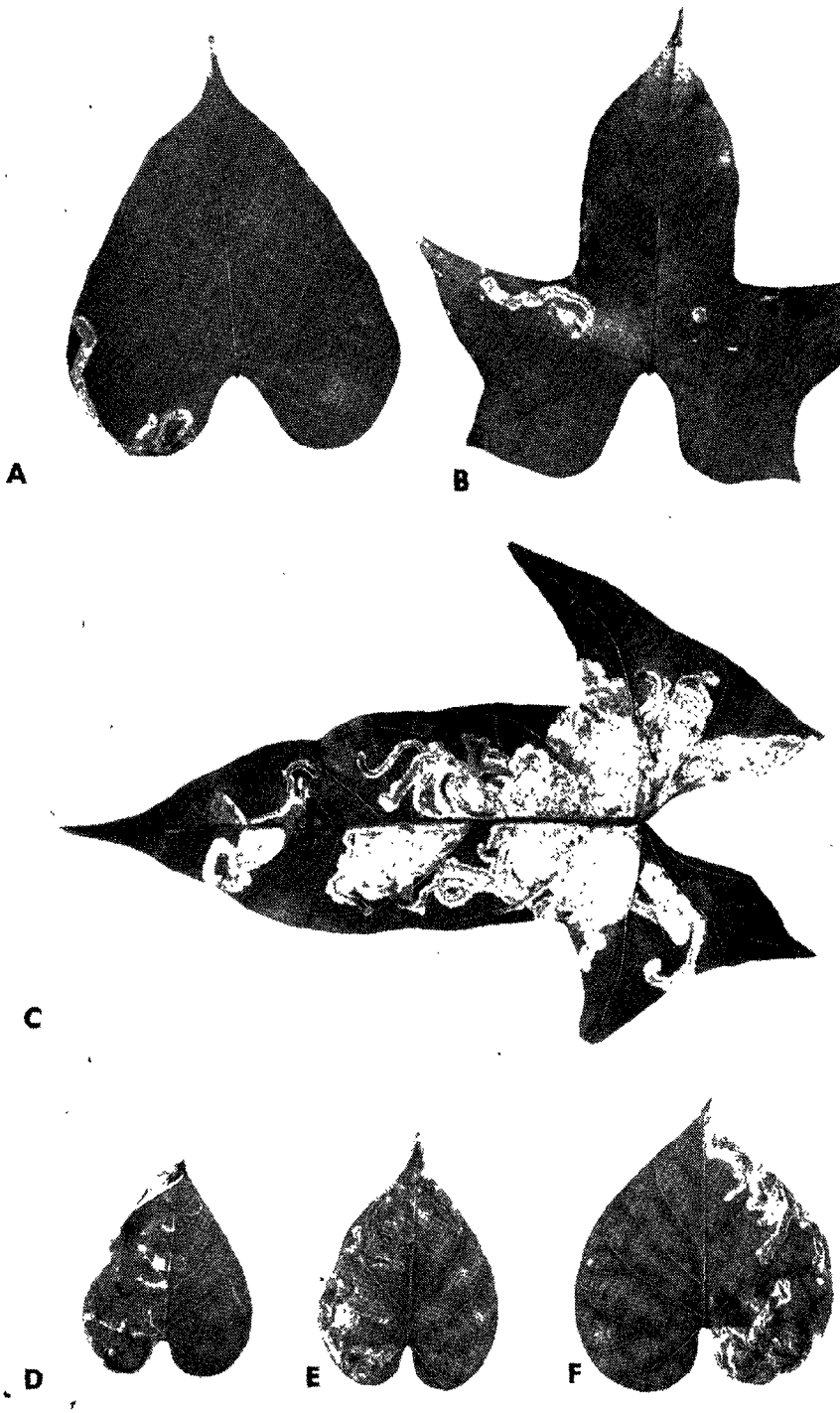
REARING RECORDS:

Calonyction aculeatum (L.) House: Hialeah, 29 Aug. 1962 (C.E.S.); Clewiston, just south of route No. 27, 21 Jan. 1966 (D. H. Habeck). Infestations on this host plant are severe from November through March in south Florida.

Ipomoea batatas Poir.: Hialeah, 18 Sep. 1963 (first emergence of adults, 26 Sep. 1963) (C.E.S.). Extremely severe infestations on sweet potatoes were noted by the author during December 1966 in Hialeah, Florida.

