

ing the temperature increases the duration of the photoperiod-sensitive developmental stage. Whether the temperature influence is a result of direct embryonic temperature perception or to the increased number of photoperiod signals received during the sensitive stage remains unresolved.

At low levels of diapause incidence, a laboratory sample of diapause pupae is predominantly male whereas at 0 and 100% diapause, males represent 50% of the sample (Denlinger 1972). Results of August and September field experiments permit comparisons with laboratory results. The small diapause segment of the August pupae (20%) was 79% male. By contrast, males represented 45% of the September pupae (99% diapause). The sexual threshold difference for diapause induction remains uninvestigated.

Larvae which have completed feeding burrow into sawdust or sand provided for them in the laboratory. Depths to which diapause-committed larvae burrow into the soil under outside conditions is unknown, but temperatures to which they are subjected may be approximated by the soil temperature at the 4-in. level. The duration of diapause is dependent on temperature; at a constant temperature of 17°C, the Illinois strain of *S. bullata* remains in pupal diapause 174 days; at 25°C, 133 days; exposure to combinations of 17 and 25°C can result in diapause termination after 95 days (Denlinger 1972). Under outside conditions, pupae entering diapause in September are ready to initiate development immediately upon the advent of higher temperatures by as early as Jan. 1. However, the cold temperatures of the ensuing winter months prevent the progression of adult development. The 1st signs of adult development were observed in early April; the remainder of the period of adult differentiation (a period which

requires 10 days at 25°C) progressed slowly April until the flies emerged in mid-May. The median day of adult emergence was the same for pupae entering diapause in August and September. Although the date for completion of "diapause development" (Andrewartha 1952) may vary depending upon the date of diapause induction, suppression of adult differentiation by the cold temperatures of January, February, and March provides a synchronization mechanism for uniform development among pupae of various ages when the developmental temperature threshold is reached early April.

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A Chalcidoid Planidium and an Entomophilic Nematode Associated with the Western Flower Thrips^{1,2}

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ABSTRACT

Chalcidoid planidia are reported as ectoparasitic on larvae of *Frankliniella occidentalis* (Pergande) from western Texas. The only previous record of a planidium on thrips was from Malaya. Many adult females were parasitized by all stages of an internal entomo-

philic nematode, *Howardula aptini* (Sharga). This is a new record of *H. aptini* for continental United States. Dark-hued male thrips are reported from Mexico, indicating that either a new melanistic phase or possibly a new taxon may be involved.

The western flower thrips, *Frankliniella occi-*

dentalis (Pergande), is an ubiquitous pest of fruits and flowers. It was recorded by Bryan and Smith (1956) as the most widespread thrips in California, with one or more individuals present on almost every flower sampled. The study was based on collections from 139 plant species in 45 families, with Leguminosae, Compositae, and Cruciferae being the

