BioOne COMPLETE

Effect of Zelus longipes (Hemiptera: Reduviidae) on Diaphorina citri (Hemiptera: Liviidae) and Its Parasitoid Tamarixia radiata (Hymenoptera: Eulophidae) under Controlled Conditions

Authors: Navarrete, Bernardo, Carrillo, Daniel, Reyes-Martinez, Ana Y., Sanchez-Peña, Sergio, Lopez-Arroyo, Jose, et al.

Source: Florida Entomologist, 97(4) : 1537-1543

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/024.097.0428

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use

EFFECT OF *ZELUS LONGIPES* (HEMIPTERA: REDUVIIDAE) ON *DIAPHORINA CITRI* (HEMIPTERA: LIVIIDAE) AND ITS PARASITOID *TAMARIXIA RADIATA* (HYMENOPTERA: EULOPHIDAE) UNDER CONTROLLED CONDITIONS

BERNARDO NAVARRETE[1,*], DANIEL CARRILLO[2], ANA Y. REYES-MARTINEZ[3], SERGIO SANCHEZ-PEÑA[3], JOSE LOPEZ-ARROYO[4], HEATHER MCAUSLANE[5] AND JORGE E PEÑA[2]

[1]Instituto Nacional de Investigaciones Agropecuarias, Estación Experimental Tropical Pichilingue, Ecuador

[2]University of Florida, Tropical Research and Education Center, Homestead, FL 33031, USA

[3]Universidad Autónoma Agraria Antonio Narro, Saltillo Coahuila, Mexico

[4]INIFAP, Campo Experimental General Terán, Carretera Montemorelos-China Km 31, General Terán C.P. 67413, Nuevo León, Mexico

[5]University of Florida, Department of Entomology and Nematology, Gainesville, FL 32611, USA

*Corresponding author; E-mail: bernardonavarrete@hotmail.com

ABSTRACT

Studies were conducted under controlled laboratory conditions to evaluate the effect of the predator, *Zelus longipes* (Hemiptera: Reduviidae) on mortality of *Diaphorina citri* (Hemiptera: Liviidae) as well as its effect on the specialized parasitoid, *Tamarixia radiata* (Hymenoptera: Eulophidae). All tested life stages of *Z. longipes* consumed significantly more *D. citri* adults than nymphs. *Zelus longipes* nymphs were only effective as predators of *D. citri* adults at a predator density of 8 individuals (or specimens) per arena. The mortality of *D. citri* nymphs caused by *Z. longipes* adult females was higher at the densities of 2 or more predators per arena. All densities of male and female adult *Z. longipes* resulted in mortality of nearly all the *T. radiata* adult parasitoids offered. The importance of intraguild predation and possible interference with *T. radiata* are discussed.

Key Words: citrus psyllid, intraguild predation, functional response, assassin bug, *Murraya*

RESUMEN

Se estudió bajo condiciones de laboratorio el efecto del depredador *Zelus longipes* (Hemiptera: Reduviidae) sobre el psílido de los cítricos *Diaphorina citri* (Hemiptera: Liviidae), así como su efecto sobre el parasitoide *Tamarixia radiata* (Hymenoptera: Eulophidae). Todos los estadios de *Z. longipes* consumieron una cantidad significativamente más alta de adultos que de ninfas de *D. citri*. Las ninfas de *Z. longipes* fueron efectivas solamente como depredadores de adultos de *D. citri*, cuando la densidad del depredador era de 8 ninfas por arena experimental. Todas las densidades de machos y hembras de *Z. longipes* consumieron todos los adultos del parasitoide *T. radiata*. Se discute la importancia de depredación intragremial.

Palabras Clave: psilido de los cítricos , depredación intragremial, respuesta funcional, chinche asesina, *Murraya*

The ubiquity and importance of intra-guild predation has been considered in numerous systems involving predators, parasitoids and pathogens (Lucas 2005). Predators and parasitoids, serving as intra-guild prey, may be attacked by other generalist predators, pathogens and parasitoids (Lucas 2005). For instance, Rosenheim et al. (1993) concluded that in aphidophagous systems, the addition of generalist predators such as *Zelus renardi* Kolenati (Hemiptera: Reduviidae) and *Nabis* spp. (Hemiptera: Nabidae) generated sufficient mortality of the predator *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) to negatively affect population regulation of the in-

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use

tended prey, *Aphis gossypii* (Glover) (Hemiptera: Aphididae).

The psyllidophagous system of *Diaphorina citri* Kuwayama (Hemiptera: Liviidae) in Florida's cultivated Rutaceae (i.e., *Citrus, Murraya)* may also demonstrate the phenomenon of intra-guild predation (Michaud 2004). Intra-guild predation on immature stages of the introduced parasitoid *Tamarixia radiata* (Waterson) (Hymenoptera: Eulophidae) in Florida citrus groves resulted in > 95% mortality of the parasitoid, thereby reducing the efficacy of this biological control agent against *D. citri*.

