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BIOLOGY OF *URESIPHITA REVERSALIS* (GUENÉE) AND COMPARISON WITH *U. POLYGONALIS MAORIALIS* (FELDER) (CRAMBIDAE)

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ABSTRACT. The biology of *Uresiphita reversalis* (Guenee) is described, and the unpublished thesis of Mulvay on *Uresiphita polygonalis maorialis* (Felder) is summarized. The biologies of the two species are identical in many regards. Eggs are cream colored and laid in overlapping clusters of up to 80. Larvae undergo five instars; they are brightly colored, gregarious, and aposematic. Pupae are dark brown. Overwintering usually occurs in the pupal stage. Adults are active nocturnally and are superficially similar, with dark brown forewings and light orange hindwings with brown markings along the outer margin. In contrast to larvae, adults of both species are suspected to be palatable to predators on the basis of their color, nocturnal activity, and absence of sequestered quinolizidine alkaloids in adults of *U. reversalis*. Both species are multivoltine. Larvae of *U. reversalis* are diurnally active but feed throughout the night under warm temperatures.

Additional key words: Pyralidae, Pyraustinae, circadian activity, geographic distribution, *Genista*.

The genus *Uresiphita* Hübner is a small group in the family Crambidae (subfamily Pyraustinae), according to Munroe's (1989) revised classification of the Pyraloidea. The biology of only one species, *Uresiphita polygonalis maorialis* (Felder), has been studied in detail, and the results of those studies are presented in the unpublished Master's thesis of Mulvay (1978). *Uresiphita polygonalis maorialis*, the kowhai moth, is indigenous to New Zealand and is a pest of introduced lupines (e.g., *Lupinus arboreus* Sims; Fabaceae) (Ferro 1976). Mulvay (1978) studied the biology of this species in the context of identifying methods to inhibit damage to lupines. Mulvay (1978) concluded that *U. p. maorialis* undergoes two or three generations per year on the North Island of New Zealand, and overwinters in the pupal stage. Laboratory studies on the circadian activity of individually isolated males and females revealed that adults were nocturnally active when exposed to alternating light and dark conditions or when subjected to constant darkness. Oviposition was primarily on the lower surfaces of *Sophora* (Fabaceae) leaves but on the upper surfaces of *Lupinus* leaves. Eggs have a lacelike pattern on the chorion and are laid in overlapping clusters of up to 75.

Mulvay (1978) described the larvae of *U. p. maorialis* as cryptically colored and suggested that they probably do not use host plant alkaloids, but presented no evidence to support this conclusion. Larvae are orange or green with conspicuous yellow and white lateral lines, and have black tubercles, white patches, long white hairs, and dorsal white spots; they

feed gregariously. Based on coloration and pattern, larvae of *U. p. maorialis* appear to be aposematic. Mulvay described larvae as cryptically colored probably because they are obscured from view on defoliated stems when they orient themselves along the length of the stem.

The number of instars of *U. p. maorialis* varied with the host plant. Larvae reared on *Sophora microphylla* Ait., *Ulex europaeus* L. (Fabaceae), or *Genista monspessulana* (L.) L. Johnson (Fabaceae) underwent five or six instars. Larvae reared on *Lupinus arboreus* had five instars and smaller head capsules than those reared on *S. microphylla*. Larvae reared on *Sophora howinsular* (W. R. B. Oliver) P. S. Green completed six or seven instars. Pupation occurred on host plant leaves, beneath loose bark, or inside crevices of the stem. Pupation did not occur away from the host plants.

Uresiphita reversalis (Guenée), the genista caterpillar, is the only member of the genus known to occur in North America (Munroe 1976). Comstock and Dammers (1933) provide the earliest and most extensive descriptions of the egg, larvae, and pupae. Other descriptions of the early stages are provided by McKenzie (1933) and Bernays and Montllor (1989). The present paper reports the results of studies on the geographic distribution, life history, and circadian activity of *U. reversalis*. Data were gathered primarily in the laboratory on populations originating from northern California. When possible, field data were gathered on populations in the San Francisco Bay region of California, and these are noted in the text.

