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Feeding on nectar and honeydew sugars improves survivorship of two nocturnal cursorial spiders

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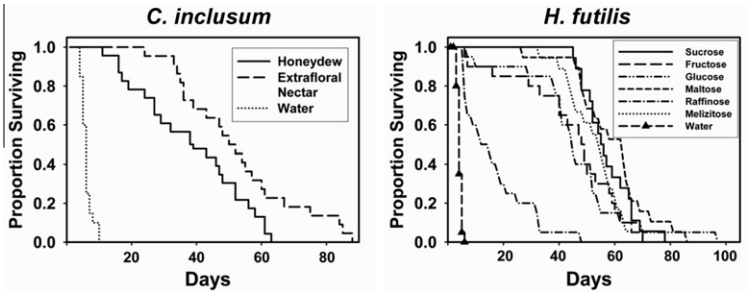
HIGHLIGHTS

- *Cheiracanthium* inclusum survived 6–8× longer on extrafloral nectar and honeydew than water.
- Spider consumption of sugar solutions is not related to a need for moisture.
- *Hibana futilis* readily fed on six sugar components of nectar and honeydew; *C. inclusum* found maltose distasteful.
- All component sugars tested improved *H. futilis* spiderling survival.

GRAPHICAL ABSTRACT



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ABSTRACT

Sugars from extrafloral nectar and honeydew may be important resources for nocturnal cursorial spiders such as *Cheiracanthium inclusum* (Hentz) and *Hibana futilis* (Banks). *C. inclusum* spiderlings given only water survived an average of 6.1 d. When provided with cotton extrafloral nectar and mealybug honeydew, their survivorship was extended to an average of 52.6 and 37.9 d, respectively (870% and 626% increases). Choice tests demonstrated conclusively that spiders fed on nectar, honeydew and sugar solutions to obtain nutrients, and not simply to obtain moisture. Component sugars of extrafloral nectar (sucrose, glucose and fructose) and honeydews (maltose, melezitose and raffinose) were equally acceptable for feeding by *H. futilis,* but not for *C. inclusum*. Maltose was fed on by *C. inclusum* for significantly shorter periods than the other plant and honeydew sugars. Consumption of each of the individual sugars by *H. futilis* improved spiderling survival significantly over water, but less for raffinose than for the other sugars. The percent improvement in mean *H. futilis* survival over water alone varied from 394% for raffinose (mean = 16.6 d) to 1414% for maltose (mean = 56.9 d). The remaining four sugars extended survival greater than 1079%. That spiderlings survived for weeks on diets comprised only of individual sugars indicates that the availability of nectar and honeydew can be of considerable importance to the survivorship of cursorial spiders in the field.

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1. Introduction

Nocturnal cursorial spiders in the Anyphaenidae and Miturgidae have recently been documented to commonly feed on extrafloral nectars (EFN) in cotton (Taylor and Pfannenstiel, 2008) and observed to feed on floral nectars and honeydews (J.M. Patt and R.S. Pfannenstiel personal observation). The availability of these sugars may provide significant benefit for development and reproduction when spiders are prey limited (Taylor and Pfannenstiel, 2009) or to survival in the absence of prey (Taylor and Bradley, 2009; R.S. Pfannenstiel, unpublished data). Spiders have generally been considered to be food limited (Nentwig 1987; Wise, 1993; Nyffeler and Sterling, 1994) so the availability of these resources might

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significantly facilitate colonization, retention and population growth of spiders in both natural and agricultural settings. In crops where extrafloral nectars are available, higher densities of these important predators (Pfannenstiel, 2005, 2008a) might improve biological control of crop pests (Lundgren, 2009). Although a small number of other studies have documented feeding on floral and extrafloral nectar (Vogelei and Greissl, 1989; Taylor and Foster, 1996; Jackson et al., 2001), little is known of the value of sugar feeding for more than a couple of species and honeydew feeding has only been documented for a single species (Lundgren, 2009). For spiders, there is some information on the value of extrafloral nectars (Taylor and Bradley, 2009; Taylor and Pfannenstiel, 2009) but data on the value of honeydews and the response of spiders (indeed most predatory arthropods) to individual sugar components of nectars and honeydews does not exist. Here we begin to look at the response of spiders to sugar resources available in the environment and their components.

This study examined two nocturnal cursorial spiders, *Cheiracanthium inclusum* (Hentz) (Miturgidae) and *Hibana futilis* (Banks) (Anyphaenidae), which are important predators of pests in agricultural systems in south Texas (Pfannenstiel, 2005, 2008a). We began by determining if feeding on cotton extrafloral nectar and mealybug honeydew improved their survival in the absences of prey. Subsequently, we evaluated the acceptability and feeding of these spiders on six sugars that are major constituents of extra-floral nectars (glucose, fructose, and sucrose) and honeydews (maltose, melezitose, and raffinose) (Wäckers, 2001). Finally, we determined the survival of immature *H. futilis* on these same six sugars.