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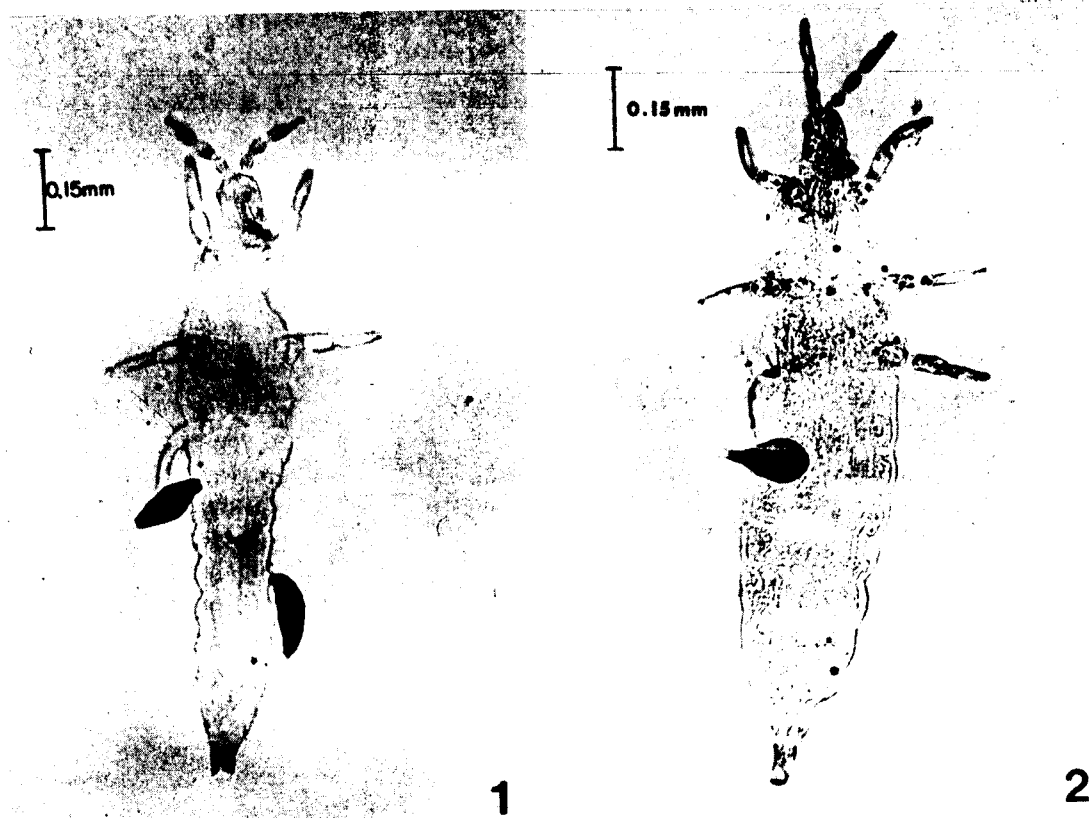


FIG. 1.—Chalcidoid planidia attached to a 2nd-stage larva of *F. occidentalis*.
 FIG. 2.—Chalcidoid planidium embedded in a 2nd-stage larva of *F. occidentalis*.

ferred hosts. This thrips has been reported from Alaska to Mexico and east to the Great Plains with an accidental collection from Connecticut. Females of the *F. occidentalis* complex are pale, intermediate, and of dark hue, and their relative abundance differs according to the season. The dark phase predominates during spring in California; the pale phase is most common during the rest of the year. The intermediate phase maintains a fairly constant proportion throughout the year. Only pale males were reported by Bryan and Smith (1956) from field collections, crosses with 3 color phases of females, and parthenogenetic rearings. Dark males of *F. occidentalis* from Mexico, deposited in the U. S. National Museum of Natural History, possibly represent a new melanistic phase or a new taxon. In addition, most of the specimens from Alaska and Texas were of the pale phase, and those from Mexico were of the dark phase. Stannard (1968) cited *F. occidentalis* as the biological equivalent of the flower thrips, *F. tritici* (Fitch). Their ranges overlap along the 100th Meridian.

A chalcidoid wasp planidium and an entomophilic nematode, *Howardula aptini* (Sharga 1932), were discovered during study of the western flower thrips. The collection represented a single population of the pale phase of *F. occidentalis* and contained males,

females, and larvae. The thrips were collected during October 1970 by heating broomweed flowers, *Nanthocephalum microcephalum* (DC.), at the base of the Franklin Mountains, El Paso, Tex. This plant blooms in Texas from June to October and is a common flowering plant in the El Paso area.

There is no apparent relationship between the wasp planidium and the nematode found in *F. occidentalis*, and each parasite is discussed separately.

PLANIDIUM

Smith (1912) introduced the term "planidium" for the free-living 1st stage larva of the perilampid *Perilampus hyalinus* Say, which is a hyperparasite of the gypsy moth, *Porthetria dispar* (L.). Clausen (1940) extended the application of the term planidium to parasitic and predaceous 1st instars of several insect orders and described the recurrence of the planidium type as a striking illustration of convergent evolution. Taxonomic categories possessing a planidium larva are: Perilampidae, Eucharitidae, and Ichneumonidae in the Hymenoptera; Cyrtidae, Tachinidae, and Sarcophagidae in the Diptera. Kirkpatrick (1957) reported an epipyropid moth, *Fulgora raeccia cerolestes*, from East Africa, in which the 1st-stage larva was a planidium parasitic on a large fulgorid of the genus *Mctaphacna*.

