THE ROLE OF EXTRAFLORAL NECTAR IN THE DIET OF THE COMMON GREEN LACEWING LARVA, *CHRYSOPERLA CARNEA*

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Abstract

The role of nectar feeding for predatory green lacewing larvae is poorly understood. First instar larvae of *Chrysoperla carnea* were observed foraging freely in the field for 4-h periods. 28 of 138 larvae fed on extrafloral nectar, with the incidence of nectar feeding increasing in areas of low prey availability. In the laboratory, mean longevity increased from 1.0 ± 0.0 day in a water-only treatment to 3.3 ± 1.3 days in a leaf extrafloral nectar treatment and 5.2 ± 1.9 days in a fruit extrafloral nectar treatment. In the field, nectar feeding again increased mean longevity substantially (mean for water treatment = 2.4 ± 1.5 days and mean for extrafloral nectar = 12.0 ± 5.0 days). Extrafloral nectar may play a key role in the ecology of lacewings.

Introduction

The use of generalist predators in agricultural biological control has been receiving increased attention in recent years. Two reasons why generalist predators can be particularly important in agroecosystems are: one, where specialists may not be able to establish until after pests have invaded and caused crop damage, generalists can colonize and establish effective densities by feeding on alternate prey; and two, by feeding on a greater range of prey, the generalist can sustain itself through transient periods of prey scarcity later during the growing season. In order to employ generalist predators more effectively in biological control there is a need to better understand their ecology.

While generalist predators are recognized to feed on a diverse range of prey species, their potential use of alternative non-prey food resources has not been widely investigated. The main objective of this study was to examine the role of cotton extrafloral nectar in the diet of the common green lacewing larva, *Chrysoperla carnea* (Chrysopidae).

During field observations of freely foraging *Chrysoperla carnea* neonates in 1995 and 1996, larvae were found to feed on extrafloral nectaries on cotton plants. Out of 138 larvae that were observed for periods up to 4 hours, 28 were observed to feed on extrafloral nectar (mean duration of feeding bouts = 56 seconds). There were also 6 larvae observed sticking their mandibles into a vein of the cotton leaf, another potential feeding behavior. This experiment is a product of the questions raised during these field observations concerning the role of extrafloral nectar in the development of common green lacewing larvae, and more generally, the role non-prey food sources in the diet of generalist predators.

Materials and Methods

Field Experiment

The development of neonate *Chrysoperla carnea* was followed on six different diets (ten replicates of each diet) in a cotton field located at the Experimental Farm in Davis, California. The larvae were confined singly in small plastic cages, each of which was glued to the underside of the fifth mainstem leaf of a cotton plant. Only leaves with a wet extrafloral nectary and free of active mite colonies were used in the experiment. The weeks during which the experiment took place had temperatures over 100 ¡F; therefore the cages were shaded with paper to prevent the condensation of moisture inside the cage. The six treatments were as follows:

1. No-leaf (NL) - prevented the larvae from gaining any food resources. A fabric shield was glued over the bottom of the cage to block the larva's access to the leaf surface.
2. Leaf-only (L) - allowed the larvae access to the leaf surface and midrib but prevented access to the extrafloral nectary. The cage was positioned over the midrib, 1 cm distal to the extrafloral nectary.
3. Water-only (W) - identical to treatment 2, but with water supplied through a cotton wick. A water vial was attached to the outside of the cage, with the wick extending into the cage through a small port, and resting on the leaf surface.
4. Extrafloral nectary (EFN) - allowed access to the extrafloral nectar. The cage was placed over the extrafloral nectary.
5. Aphids-only (A) - provided the larvae with a diet of aphid prey. The cage was placed over the midrib, but out of reach of the extrafloral nectary and was supplied with ten cotton aphids, *Aphis gossypii*..
6. Aphids + extrafloral nectary (A+EFN) - provided the larvae with aphid prey, as well as giving them access to extrafloral nectar. The cage was placed over the extrafloral nectary and was supplied with ten cotton aphids.

The cages were checked every 24 hours and the status of the larvae (dead/alive, resting/feeding/foraging) and nectaries (wet/dry) were recorded. The aphid treatments were collected on the fifth day, after most of the larvae had reached the second instar, and live larval weights were

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recorded. All other treatments were allowed to continue until the larvae either died or escaped from the cage. For the aphid, aphid+extrafloral nectar, and extrafloral nectar treatments, larval head capsule width was also recorded to determine larval instar.

Laboratory Experiment

Lacewing larvae were followed on three different diets (10 replicates of each diet) inside a growth chamber at 86¡F and 15:9 photoperiod. The larvae were confined singly in 20 ml plastic vials whose lids were provided with cloth covered openings. The vials were laid on their sides, and 2 small droplets of each extrafloral nectar diet (a wick in the case of water) were placed on the side wall of the vial with a microsyringe. The three treatments were as follows:

1. Water only (W) - gave the lacewing access to water. The water wick was passed through the lid and placed on the vial wall.
2. Leaf extrafloral nectar (EFN/leaf) - gave the lacewing access to extrafloral nectar collected from cotton leaves.
3. Fruit extrafloral nectar (EFN/floral) - gave the lacewing access to extrafloral nectar collected from cotton fruiting structures.

The cages were checked every 24 hours and larval status was recorded as in the field experiment. Larvae were transferred to new vials with fresh extrafloral nectar or water every three days.