Fig. 3 (A, B, and C). Mines of *Calycomyza ipomaeae* on leaves of a moonflower, *Calonyction aculeatum.*

Fig. 3 (D, E, and F). Mines of *Calycomyza ipomaeae* on leaves of a morning glory, *Ipomoea tiliacea.*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Ipomoea sp. (unidentified morning glory): Miami, 12 June 1963 (first emergence of adults, 28 June 1963) (C.E.S.).

Ipomoea tiliacea (Willd.) Choisy: Hialeah, 8 June 1963 (first emergence of adults, 19 June 1963) (C.E.S.); Hialeah, 4 July 1966 (leaf mines only) (C.E.S.). The July 1966 infestation was noted to be a severe infestation on the leaves of the morning glory.

LEAF MINE VARIATIONS OF *Calycomyza ipomaeae* IN SOUTH FLORIDA

Ecological studies on the leaf mine forms of *C. ipomaeae* were observed by the author on the cited host plants. First, Spencer's (1963) notations on the leaf mine forms should be discussed. He found mines on *Ipomoea* sp. leaves in Jamaica to be as follows: "There is initially a very narrow, rather long linear mine and finally a large primary blotch with fine, scattered frass. Mines on *Ipomoea* sp. at Santos, Brazil, 18 viii. 1957 (K.A.S.), closely resemble those from Jamaica. However, the initial mine is not so narrow and later gradually widens to form a secondary blotch, but it remains essentially linear; frass is in a diffused greenish line. . . . ".

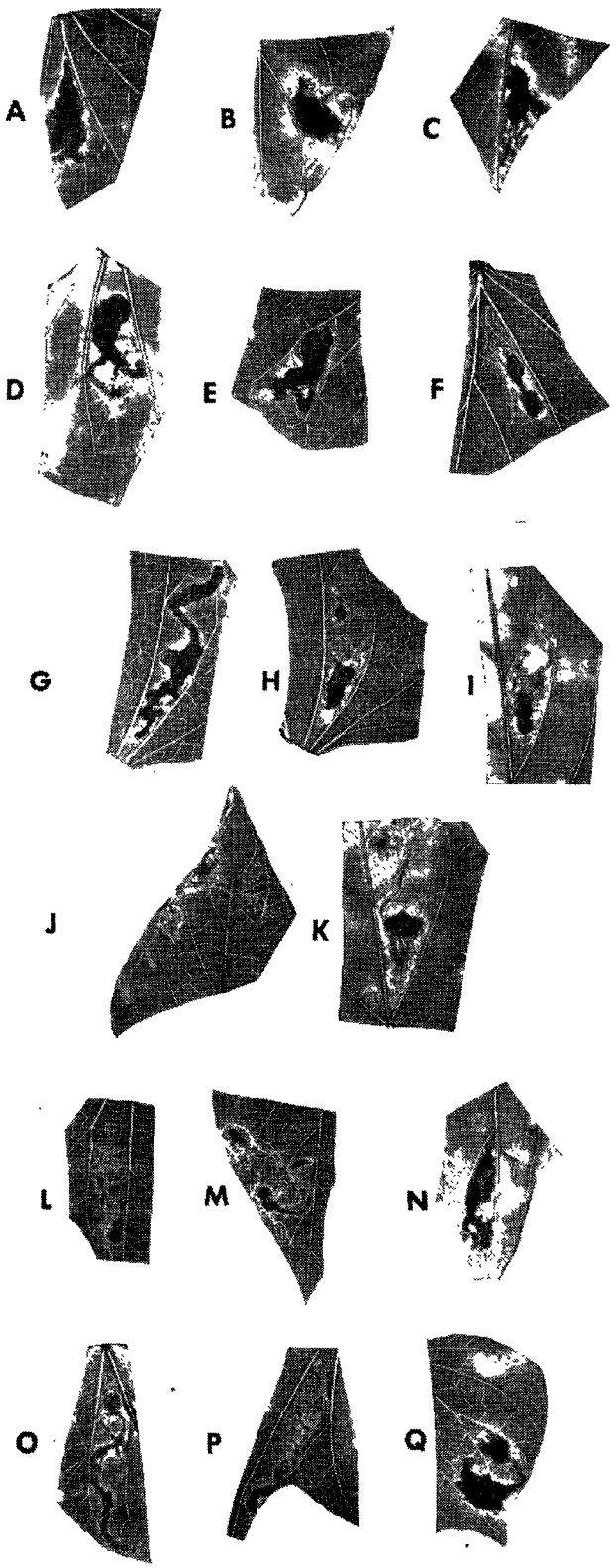
Fig. 3 (A, B, and C) illustrates leaf mines of *ipomaeae* on leaves of moonflower, *Calonyction aculeatum* (L.) House; the mines in Fig. 3A and 3B on the moon flower leaves are essentially linear in form. The moonflower leaf with multiple blotch mines, Fig. 3 C, illustrates many digitate processes or short linear mines radiating from many blotch mines of *C. ipomaeae*. The larvae do not cross the midrib of the leaf as shown in Fig. 3 C. Fig. 3 (D, E, and F) shows three leaves of a morning glory, *Ipomoea tiliacea* (Willd.) Choisy, and each leaf contains a blotch mine of *C. ipomaeae*. (Fig. 3 E and F contain two mines in each leaf). The digitate processes also radiate from the large blotch mines on the morning glory leaves, and the mines are formed along the outer edges of the leaves. The digitate processes are directed inward between the lateral leaf veins.