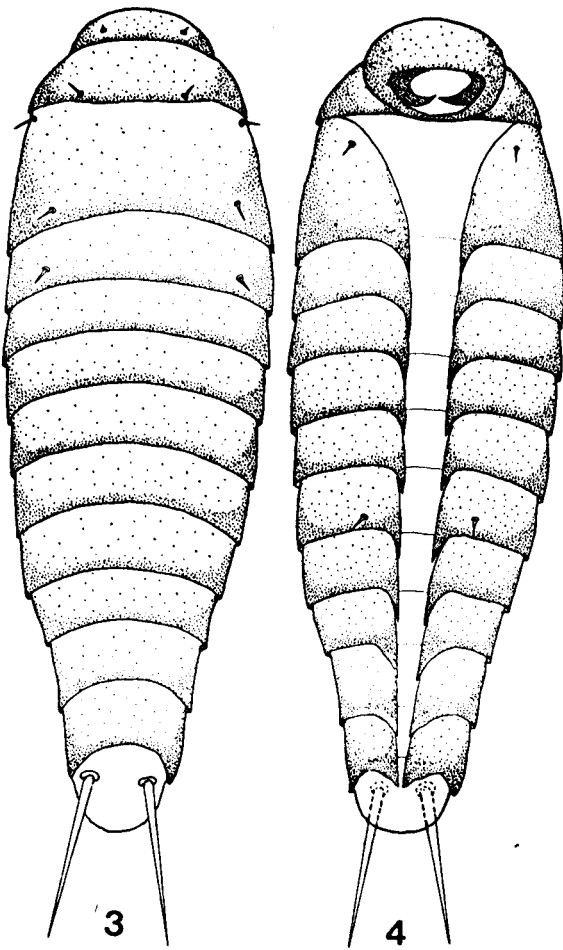


FIG. 3.—Dorsal aspect of the chalcidoid planidium found on *F. occidentalis*.

FIG. 4.—Ventral aspect of the chalcidoid planidium found on *F. occidentalis*.

Three families of Coleoptera (Meloidae, Rhipiphoridae, and Stylopidae) have planidia, but these larvae are conventionally referred to as triungulins. This term is based on the generic name *Triungulinus* which Dufour (1828) designated for a species named for a 1st-stage larva of *Meloe*.

The planidium associated with the western flower thrips was identified as chalcidoid but could not be placed in a more precise taxon, since only the planidium was collected. The planidium resembles those illustrated for the Eucharitidae by Kirkpatrick (1957: 183). All eucharitid species in which the biology is known are parasitic on larval ants. The planidia hatch from eggs laid in plant tissue and attach to passing forager ants. The ants phoretically transport the planidia to the nest, where the planidia drop off and attach to larval ants.

The planidia on *F. occidentalis* were found attached by their mandibles to the abdominal integu-

ment of the minute 1st-stage thrips larvae but were embedded in the abdomen and those of the larger 2nd-stage larvae (Fig. 2). No planidia were observed on the adult thrips. Larvae of *F. occidentalis* totaling 72 were examined, and 10 planidia were found attached to or embedded in the abdomen of 1st-stage larvae. A single 1st-stage larva had 3 planidia attached to its abdominal integument and 3 second-stage larvae had 2 planidia embedded in the abdomen. Most planidia were positioned on the intermediate abdominal segments. The planidia are entirely blackish brown. The average length of planidia (excluding the anal spines) is 143μ (range 127–186) and the average width is 52μ (range 46–62). The anal spines have an average length of 28μ (range 24–31). The body is composed of 10 segments, and each segment has a heavily sclerotized plate extending over the dorsum and lateroventral areas, terminating ventrally in wedgelike projections (Fig. 3, 4). The planidia collected were newly hatched, and the segmental plates overlapped to give a telescopic effect. There are 2 pairs of small setae on the dorsal surface of the head and a pair of posterolateral spinelike setae on tergites II–IV. The abdomen terminates in a suckerlike organ used in the looping motions by which the planidia move. The body setae are small except for the pair of anal spines on the terminal abdominal segment. The planidium supposedly fastens the caudal sucker to the leaf surface and props itself up in an erect position against the anal spines. This position has been referred to as the "waiting attitude" and is assumed by the planidium until a host passes within reach. The planidium then springs forward and attaches to the host by a pair of sharply-pointed mandibles to the integument of the host (Clausen 1928: 83). As illustrated by Tripp (1962: 1256) the planidia expand tremendously with extensive feeding.

