

Peach Extrafloral Nectar Impacts Life Span and Reproduction of Adult *Grapholita molesta* (Busck) (Lepidoptera: Tortricidae)¹

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ABSTRACT This study evaluated the longevity and fecundity of a laboratory strain of *Grapholita molesta* (Busck) (Lepidoptera: Tortricidae) when provided peach, *Prunus persica* L., extrafloral nectar for nourishment. Moths lived longer and females had a greater reproductive output when presented with extrafloral nectar and a source of water compared with moths provisioned only with water. Adult male *G. molesta* presented with nectar and water lived an average of 28.7 days, whereas, males provided only water lived about 17.8 days. Adult female *G. molesta* provided nectar and water lived 33.7 days and produced an average 255.9 fertile and 10.9 infertile eggs, whereas, females provided only water lived 14.4 days and produced an average 117.2 fertile and 2.1 infertile eggs. The higher number of infertile eggs laid by nectar fed females is attributed to an extended oviposition period of 29.4 days compared with 10.0 days for females provided only water. Peach extrafloral nectar did not affect the duration of preoviposition and postoviposition periods. It is quite possible that orchards planted with extrafloral nectar bearing varieties of peaches and nectarines may contribute to the longevity and reproductive potential of *G. molesta* in the field.

KEY WORDS Oriental fruit moth, *Prunus persica*, oviposition, survivorship, longevity, fecundity, bioassay

Carbohydrates, lipids, and proteins are important nutritional factors for adult tortricids (Lepidoptera: Tortricidae) (Benz 1991). In particular, adult female *Grapholita molesta* (Busck) (Lepidoptera: Tortricidae) provided with honey and water produced more eggs than moths that did not feed (Rothschild & Vickers 1991). In our efforts to understand *G. molesta* population trends in peach (*Prunus persica* L.) orchards, we hypothesized that peach extrafloral nectar from leaf glands might be an important natural food resource that may affect abundance of this pest. Likewise, it is possible that the presence or absence of peach extrafloral nectar may impact *G. molesta* longevity and fecundity because peach extrafloral nectar contains numerous carbohydrates, amino acids, and fatty acids (Caldwell & Gerhardt 1986). The influence of peach extrafloral nectar on various biologic parameters may contribute to *G. molesta* population dynamics. Currently, most

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commercial peach varieties have extrafloral glands at the base of leaves (Okie 1998).

The objective of this study is to evaluate peach extrafloral nectar as a food source for *G. molesta*. Specifically, we want to elucidate the impact of peach extrafloral nectar on adult *G. molesta*'s lifespan and reproductive potential.

Materials and Methods

Source of nectar. Nectar was collected from reniform-shaped leaf glands of 2-yr potted 'Lovell' peach seedlings and provided as a food source to adult *G. molesta*. During the experiment, fresh drops of nectar were collected daily from the leaves and transferred to the bottom of Petri dishes (50 × 9 mm) using a teasing needle. Seedlings were grown in a greenhouse under ambient temperature and light regimen. The trees were watered every morning, and late afternoon if needed. They were fertilized twice monthly (Miracle-Gro, Scotts Miracle-Gro Products, Marysville, Ohio) and pruned when needed.

Impacts of peach extrafloral nectar on *G. molesta*. Laboratory reared *G. molesta* moths, maintained on green thinning apples (approx. 3 cm dia.) with a method similar to the one described by Pree (1985), were used for this study. The colony was approximately 3 years old at the start of the study. Pupae were removed from the colony, sexed, and then placed individually in separate Petri dishes (100 × 15 mm). Dishes with pupae were kept in a chamber at 25°C and a photoperiod of 16:8 (L:D) h until moths emerged. Pupal weight varied; to minimize the weight effect on fecundity (Fraser & Trimble 2001), only pupae in a narrow weight range (male 8.9–10.2 mg, female 11.7–13.0 mg) were used. To standardize the start up age of moths in trials, only newly emerged moths (age <6 h) were used. One virgin female and two virgin males were placed together in individual clear plastic test containers (capacity ≈ 0.51) turned upside down. Each replication consisted of 3 test containers. During this study, a total of 3 replications were provided for each treatment. For each replication, both treatments started simultaneously at approximately monthly intervals. During the experiment, containers with moths were held in a laboratory at 23°C to 25°C and a 16:8 (L:D) h photoperiod. Nectar fed moths were provided daily with a drop of peach leaf extrafloral nectar (0.43 ± 0.04 mg) placed on the bottom of a Petri dish (50 × 9 mm) and de-ionized water for drinking dispensed from a 2-cm piece of cotton dental wick. Control moths were provided only de-ionized water. Every morning between 0800–1000 hr until the moths died they were moved into new containers with a drop of fresh nectar and/or a fresh water source. Before the moths were manually transferred into new containers, they were first cooled for 1 min by putting the containers in contact with frozen artificial ice. Chilling the moths slowed their activity to facilitate the transfer process. Longevity of each moth was recorded every morning during the experiment until they died. The preoviposition period (number of days between emergence of adult females and deposition of the first egg), oviposition period (number of days eggs were laid), and postoviposition period (number of days from deposition of the last egg to the death of individual female moths) were determined daily by observing oviposition and moth vitality. Fecundity (total number of eggs laid) for each female was determined throughout its life by counting the number of eggs laid daily. Egg fertility was also determined daily. An egg was categorized as fertile if an embryo developed and a