Fig. 4 illustrates numerous variations in leaf mines on *Ipomoea batatas*, sweet potato, produced by the larvae of *C. ipomaeae*. Fig. 4 (A, B, C, D, E, and F) illustrates the typical mine form of *ipomaeae*, while Fig. 4 (G, N, and O) depicts the leaf miner forming linear-blotch type mines. Fig. 4 (F, H, K, M, and Q) illustrates a single mine of *ipomaeae* as a double blotch. Fig. 4 (J) is essentially a linear mine with short digitate processes. Fig. 4 (L, M, and P) shows *ipomaeae* mines as a serpentine-blotch form. The illustrations definitely show that mine variations exist within the same host plant species.

REASONS FOR THE VARIATIONS OF THE AGROMYZID LEAF MINE FORMS.

Hering (1951) discussed the leaf mine habits of several orders of leaf-mining insects and their biology in Europe. He stated that a leaf miner avoids certain plant tissue, such as the midrib and strong lateral veins in the leaves of some plants, as they contain a tough, cellulose material. This fact, combined with the rather weak mouthparts of the larvae, may be a partial explanation as to why the midribs are not consumed.

Fig. 4A through 4Q. Leaf mine variations of *Calycomyza ipomaeae* on sweet potato leaves, *Ipomoea batatas*. The various types of leaf-mine forms are discussed in the text.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Hering speculated that an endophagous habitat of the leaf miners represents a specialization in the type of food consumed by the immature stages. The larval ability to digest cellulose in certain leaf miners is lacking. He stated that many leaf miners avoid the vascular bundles in the leaves as they contain cells of a woody nature and lack much needed food value. Hering stated, " . . . most species of leaf miners have a tendency to avoid leaf veins when constructing their mine. In many cases this results in the characteristic shape of the mine channel, which avoids crossing leaf veins where they are strongly developed and, instead, runs along beside them; only when the vascular bundle has branched many times and is consequently not so strong, is it crossed."

The tough fibers composing the midrib and strong lateral veins in the sweet potato leaves thus confine the larvae in their feeding areas to spaces between the stronger leaf veins which produce the many types of leaf mine forms illustrated in Fig. 4.

Parasites of the *Calycomyza* Species

Musebeck, Krombein, and Townes (1951) reported *Diaulinopsis callichroma* Cwfd., from the following insect hosts: *Agromyza scutellata* Fallen (present generic position is *Chlorops scutellata* Panzer, Chloropidae, Diptera), *Calycomyza artemisiae* (Kalt.), *Cerodontha dorsalis* Loew, and *Liriomyza pusilla* Meig., a synonym of *Liriomyza munda* Frick. Distributions of *D. callichroma* were cited by Musebeck and others (1951) as: Indiana, Florida, Mississippi, and Arizona. I have reared *D. callichroma* from *Calycomyza malvae* and from *Calycomyza ipomaeae* in south Florida.

Closterocerus cinctipennis Ashm. has been recorded by Muesebeck, Krombein, and Townes (1951) from the following insect hosts: *Brachys-aerosus* Melsh., *B. obovatus* Web., *Cameraria hamadryadella* (Clem.), *C. umella* (Chamb.), *Bucculatrix canadensisella* Chamb., *Nepticula gossypii* F. and L., *Caliroa cerasi* (L.), *Neodiprion rugifrons* Midd., and *N. swainei* Midd. *C. cinctipennis* is reported from Canada, Connecticut, New Jersey, Washington, D. C., Florida, and Iowa. Harding (1965) reported *cinctipennis* from Texas as a major parasite of *Liriomyza munda.* I have also reared the species from *Calycomyza ipomaeae* and from *C. malvae* in south Florida.