The planidia attached to *F. occidentalis* appear very similar to the illustrations presented of a *Perilampus* planidium found parasitizing the small green grasshopper *Conocephalus fasciatus* DeGeer in Ontario (Ford 1922: 201). The planidia on *F. occidentalis* larvae never completely penetrated into the body cavity. All the planidia that were embedded in the thrips were partially enclosed by a thick bell-shaped capsule produced by the thrips (Fig. 5, 6). A food channel was observed at the base of the capsule through which the planidia fed. Hinks (1971) reported the encapsulation of planidia of *P. hyalinus* Say found in the haemocoel of the red-headed pine sawfly, *Neodiprion lecontei* (Fitch). Most of the *P. hyalinus* planidia avoided encapsulation by embedding in the brain and ganglia of the ventral nerve cord of the sawfly.

Dr. B. D. Burks (communicated by Dr. Reece I. Sailer) reported that he had seen similar planidia on other species of the thrips genus *Frankliniella* from Alpine, Calif., in 1966, and from Portland, Ariz., in 1964. The only previously published account of planidia in thrips was concerned with a eucharitid species of *Psilogaster* from Malaya in

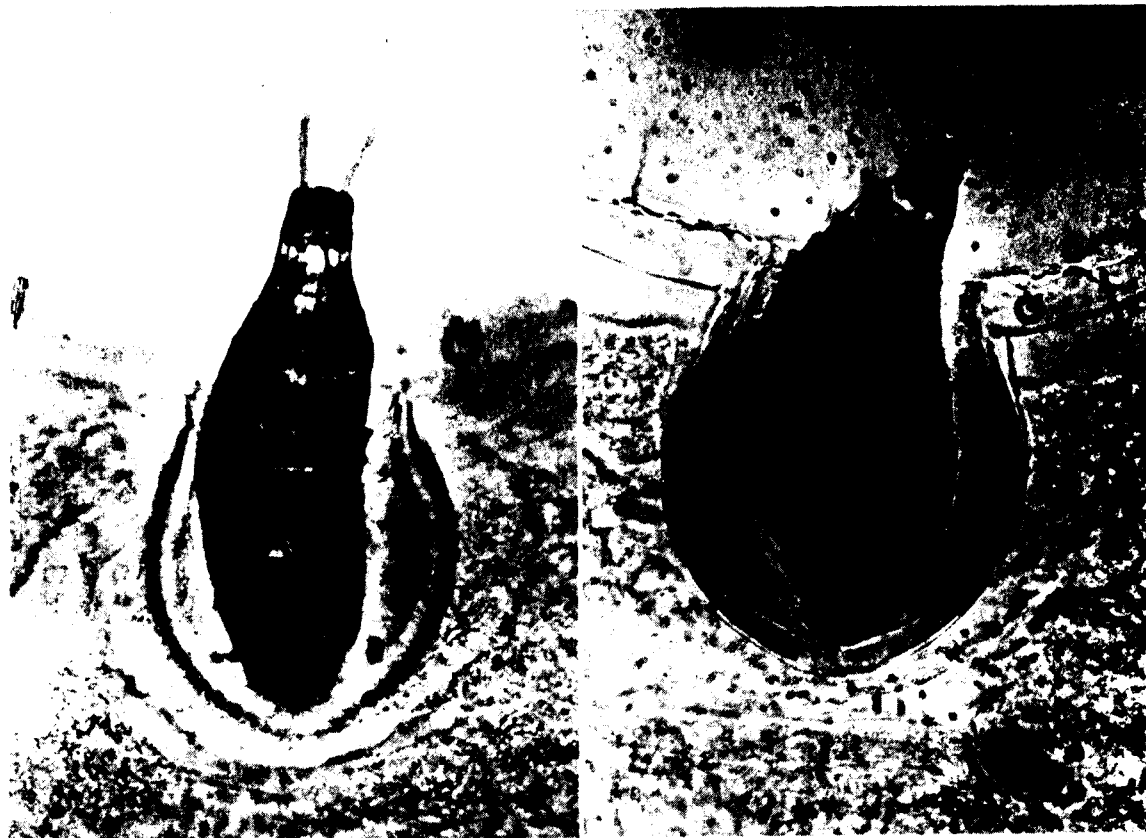


FIG. 5.—Capsule partially surrounding the planidium embedded in a 2nd-stage larva of *F. occidentalis*.