DISTRIBUTION

Distribution information on *U. reversalis* was obtained through a review of the literature and museum collections (see Leen 1992 for specific sources). *Uresiphita reversalis* is a North American species with a latitudinal distribution from Nova Scotia, Canada, into parts of Mexico. Specimens have been collected from nearly all states in the U.S. except those surrounding and directly west of the Great Lakes. Colorado, Nebraska, Iowa, and Illinois represent the northern limits of distribution in the midwestern U.S. The western range extends to Arizona and California, including the California Channel Islands. I found no records of *U. reversalis* from Nevada or Utah although apparently acceptable host plants are present there.

The current distribution of *U. reversalis* in central and northern California is attributed to a range expansion that occurred in the early 1980s (Powell 1992). According to the California Department of Agriculture identification records, the distribution of *U. reversalis* extended northward during the 1980s. In 1980 and 1982, it was collected in the northern interior county of Shasta. In 1990, the moth was collected

at Fort Bragg in Mendocino County, the northernmost site recorded on the California coast. Freezing temperatures during December 1990 markedly decreased field populations throughout northern California, although *U. reversalis* was collected again in Mendocino County (Ukiah) in October 1991. The eastern limit of its distribution in California lies near the state boundary. Specimens have been collected from the foothills of Placer and San Bernardino counties.

LIFE HISTORY

The developmental rates of *U. reversalis* from egg through adult were observed in the laboratory at 20°C and 16L:8D. Adult longevity and egg productivity were studied under the same conditions.

Eggs

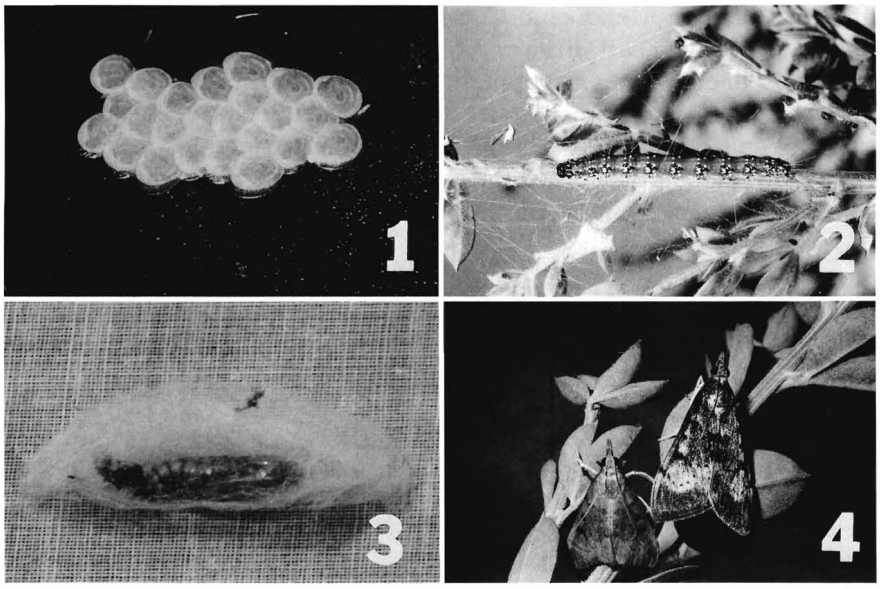
Observations of oviposition patterns and egg numbers were made in both the laboratory and the field. Eggs are shiny and yellow, and laid in clusters in an overlapping pattern resembling fish scales (Fig. 1). Cluster size ranged from 1 to 88 ($\bar{x}$ = 19; n = 91) in the laboratory. Clusters observed in the field ranged from 3 to 65 ($\bar{x}$ = 39; n = 35).

Egg clusters are laid on both the lower and upper surface of leaves. On *Genista monspessulana,* 63% (50/79) of clusters observed in the laboratory and 68% (17/25) of clusters observed in the field were on the upper leaf surface. Additional field observations on other host plants also show surface placement is variable. Clusters were observed on the upper surface of *L. arboreus* 67% (4/6) of the time and on the upper surface of *Baptista leucantha* Torr. and Gray 25% (1/4) of the time. None of the laboratory or field values differ significantly from 50% (z-test, $p > 0.05$). Field data were gathered from potted plants maintained in Albany, California.

Larvae

Egg incubation averaged five days (n = 50). Newly emerged larvae occasionally cannibalized larvae that were slower to emerge. The chorion often was eaten after emergence, suggesting that cannibalism is probably an indirect consequence of this feeding. The time required for development from larval (Fig. 2) to pupal stage when fed *G. monspessulana* was 28 days (based on 217 larvae from 29 separate clusters of eggs).