Chrysocharis spp. have been recorded as parasites of Lepidoptera and Diptera by Muesebeck, Krombein, and Townes (1951). Most of their rearing records were from leaf miners of both orders. I have reared *Chrysocharis* species parasitizing a new species of *Ophiomyia* (a seed-feeding agromyzid on *Lippia nodiflora* Michx). *Chrysocharis* species (possibly undescribed) has been reared from the following agromyzids: *L. munda, L. trifolii* (Burgess), *L. brassicae* (Riley), *L. sorosis* (Williston), *Phytobia (Amauromyza) maculosa* (Malloch), *Calycomyza malvae,* and *Calycomyza ipomaeae.* All rearings of the cited *Chrysocharis* spp. were from agromyzid host insects collected for rearing purposes in south Florida.

Derostenus spp. has been reared by the author from *L. trifolii, L. munda, Phytobia (Amauromyza) maculosa, Calycomyza jucunda,* and *Calycomyza ambrosiae.* These records concern the south Florida agromyzids; however, other species of *Derostenus* might well be expected to occur in

the central and northern limits of Florida as parasites of dipterous and lepidopterous leaf miners.

One *Zagrammosoma* species has been reared by the author in south Florida as a hymenopterous parasite of the sweet potato leafminer, *Calycomyza ipomaeae*. This eulophid parasite is possibly new and has been recorded from Hialeah, Florida.

ACKNOWLEDGMENTS

The author is indebted to the following persons for their help and contributions: Kenneth A. Spencer of London, England, for his suggestions, and determinations of the cited leaf miners; the late Professor Erdman West, Mycologist and Botanist, University of Florida, and Dr. Kenneth R. Langdon, Nematologist and Botanist, Division of Plant Industry, Florida Department of Agriculture, for their numerous determinations of host plant material; Harold A. Denmark, Chief, Entomology Section, Division of Plant Industry and Dr. Howard V. Weems, Jr., Curator, Florida State Collection of Arthropods, D.P.I., Florida Department of Agriculture, for their joint efforts in furthering the knowledge of the Agromyzidae in Florida. The author is especially indebted to Dr. Dale H. Habeck, Entomologist, Department of Entomology, University of Florida, for his numerous agromyzid collections and suggestions concerning this project; George W. Desin, Plant Pest Control Division, ARS, USDA; Dr. B. D. Burks and C. F. W. Muesebeck, Entomology Research Division, ARS, USDA, for their determinations of hymenopterous parasites; and to the following for their critical comments on the manuscript: George C. Steyskal, Entomology Research Division, ARS, USDA, Harold A. Denmark, Chief, Entomology Section, D.P.I., F.D.A., and Dr. James Nation, Associate Editor, Zoology Department, University of Florida.

All photographs are courtesy of the Division of Plant Industry, Florida Department of Agriculture, Mildred Eaddy, photographer.