FIG. 6.—Planidium embedded in abdomen of 2nd-stage larva of *F. occidentalis*; partially encapsulated by the thrips.

the planidia attached to *Scenothrips rubrolineax* (Giard) (Clausen 1940: 223-6). The *Psilothrips* female deposited stalked eggs in a cluster surrounding a single thrips egg embedded in a mango leaf. It is not known whether *F. occidentalis* is a true or an accidental host of this chalcidoid wasp.

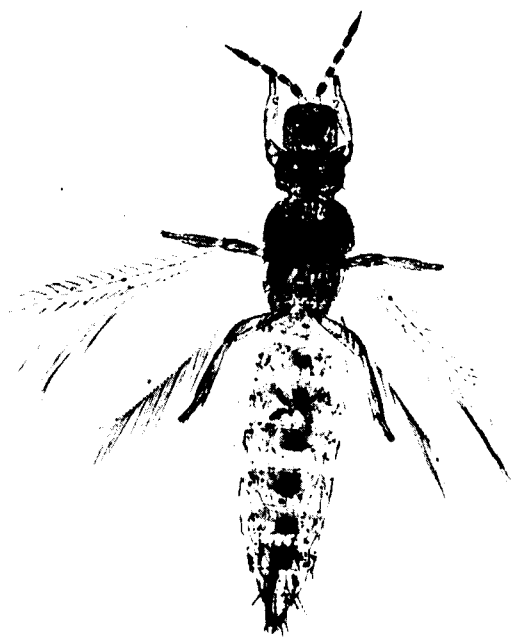
NEMATODE

The 1st North American record of the entomophilic nematode *H. aptini* was reported by Nickle and Wood (1964) from parasitized blueberry thrips, *Frankliniella vaccinii* Morgan, in New Brunswick. These authors redescribed and illustrated the different stages of this nematode. Five different genera of thrips are known hosts of the nematode genus *Howardula*. Nickle and Wood (1964: 846) stated that the sulphuretylenchoid stylet that usually occurs in the more pathenogenic allantonematids and the shepherd's crook gubernaculum are diagnostic for Canadian forms. Lysaght (1937) presented an ecological study of *H. aptini* which included a detailed account of its biology.

Nickle (personal communication) stated that "we do not know much about the biology of this parasite [*H. aptini*]. I would think that larval thrips are

attacked by the fertilized infective stage female nematode. [the female] swells up in the abdomen of the immature thrips and when the insect [thrips] becomes adult the large adult parasitic female nematode lays eggs in the haemolymph. These eggs hatch rapidly and undergo successive nematode larval stages resulting in the numerous nematodes as [found] in the body cavity of the insect specimens examined" (Fig. 7, 8).

The collection of *H. aptini* from El Paso, Tex., is the 1st record of this nematode parasite from the United States. Of the 39 adult thrips collected (20 ♂, 19 ♀) only 5 ♀ were parasitized by nematodes. None of the 72 larval thrips was parasitized by nematodes. The average number of all life stages of nematodes in each adult female thrips was 44. The average body length of the nematode (including all stages except egg) was 229 μ (range 204-246). The nematodes were generally restricted to the abdominal cavity of the thrips, but a few were observed in the thoracic cavity. Nickle and Wood (1964) stated that parasitized thrips probably do not produce eggs, as the ovarial tissue is greatly reduced by the nematode. No eggs were present in the parasitized thrips' abdomens, while eggs were observed in many of the nonparasitized female thrips.



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FIG. 7.—Adult female of *F. occidentalis* (photograph by Wilmer Zehr, Illinois Natural History Survey).
FIG. 8.—Abdomen of female *F. occidentalis* infested with the nematode *H. aptini*.

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