Results

Field Experiment

Some larvae escaped from the cages. Larvae that disappeared within the first 24 hours were excluded from the experiment. For the purpose of reporting mean longevities, larvae which disappeared after day 1 were assigned a longevity equal to the average longevity of the larvae still present at the time of the disappearance.

There was no significant difference between the mean longevity of lacewings in the no leaf treatment (1.4 ± 1.5 days) versus the leaf only treatment (1.3 ± 0.5 days; Wilcoxon test: $X^2 = 0.04$, $P = 0.53$), suggesting that the larvae were not gaining sustenance from the leaf surface or veins (Fig 1). Access to water did, however, produce somewhat enhanced longevities (mean = 2.4 ± 1.5 days) when compared to the leaf only treatments ($X^2 = 3.7$, $P = 0.05$). Larvae given access to the extrafloral nectar showed substantially enhanced longevities (mean = 12.0 ± 5.0 days) compared to the water only treatment ($X^2 = 5.8$, $P = 0.02$), suggesting that nutrients in the extrafloral nectar are important in addition to its role as a source of water (Fig. 1).

There was no significant difference between the probability of survival through the first 5 days of the experiment for lacewing larvae in the aphids only or aphids + extrafloral nectar treatments versus the extrafloral nectar treatment ($X^2 = 1.1$, $P = 0.29$). Thus, at least for this initial period, extrafloral nectar was as capable as a diet of prey of supporting lacewing larval survival. However, none of the neonates in the extrafloral nectar treatment ever reached the second instar, whereas 10 of 10 larvae in the aphid only treatment and 8 of 10 larvae in the aphids + extrafloral nectar treatment reached the second instar by day 5 of the experiment (comparison of extrafloral nectar vs. treatments with aphids provided, $X^2 = 15.2$, $P < .001$). Arthropod prey therefore appear to be necessary for lacewing development. The mean live weight of 5-day old lacewing larvae in the aphids + extrafloral nectar treatment (1.00 ± 0.17 mg) was not significantly different from that of the lacewings in the aphids only treatment (1.20 ± 0.30 mg), suggesting that extrafloral nectar does not enhance lacewing development in the presence of abundant prey.

Laboratory Experiment

Larvae in the water treatment all died within the first day (Fig. 2). Larvae lived significantly longer when given access to leaf extrafloral nectar (mean longevity = 3.3 ± 1.3 days; $X^2 = 16.9$, $P < 0.001$) or the fruit extrafloral nectar (mean = 5.2 ± 1.9 days, $X^2 = 15.9$, $P < 0.001$). The enhanced longevity of larvae on fruit vs. leaf extrafloral was significant ($X^2 = 5.8$, $P = 0.016$), suggesting that extrafloral nectar may vary in quality within the cotton plant.

Discussion

Laboratory and field experiments suggest that lacewing larvae are able to survive significantly longer on an extrafloral nectar diet than on a diet of water only, or access to the leaf surface only. It can therefore be concluded that the larvae are able to use the nutrients present in the extrafloral nectar as a source of sustenance. The extrafloral nectar did not, however, permit larvae to reach the second instar, even though some larvae were alive and foraging for over two weeks (the normal duration of the first instar is four or five days when abundant prey are provided). The nectary is a rich energy source (it contains fructose, glucose, and, in lower concentrations, sucrose, as well as many amino acids), but it lacks some of the amino acids that are required for insect growth. Larvae may have remained first instars because the nectar did not provide them with a complete diet.

This study suggests that extrafloral nectar may sustain lacewings during times of prey scarcity, thereby enhancing their efficacy as biological control agents in agroecosystems where pest densities may show substantial fluctuations.

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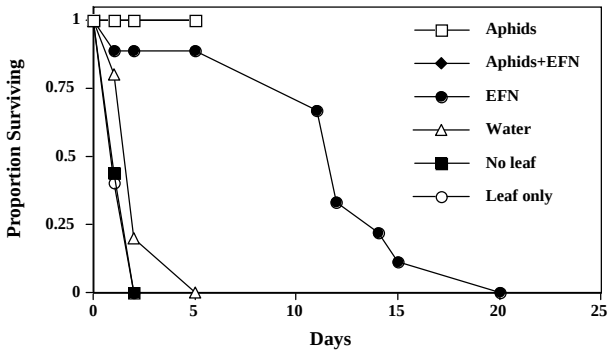

Figure 1. The proportion of *Chrysoperla carnea* larvae surviving in cotton on six different diets: no leaf, leaf only, water only, extrafloral nectar (EFN), aphids only, aphids+EFN.
*Larvae in the aphids and aphids+EFN treatments were collected early on day 5.

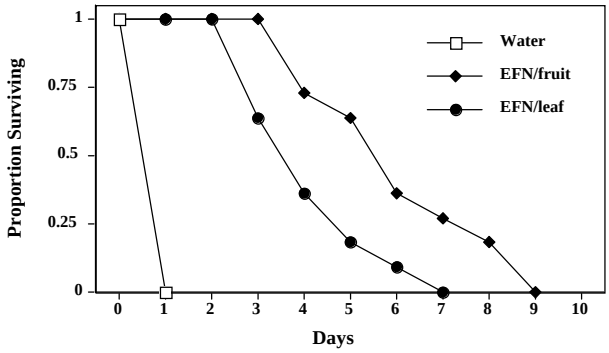

Figure 2. The proportion of *Chrysoperla carnea* larvae surviving in the laboratory on three different diets: water only, leaf extrafloral nectar, and fruit extrafloral nectar.