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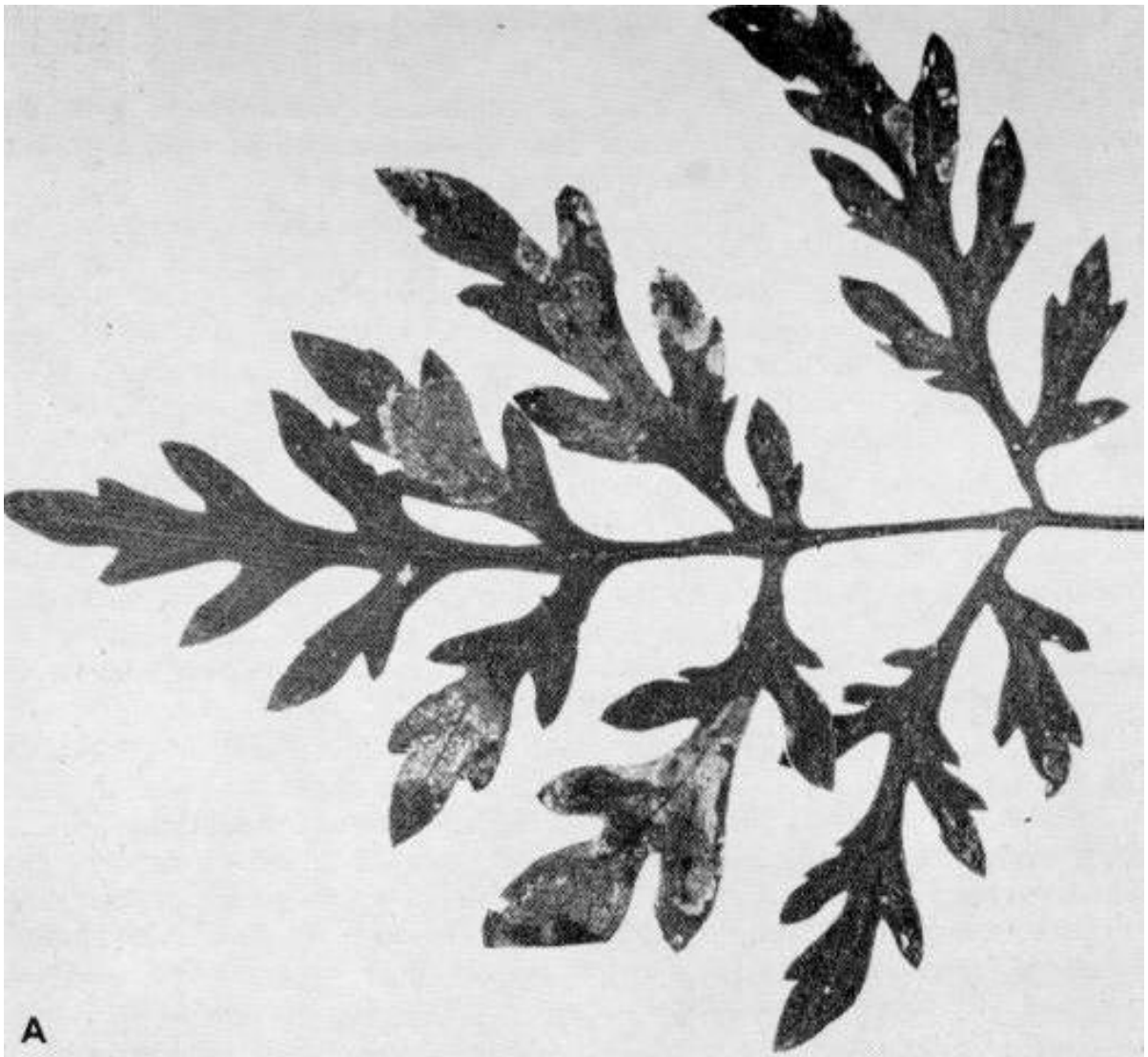