darkened head capsule was observed or as infertile when no embryo developed. Fecundity consisted of the combined number of fertile and infertile eggs laid per female. Similarly, egg fertility and infertility was defined as the total amount of fertile and infertile eggs laid per female, respectively.

Data analysis. The experiment was organized as a randomized block design. Two treatments with a laboratory strain of adult *G. molesta*, provided nectar or not, were investigated. Blocking was based on the three different times the experiment was conducted. All results are presented as means \pm SEM. Differences in longevity, fecundity, fertility, infertility, and the duration of preoviposition, oviposition, and postoviposition periods between treatments were analyzed using ANOVA (SAS Institute 1991). To meet the assumptions of equal variances, means, with exceptions of male longevity and the duration of pre- and postoviposition periods, were transformed ($\log(x + 1)$) before analysis.

Results

Impacts of peach extrafloral nectar on *G. molesta*. Our laboratory strain of *G. molesta* lived longer when provided with peach extrafloral nectar and water when compared with *G. molesta* moths provided only water (females: $F = 23.72$; $df = 1, 2$; $P = 0.040$, males: $F = 20.94$; $df = 1, 2$; $P = 0.045$) (Table 1). The daily survivorship curves were similar between treatments during the first 11 and 7 days for female (Fig. 1A) and male moths (Fig. 1B), respectively. Adult *G. molesta* females provided with peach extrafloral nectar and water laid more eggs when compared with those provided only water (fertile eggs: $F = 25.00$; $df = 1, 2$; $P = 0.038$, infertile eggs: $F = 130.30$; $df = 1, 2$; $P = 0.008$, total eggs: $F = 63.87$; $df = 1, 2$; $P = 0.015$) (Table 1). Oviposition of females provided with peach extrafloral nectar and water or only water peaked when moths were 7 d old and a different pattern of egg laying between both treatments followed (Fig. 1C). Most of the infertile eggs were laid during the second half of the oviposition period for both treatments (Fig. 1D). Feeding on peach extrafloral nectar by *G. molesta* females did not affect the duration of their preoviposition period ($F = 0.03$; $df = 1, 2$; $P = 0.88$) or postoviposition period ($F = 0.19$; $df = 1, 2$; $P = 0.707$) (Table 2) when compared with non-nectarfed females. However, feeding on peach extrafloral nectar did extend the oviposition period of *G. molesta* females considerably ($F = 57.06$; $df = 1, 2$; $P = 0.017$) (Table 2).

Discussion

This study demonstrates the dietary value of peach extrafloral nectar to adult *G. molesta*'s longevity and reproductive output. Adult *G. molesta* lived longer and female moths had higher fecundity and an extended oviposition period after feeding on peach extrafloral nectar when compared with moths provided only water. These findings were similar to what we observed when we provided peach extrafloral nectar to a natural enemy of *G. molesta*. In that study, we demonstrated that peach extrafloral nectar significantly increased the fitness and fecundity of *Trichogramma minutum* Riley (Hymenoptera: Trichogrammatidae) (Shearer & Atanassov 2004). Similar beneficial effects of extrafloral nectar have been shown for other insects on cotton (Lukefahr & Rhyne 1960, Schuster et al. 1976,

Table 1. Impact of peach extrafloral nectar on *Grapholita molesta* longevity and fecundity, Bridgeton, New Jersey USA, 2001.

Treatment	Mean \pm SEM longevity in days		Mean \pm SEM number of eggs laid per female		
	Females (n = 9)	Males (n = 18)	Fertile	Infertile	Total
Provided nectar and water	33.7 \pm 5.9a	29.7 \pm 2.9a	245.0 \pm 29.6a	10.9 \pm 4.8a	255.9 \pm 27.1a
Provided only water	14.4 \pm 0.9b	17.7 \pm 1.6b	117.2 \pm 6.8b	2.1 \pm 1.6b	119.3 \pm 7.3b

Means in the same column followed by different letters are significantly different (ANOVA; $P \leq 0.05$).

