AGGREGATION BEHAVIOR OF *CHLOSYNE LACINIA* LARVAE (NYMPHALIDAE)

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The objective of this study is to describe the larval aggregation behavior of *Chlosyne lacinia crocale* (Edwards) in terms of a daily activity pattern and the relation of larval size to the tendency to aggregate. Although other authors mention these topics, (Edwards, 1893; Bush, 1969; Drumond *et al.*, 1970), they provide little quantitative support for their conclusions.

Chlosyne lacinia crocale ranges from the southwestern United States to Mexico (Emmel & Emmel, 1973). From March–November, adult females deposit multiple broods on leaves of the common sunflower, *Helianthus annuus* L., and related species (Drummond *et al.*, 1970; Neck, 1973; Gorodenski, 1970). There are five instars, each lasting 3–7 days, with an average generation time in the field of 35–40 days (Edwards, 1893; Drummond *et al.*, 1970). Hatching synchronously, the larvae feed gregariously under a silk web on the underside of a leaf through the first instar (Edwards, 1893; Bush, 1969). After a leaf is devoured by a group, individuals move single file to a new leaf using and reinforcing silk thread trails (Bush, 1969). Coinciding with the appearance of distinct larval color patterns, dispersal by single individuals to different leaves and plants occurs in the fourth and fifth instars (Drummond *et al.*, 1970).

METHODS

Larvae were observed on sunflower plants (*Helianthus annuus*) along fence rows in Tempe, Arizona. Observations were made between 0700 and 1800 hours from 10 October–15 November 1975. The mean minimal temperature for this period was 12.1°C, and the mean maximal temperature was 27.7°C. A record was made of the type of plant part used, height on plant of larvae, number of larvae per group, and length of larvae, in mm. Testor's red enamel paint was used to mark the larvae.

To study the tendency to aggregate, 10 portions of sunflower plants were placed in containers with water in the laboratory at 24°C. Each portion had two main stems of about equal diameter, length, and number of healthy leaves, buds, and flowers. On five of these plants, a group of

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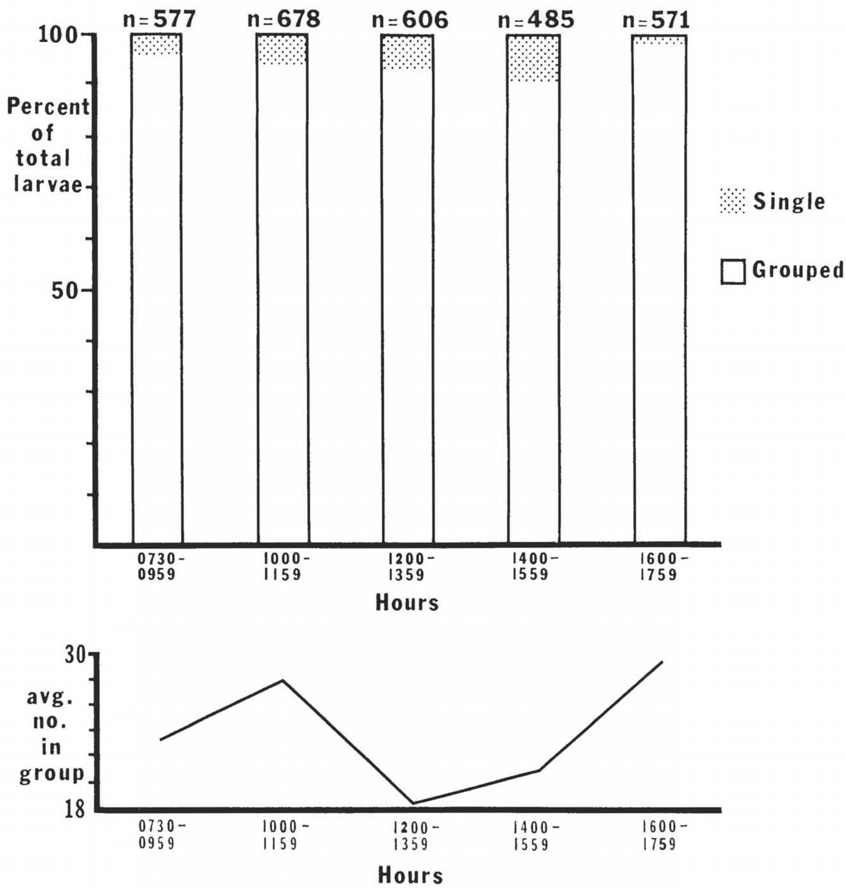

Fig. 1. Daily activity patterns of *Chlosyne lacinia.* Upper—the proportion of solitary and aggregated larvae by 2-hour intervals. Lower—average size of group.

five larvae was placed at the divergence of the two main stems. On each of the other five plants, five larvae were placed singly at diverging stem points. The number of larvae in groups was recorded every half hour for 3.5 hours. This experiment was conducted four times with large larvae (5–10 mm in length).