2. Materials and methods

Spider colonies were initiated from *C. inclusum* and *H. futilis* collected from cotton and soybean fields at the research farm of the USDA-ARS laboratory in Weslaco, TX. Field-collected individuals were placed in a 90 × 15 mm plastic Petri dish with a moistened dental wick and fed *Helicoverpa zea* (Boddie) (Lepidoptera: Noctuidae) eggs *ad libitum*. Both of these species develop well on a diet of *H. zea* eggs (Pfannenstiel, 2008b; R.S. Pfannenstiel, unpublished data). Females were mated at maturity and the resulting spiderlings used for these studies. On emergence from the egg sac spiders for utilization in these trials were placed individually in 90 × 15 mm Petri dishes and handled as appropriate for each study. *H. zea* eggs for prey were obtained from a laboratory colony reared by modified methods of Ignoffo (1965). Eggs were collected daily and fresh frozen at −16 °C. Eggs were stored frozen and used within one month.

Extrafloral nectar (EFN) was collected directly from cotton plants (cv. Deltapine 54-RR) grown under greenhouse conditions. A small spatula was used to remove droplets of nectar from the circumbracteal or leaf mid-rib nectaries and the EFN was placed into a scintillation vial that was stored in a freezer at −16 °C. Collections were made daily until enough EFN was collected to initiate the study. Honeydew was collected from greenhouse grown cotton plants infested with a mealybug [most likely *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae)]. Leaves containing mealybugs were excised and brought to the laboratory and examined under a dissecting microscope. Droplets of honeydew were collected from infested leaves with a spatula and streaked on plastic coverslips that were placed in a large plastic Petri dish and then stored in a freezer at −16 °C. Honeydew was used within 2 weeks of collection.

2.1. Survival of C. inclusum on cotton EFN and mealybug honeydew

Egg masses of *C. inclusum* were obtained from a laboratory colony and observed for spiderling emergence. Newly emerged spiderlings from two egg masses were placed individually into 90 × 15 mm plastic Petri dish with a moistened dental wick and randomly assigned to each feeding treatment. Each dish contained a plastic cover slip streaked with cotton EFN, mealybug honeydew, or reverse osmosis water (25 spiderlings for each treatment). Each food source was replaced twice weekly for the life of the spider. Spiders were maintained at 26 ± 1 °C with a 14:10 (L:D) photoperiod and observed daily until death.

2.2. EFN acceptance and feeding

An initial study was conducted to ensure that spiders fed on the EFN droplets to obtain sugar, not to simply obtain moisture. Both *C. inclusum* and *H. futilis* were tested. For this and the following study, spiders were reared to the 3rd instar to facilitate observation. Newly emerged spiderlings were placed individually within a 50 × 9 mm plastic Petri dish with *H. zea* eggs and a moistened dental wick. The spiderlings were fed moth eggs *ad libitum* and provided with water until they completed their second molt (to the third instar). After molting to the third instar, the spiders were starved but provided with water for 2–4 d and then tested. The spiders were maintained at 26 ± 1 °C and a 14:10 (L:D) photoperiod. The dark phase was timed to begin at 1 PM so that assays could be conducted when the spiders would normally be foraging. For each of the following studies, spiders were randomly assigned to each treatment.

A choice test was used to distinguish sugar feeding from simple water imbibition. The test was conducted in an arena consisting of the bottom of an upside down Petri dish with two droplets (ca. 2 μl), one water and one cotton extrafloral nectar, placed ca. 2 cm apart (Fig. 1). Immediately prior to testing, individual spiders in their Petri dishes were anaesthetized by gently chilling them in a freezer at −4 °C for approximately 90–105 s for *H. futilis* and 120–150 s for *C. inclusum* (Patt and Pfannenstiel, 2008). Observations have shown that *C. inclusum* is much more tolerant to cold and required longer chilling to anesthetize each individual.

At the beginning of each test, an anesthetized spider was placed ca. 2 cm from the mid-point between the two droplets. The spider and droplets were covered with an inverted watch glass so that the spider could be observed after recovery from anesthesia (Fig. 1). Specific events tracked were the first type of droplet contacted and the type of droplet chosen for feeding. Twenty spiders were assayed for each species. Because of the limited space above the droplets and the spiders' ability to walk either upright on the Petri

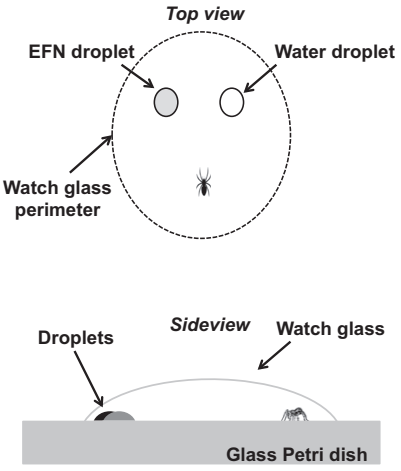

Fig. 1. Arena utilized to assay spider choice of water vs. extrafloral nectar for consumption.