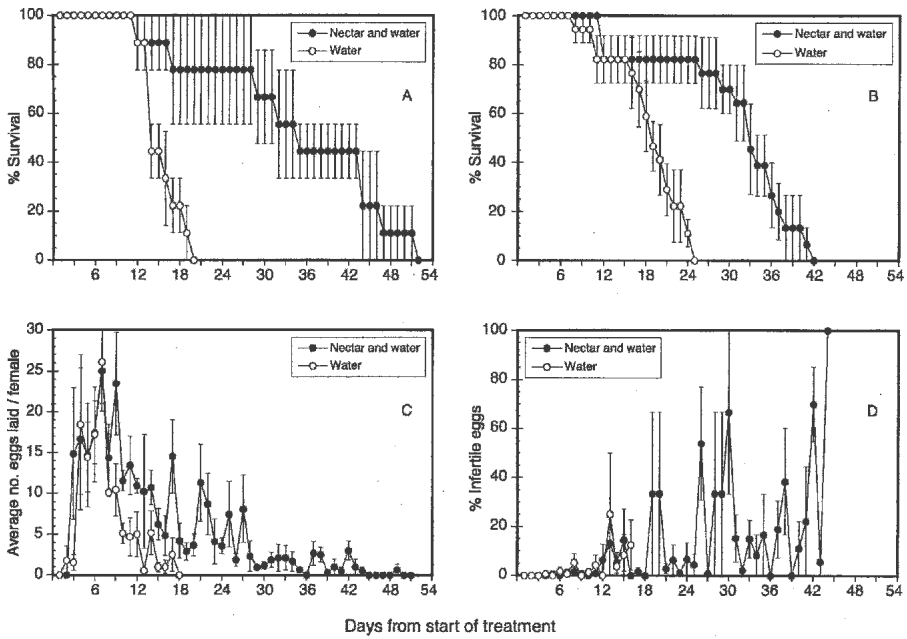


Fig. 1. The effects, represented as means and SEM bars, of providing a laboratory-reared strain of *Grapholita molesta* with peach extrafloral nectar on (A) female longevity, (B) male longevity, (C) fecundity, and (D) infertility.

Yokoyama 1978, Bailey et al. 1984, Flint et al. 1986, Limburg & Rosenheim 2001) and almond (Limburg & Rosenheim 2001).

In this study, *G. molesta* fertility curves were age-related and similar to the delayed peak fertility curve described by Barclay & Judd (1995) such that daily oviposition increased for about a week then gradually decreased during the life of the moth. Additionally, the longer oviposition period of nectar-fed *G. molesta* resulted in an increase in the number of infertile eggs late in the oviposition period. We attribute this increase in the number of infertile eggs as a function of female aging. Similarly, Tisdale & Sappington (2001) documented an increase in

Table 2. Mean \pm SEM duration in days of pre-oviposition, oviposition, and post-oviposition periods of *Grapholita molesta*, Bridgeton, New Jersey USA, 2001.

Treatment	Pre-oviposition period (d)	Oviposition period (d)	Post-oviposition period (d)
Provided nectar and water	4.0 \pm 0.4a	29.4 \pm 4.2a	1.3 \pm 0.4a
Provided only water	4.0 \pm 0.4a	10.0 \pm 0.9b	1.7 \pm 0.4a

Means in the same column followed by different letters are significantly different (ANOVA; $P \leq 0.05$).

abundance of infertile eggs of laboratory reared *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae) as females aged.

Fraser & Trimble (2001) reported that the duration of *G. molesta* preoviposition period depended on the age of mated females. Similarly, Karalius & Buda (1995) found age dependent reproduction of *Cydia pomonella* L. (Lepidoptera: Tortricidae) was based on the time of mating. In our study, we excluded these effects because moths in our study were paired shortly after emergence. Stevens et al. (2002) reported an extended postovipositional period of *Ctenopseustis obliquana* (Walker) (Lepidoptera: Tortricidae) after adults were fed honey. In our study, peach extrafloral nectar did not affect the duration of the pre and postovipositional periods.

Grapholita molesta fecundity varies (Phillips & Procter 1969) and adult nutrition is one of several factors that affect the number of eggs laid (Rothschild & Vickers 1991). In our study, we recorded an average of 255.9 eggs laid per female when adults were fed peach extrafloral nectar. This egg number is vastly higher than what was reported elsewhere (Yetter & Steiner 1932, Dustan 1960, Phillips & Procter 1969, Fraser & Trimble 2001). It is possible that peach extrafloral nectar contributed to this high level of fecundity although we did not compare peach extrafloral nectar with other forms of nutrition such as honey to test this observation. We also observed that nectar fed adult *G. molesta* lived about 30 days in our test conditions. This life span is greater than what was previously reported (Stearns & Peterson 1928, Fraser & Trimble 2001).

Results from this laboratory study revealed a considerable positive effect of peach extrafloral nectar on *G. molesta* survivorship and fecundity and provides further evidence to support our hypothesis as to the benefits of peach extrafloral nectar. However, additional field studies are needed to determine the impact that peach orchards planted with extrafloral nectar bearing peach and nectarine varieties have on *G. molesta* abundance and longevity.

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