RESULTS

Small, light-colored larvae (<2 mm in length) usually clustered on the underside of large leaves. Individuals often fed at the same site on a leaf. These groups fed on one large leaf for several days and usually molted before moving to a new leaf.

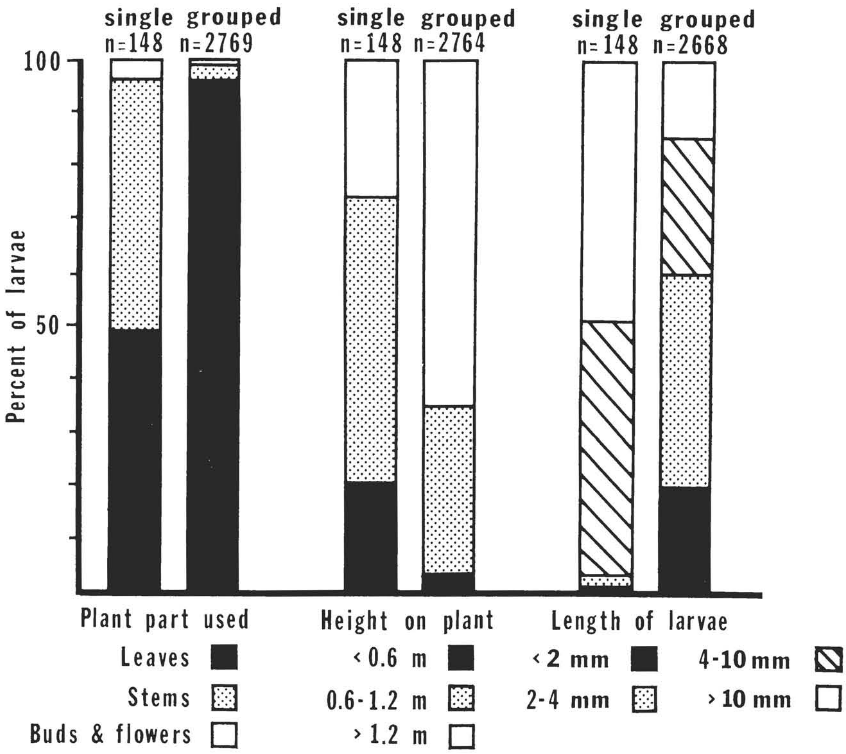

Fig. 2. Comparisons of single larvae and larvae in groups.

Larger, darker larvae (5–10 mm) clustered on one or both sides of a leaf, devoured it in a few hours, and, leaving only the network of the leaf intact and scattered dark fecal pellets, departed for a new leaf.

Tendency to aggregate was dependent on time of day (2 × 5 contingency table with $\chi^2 = 33.35$ and $p < 0.001$). As a day progressed, the percentage of aggregated larvae decreased to 91.5% and then increased to 98.2% after 1600 hours (Fig. 1). Correspondingly, the average number of larvae per group was lowest after noon and rose sharply by 1600 hours. Throughout the daylight hours, grouped larvae fed exclusively on leaves and spent most of their time on them (Fig. 2). The percentage of aggregated larvae on stems was highest between 1400 and 1559 hours, when larval movement was greatest. Most (97.0%) of the grouped larvae were on leaves higher than 0.6 m from the ground.

Through the day, increasing numbers of single, active larvae were observed, but after 1600 hours, the number of solitary larvae decreased