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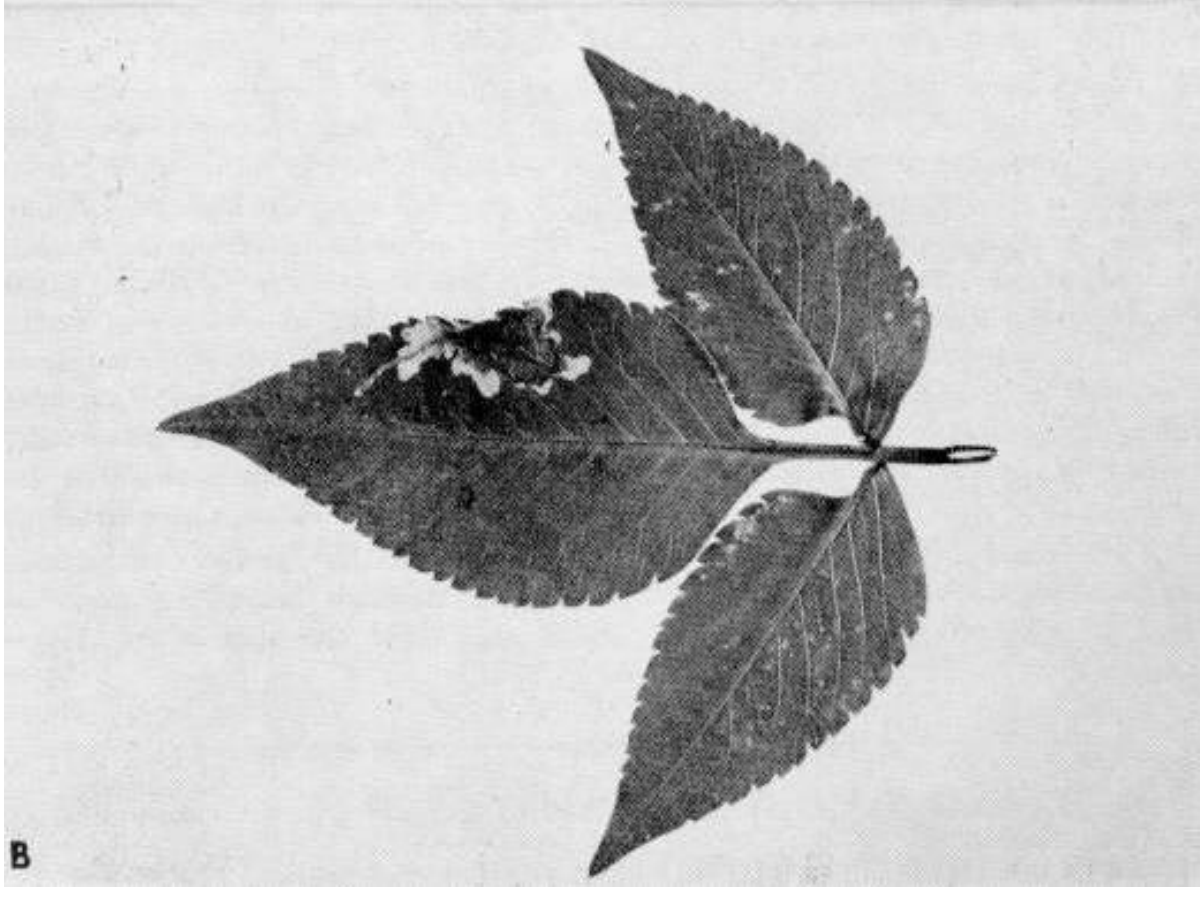