Head capsule widths were measured for 205 larvae reared on *G. monspessulana* in the laboratory. Larvae go through five instars with head capsule widths ranging from 0.18 to 0.36 mm for the first instar; 0.45 to 0.72 mm for the second; 0.81 to 1.17 mm for the third; 1.26 to 1.89 mm for the fourth; and 1.98 to 2.34 mm for the fifth.



FIGS. 1–4. Life stages of *Uresiphita reversalis*. **1**, Eggs (approximately 1 mm in length); **2**, Larva; **3**, Pupa; **4**, Adult *U. reversalis* (left) (forewing length 17 mm); adult *U. polygonalis* (right) from Masca, Tenerife, Canary Islands, Spain.

Larvae fed on the foliage and flowers of the host and ate bark and other soft stem tissues when foliage was not available. First instars initially fed on the leaf surface (upper or under) upon which the eggs were oviposited rather than exclusively on the upper surface, as implied by Bernays and Montllor (1989). Coloration has been described accurately by several authors (Comstock & Dammers 1933, Bernays & Montllor 1989), and need not be repeated here. Aspects of the aggregative behavior are discussed in Leen (1992).

Pupae

The pupae are dark brown with an average weight of 80 mg (n = 20) for males and 92 mg (n = 49) for females (Fig. 3). Development from pupa to adult averaged 18 days (n = 21). A solid, thick cocoon is formed prior to pupation, which occurs away from the host plant. Pupae were found under wood at 2 and 10 m from the host plant; larvae searched for pupation sites at even greater distances (20 m). Pupation occurred on a host plant when additional shelter (e.g., 5 cm wide tape) was provided but did not otherwise occur there.

In the laboratory, larvae cannibalized pupae, even when host plant foliage was available. Although silk and larvae contain quinolizidine

TABLE 1. Average longevity and weight of adult *Uresiphita reversalis*.

	Females	Males
Live weight after emergence (mg)	47.5 (n = 41)	38 (n = 19)
Life span when fed honey and water (days)	20 (n = 21)	19 (n = 16)
Life span when fed water only (days)	7.8 (n = 52)	7 (n = 42)

n = number of individuals measured.

alkaloids, pupae do not (Wink et al. 1991). When pupae are exposed as a result of damage or movement of the cocoon, the opportunity for cannibalism by larvae was provided and occurred. However, there was no evidence of cannibalism in the field where pupation occurs away from the host plant.

Adults

Adults have velvet-brown colored forewings and light orange hindwings, and are relatively large in comparison to most other crambids (Fig. 4). The forewing of *U. reversalis* is without conspicuous pattern elements. By contrast, the forewing of *U. p. maorialis* and other *Uresiphita polygonalis* Denis and Schiffermüller subspecies (Fig. 4) features an intricate brown and silver pattern. Most *Uresiphita* species have some degree of brown coloring along the margin of the light orange hindwing.

Seventeen pairs of adults were isolated in pint-sized paper cups containing water and honey. A bouquet of *G. monspessulana* was placed outside the cups. Egg productivity was recorded and averages were calculated. Oviposition was initiated three days after emergence; the total egg-laying period was 10 days. The mean number of eggs produced was 276; the mean number of batches produced was 13; mean number of eggs per batch was 21.4; the mean number of eggs per day during the egg-laying period was 30.26; and the mean number of batches per day during the egg-laying period was 1.5.

Additional measurements were made on isolated adults maintained under similar conditions. Average female weight was almost 10 mg greater than male weight (Table 1). Longevity for females exceeded that of males by one day when fed either water and honey or water only. When either sex was provided honey in addition to water, longevity doubled. Females in colony cages were capable of ovipositing viable eggs without imbibing honey or water.

Overwintering Stage

Uresiphita reversalis did not overwinter in the larval stage during the study period 1985–1989. They usually overwinter as pupae and less

often as adults. Collection records for California and Florida indicate adults may be collected throughout the year.

CIRCADIAN ACTIVITY

Methods

The circadian activities of eggs, larvae, and adults were examined over three 24-hour periods: 28 October, 12 November, and 25 November 1989. Observations were recorded at one-half hour to one-hour intervals, depending upon the frequency of activity, with a 16L:8D light regime at 20°C. A red light filter was used for observations during the dark period (2200–0600 h). Activities observed include hatching of larvae; feeding of fourth and fifth instar larvae; and adult emergence, feeding, drinking, mating, and oviposition.