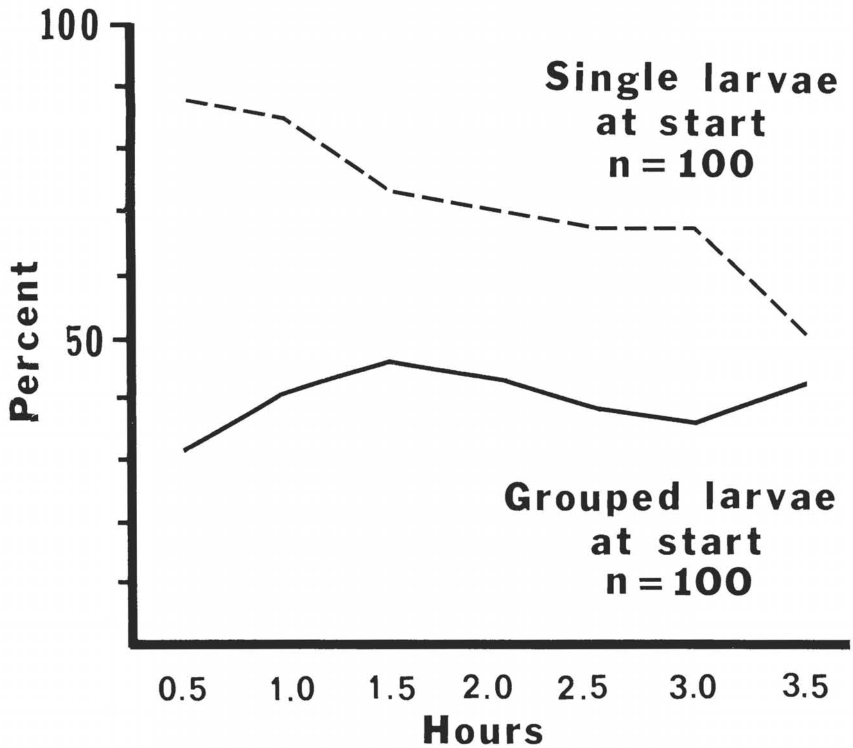

Fig. 3. Testing aggregation tendency. Percent of single larvae are indicated by solid and dashed lines. Larvae placed singly on sunflower stems tend to move until they reach other individuals. Larvae placed in groups tend to remain in groups after some initial scattering. See text for additional explanation.

(Fig. 1). Solitary larvae were encountered more frequently than aggregated larvae on stems, buds, and flowers (Fig. 2). Although the majority of single larvae were found on plant parts higher than 0.6 m from the ground, 26.4% of the solitary larvae were closer to the ground (<0.6 m) as a result of their tendency to wander.

Most (60.0%) of the aggregated caterpillars were <4 mm in length, whereas only 2.0% of the solitary larvae were this small (Fig. 2). Of the single larvae, 50.3% were 4–10 mm and 47.0% were >10 mm.

An experiment was conducted to test whether the larvae tend to aggregate (Fig. 3). The percentage of solitary larvae on plants originally provided with single larvae was compared with the percentage on plants stocked with group larvae. In the first group of plants, percentage of solitary larvae decreased significantly with time (2 × 7 contingency table with $\chi^2 = 26.65$ and $p < 0.001$). Percentage of solitary larvae in the second group of plants remained fairly constant (2×7 contingency table with $\chi^2 = 5.55$ and $0.50 > p > 0.20$), with a mean of 41% single larvae.

Several aggregations on sunflower plants were marked to determine whether these groups remained together, but the results were inconclusive. One group of 20 larvae remained together for three days and did not mix with a second group of 67 individuals 0.6 m higher on the plant. However, another marked group of 18 larvae was scattered singly or in pairs over its host plant on the second day. An unmarked group was also scattered, and two pairs of larvae consisted of marked and unmarked individuals.

DISCUSSION

Larvae of *C. lacinia* tend to form groups, with individuals leaving and wandering in the afternoon, then rejoining groups by early evening. The large larvae are more likely to wander and be found as isolated individuals.

What are the advantages associated with the formation of aggregations? Larvae in groups, especially small individuals (<4 mm), exhibited synchrony in feeding, molting, and moving to a new leaf. By moving in a group, individuals may gain an advantage in exploiting the food source. Ghent (1960) found that small larvae of the jack pine sawfly (*Neodiprion pratti banksianae* Roh.) had difficulty boring into pine needles, but once one individual was successful, others could easily join in feeding at that site.

As larvae grow larger, the feeding advantage linked with being in a group decreases. The larger caterpillar can more easily chew into a leaf, and competition for food becomes more intense. Large larvae (5–10 mm) consume leaves at a much faster rate than small caterpillars. Consequently, large larvae move to new feeding sites more often, which requires an increased expenditure of time and energy. If a larva locates a leaf and devours it alone, it will maximize eating time and minimize time and energy expended on movement.

Though probably a function of food competition, dispersal may also reduce disease, parasitism, and predation in the fourth and fifth instars (Drummond *et al.*, 1970). Parasitism is especially high in the third, fourth, and fifth instars, but there is some evidence of differential parasitism among the three larval color morphs (Drummond *et al.*, 1970). Perhaps to avoid pupal parasitism, fifth instars migrate singly to pupation.

Costs and benefits of group membership change radically with age and size of larvae, which leads to age-linked changes in the tendency to aggregate.

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A MELANIC FORM OF *PHIGALIA STRIGATARIA* (GEOMETRIDAE)

A dark geometrid moth was caught by the author at black light at Lebanon, New Jersey on 5 April 1972. A genitalic slide proved it to be a melanic form of *Phigalia strigataria* Minot. On p. 128 of "A revision of the New World Bistonini," Frederick H. Rindge states that he never saw a melanic specimen of *P. strigataria*. This apparently is the first verified one. I gave the specimen with genitalia slide to the American Museum of Natural History, New York.

Compared with *Phigalia titea* form "deplorans" no difference can be detected. Forewing length of this *strigataria* from apex to base is 16 mm. Small sizes of "deplorans" are also found, but most are larger. Colors of both are the same.

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