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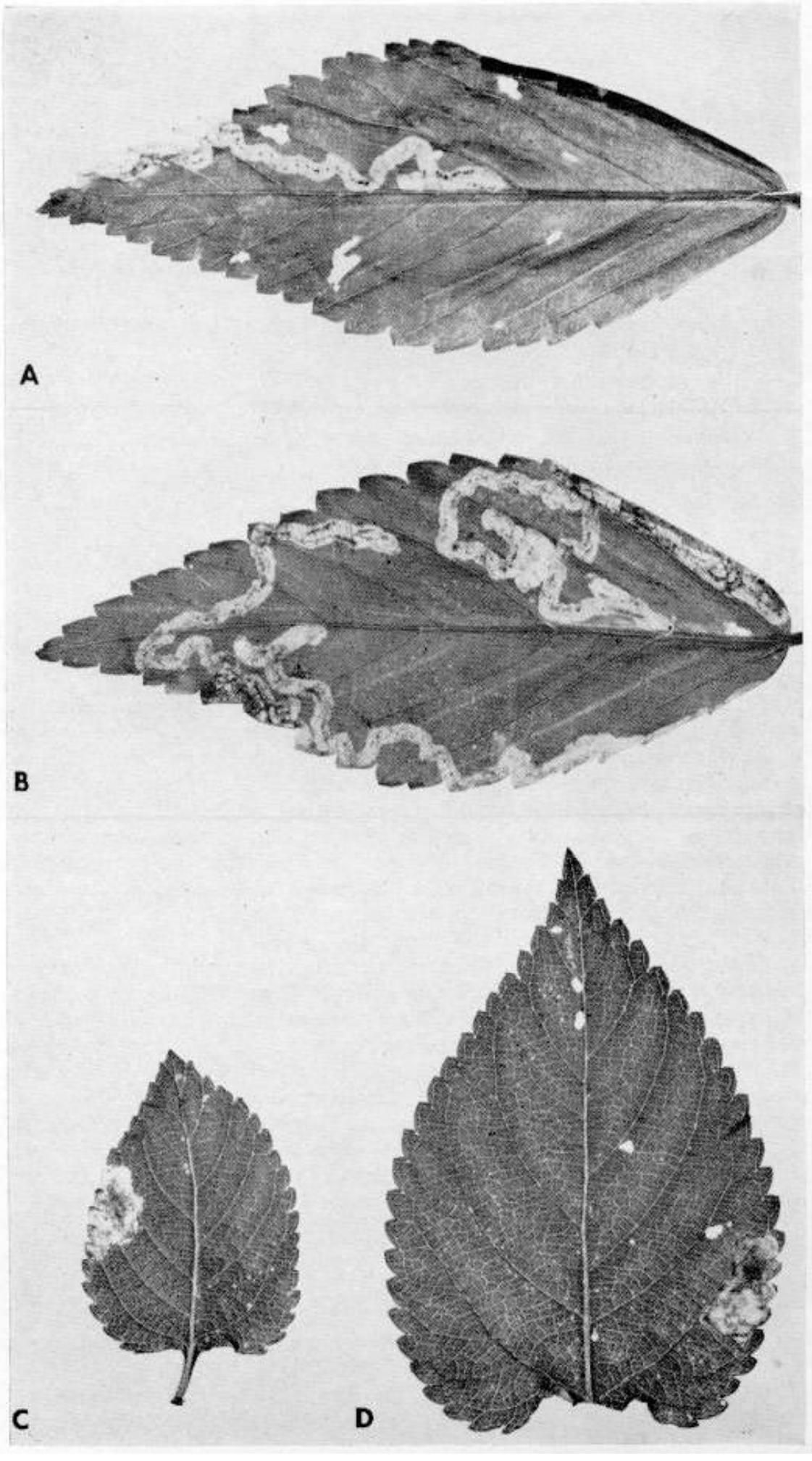
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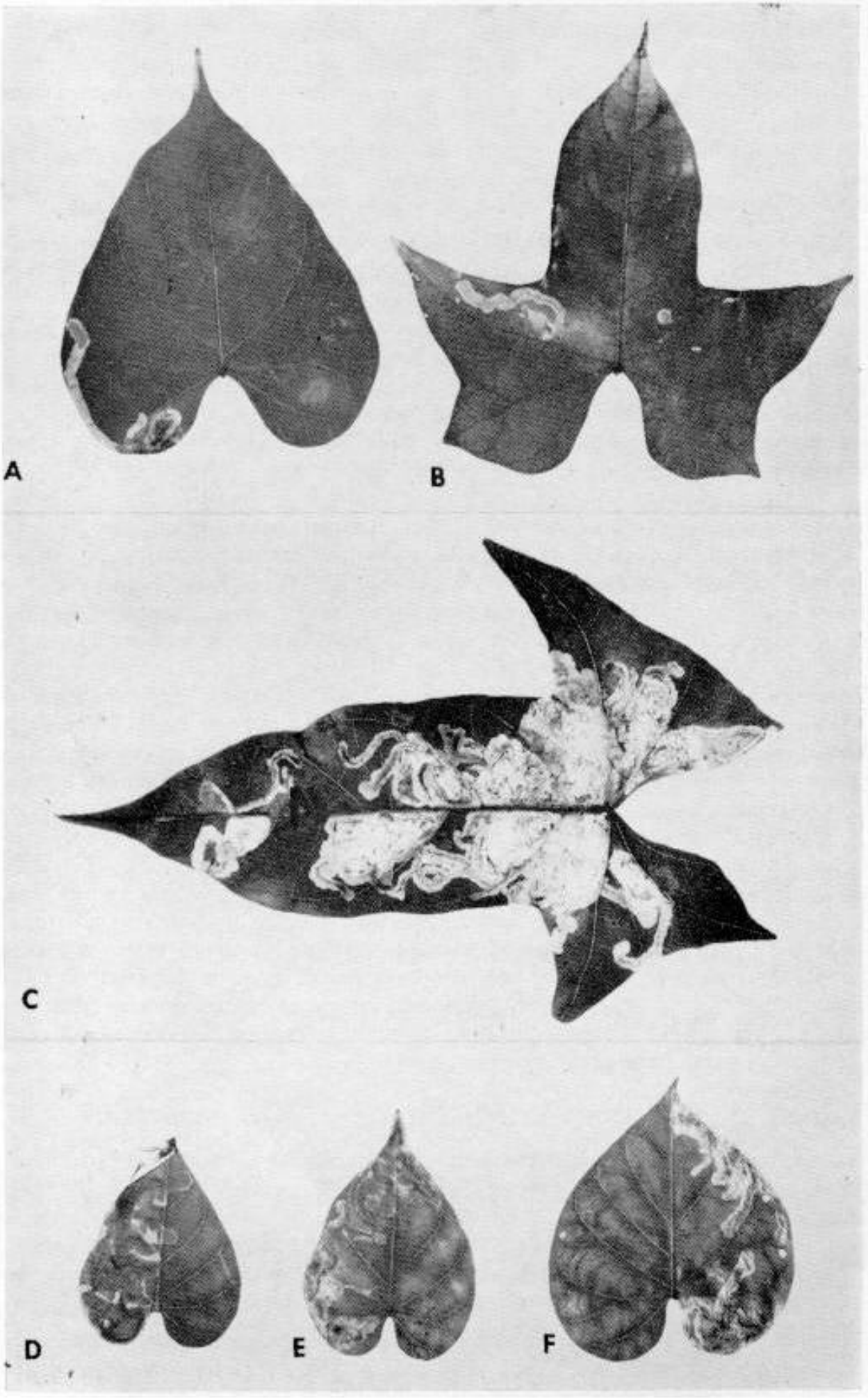