Clusters of eggs laid upon leaflets in the laboratory were placed on moistened filter paper in petri dishes and observed for hatching. Most eggs in a cluster hatch within minutes after hatch of the first egg. The time of hatch thus was recorded as the time the first larva in a cluster hatched. Feeding of fourth and fifth instars was observed by placing a single cutting of *G. monspessulana* in a bottle of water and placing one larva upon the cutting. Larvae were noted as eating if their mandibles were in motion at the time of observation.

Adult emergence was recorded as the presence of new adults in a cage where only pupae were present previously. Adults were not sexed but were observed for mating and oviposition activities. Three separate cages of adults that had emerged on day one, two, and three were observed over a 24-hour period to determine the time between emergence and first oviposition. Additional adults were placed in 0.6 m × 0.6 m cages and observed for mating, oviposition, drinking, and feeding behaviors. Each cage contained a vial of water with a cotton wick for drinking and streaks of honey on the outside of the vial for feeding. Another vial with a branch of *G. monspessulana* was placed in each cage for oviposition. Drinking or feeding was recorded when a moth extended its proboscis onto the wick or honey.

Results

The greatest proportion (95%, n = 70 clusters) of eggs hatched during daylight hours, with two peak periods of emergence at 1200 h and 1500 h. Larval feeding also occurred during the daylight hours but continued at the same levels during the night. Feeding is not light dependent for either fourth (n = 64) or fifth (n = 51) instars.

Adult emergence (n = 42) is primarily nocturnal and occurs more frequently after 2400 h than at other times of the night. Emergence

did not occur between 1200 and 1700 h. Mating also is primarily nocturnal but occurs more often during the matinal hours (0430–0630 h). Over 200 adults were observed over the three 24-hour periods, but only 67 pairs mated during the three days of observations. Mated adults ranged from one day to over two weeks old. Occasionally, a pair failed to separate and remained paired long after or permanently after the lights were turned on. Nearly all pairs recorded mating after 0800 h initiated the mating earlier in the night. Curiously, within a half hour of the lights going out, most adults spread the forewings about half way apart, exposing the lighter hindwings. This clearly is not associated with mating since less than 15% of all adults mated in the three observation periods. It also probably is not associated with thermoregulation since it was not related to changes in temperature.

Oviposition was primarily crepuscular, was less frequent during the night, and ceased during midday hours. Thirty-four females oviposited during the three 24-hour periods. General observations of caged females in the laboratory indicate that oviposition occasionally occurred during late afternoon hours as well. The time from emergence to first oviposition was greater than 48 hours but less than 72 hours. Oviposition did not occur during the first 24 hours (n = 30) or 48 hours (n = 60) after emergence, but did occur after 48 but before 72 hours following emergence (n = 25). The exact interval cannot be determined since the exact time of emergence was not known. Mating and feeding began within 24 hours after emergence (n = 30). Drinking was almost exclusively nocturnal and increased during matinal hours (0500–0700 h). Feeding was primarily nocturnal and remained steady throughout the night.

DISCUSSION

Many characteristics of *U. reversalis* and *U. p. maorialis* are similar and may be representative of other species in the genus. The color and pattern of larvae and adults of these two species are the same as those of other species of *Uresiphita*, based on published illustrations and examination of museum specimens. The habits of *U. reversalis* and *U. p. maorialis* seem to be associated with their color and pattern. The available data indicate that larvae of *Uresiphita* defoliate their host plants and specialize on quinolizidine alkaloid-bearing plants in the fabaceous tribes Genisteae, Sophoreae, Thermopsidae, and Bossiaceae (Leen 1992). Confirmation of sequestration of quinolizidine alkaloids by *U. reversalis* larvae was confirmed by Montllor et al. (1990), although these chemicals are not transferred to pupae or adults. Other species of *Uresiphita* probably are diurnally active and have gregarious larvae that sequester quinolizidine alkaloids from their host plant, and thus are aposematic. Other *Uresiphita* adults do not appear to be apose-

matically colored, and alkaloids probably are eliminated at the pupal stage as in *U. reversalis*.

Other similarities between *U. reversalis* and *U. p. maorialis* include cream colored eggs laid in overlapping clusters of up to 80, larvae that undergo five instars, and pupae that are plain dark brown. Both species are multivoltine and usually overwinter as pupae. Pupation sites are not uniform between these two species. Data on other species of *Uresiphita* are needed before generalizing further.

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