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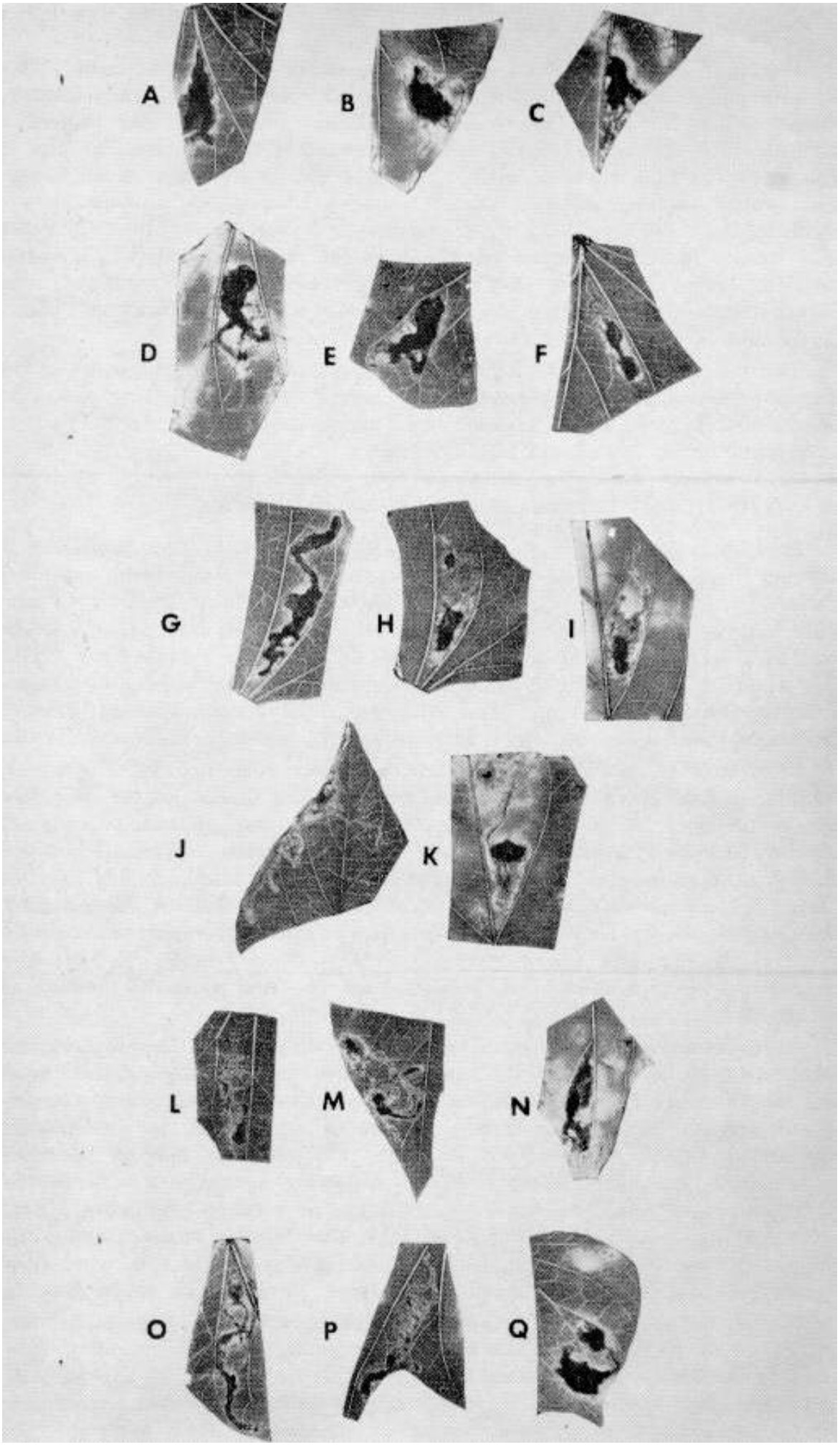
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