A component of this psyllidophagous system is the assassin bug, *Zelus longipes* (L.) (Hemiptera: Reduviidae: Harpactorinae), a generalist predator (Kalsi & Seal 2011) of *D. citri* (Peña et al. 2008). The abundance of *Z. longipes* on Rutaceous plants has been verified in the field. For example, *Z. longipes* was reported preying upon *D. citri* on citrus in central and central-east Florida (Michaud 2002; Hall et al. 2008) and in *Murraya exotica* L. (formerly *M. paniculata)* in south Florida (Peña et al. 2008). *Zelus longipes* was observed eating adults of *T. radiata* on an 80-m-long *M. exotica* hedge during observation periods from 10:00 till 11:00 and from 13:00 till 14:00 each day over a period of 4 consecutive weeks (Peña et al. 2008). Numbers of *Z. longipes* recorded did not differ during morning and afternoon hours. The mean density of *Z. longipes* throughout the study ranged from 7.8 to 24.3 per 30 min of observations while the number of *D. citri* adults /flush fluctuated between 0.15 and 4.95. Pena (unpubl. 2009) recorded 0 to 12 *D. citri* adults, 0 to 52 eggs, and 0 to 62 nymphs/flush in a 20-m-long *M. exotica* hedge. During the same study, he recorded from 1 to 66 *Z. longipes* during a 2-min walk conducted 3 times a day around a 10-m-long portion of the same *M. exotica* hedge. Additionally, *Z. longipes* activity was surveyed every other day during 4 weeks for 1 h at 8:00, 11:00 and 16:00 during the spring of 2011 (AYRM, unpubl. data). A total of 1677 individuals were observed, resting or preying on *D. citri*, but also preying on other natural enemies such as the parasitoid *T. radiata* and the predator *Hippodamia convergens* Guérin-Méneville (Coccinellidae). During surveys on *M. exotica* of predator activity and density in the spring and summer of 2012, *Z. longipes* was recorded as the most frequent predator, and was observed feeding on *D. citri* and also on coccinellids, tachinid flies, and small wasps, such as *T. radiata* (BN, unpubl. data).

Clearly there are abundant anecdotal observations to indicate that *Z. longipes* is an abundant predator with the potential to reduce *D. citri* population suppression through intra-guild predation. To supplement those observations, here we present studies conducted under controlled conditions to evaluate the possible effect of *Z. longipes* on *D. citri* and on the specialized parasitoid, *T. radiata*.

Materials and Methods

Plant Material and Experimental Arenas

Murraya exotica (formerly known as *M. paniculata)*, which is grown as an ornamental hedge in Florida, and is a host of *D. citri* was used in all experiments. *Murraya exotica* plants were grown in 3.8-L plastic pots with potting media (pine bark, 60% + Canadian sphagnum peat and vermiculite). The plants were placed inside 91.4 × 61 cm screen cages (mesh size 1 mm^2) and kept inside a greenhouse to avoid unwanted arthropod infestations. Experimental arenas were constructed by cutting *M. exotica* flushes free of any damage, leaving a 5-cm stem to hold the cutting firmly upright when formed into bouquets with exposed leaves. Bouquets were formed by inserting the stems into a 26-mL vial (polystyrene, measuring 26 × 51 mm with snap-on caps, Fisherbrand® cat. # 03-338-3c) filled with 20 mL water and a small hole in the cap. The bouquets were placed inside wide-mouth mason jars (Ball®, 946 cm^3 volume) with a fine screen (0.25 mm^2) mesh lid and a piece of wet cotton inside to provide moisture. All experiments were conducted in an insectary at the Tropical Research and Education Center (TREC), in Homestead, Florida under 25 ± 2 °C, 12:12 h L:D and 65 ± 2% RH, unless stated otherwise.

Insect Colonies

A 30 m long × 1 m tall unsprayed *M. exotica* hedge located at TREC that had a long term infestation with *D. citri* was the source of insects. Adult *D. citri* were collected with an aspirator and nymphs were collected by cutting infested flushes.

Zelus longipes adults of both sexes were collected from the *M. exotica* hedge with a paintbrush and placed inside plexiglass cages (30 × 30 × 30 cm) with 200 cm^2 of corrugated cardboard that served as oviposition substrate. Honey was supplied on 2 pieces of paper (5 × 5 cm) affixed to the cage walls. Water was provided in a clear plastic container, with a cotton roll inserted through the container lid to serve as a wick. After 2 days of oviposition the corrugated cardboard with the eggs was transferred to a new cage. *Zelus longipes* first instars emerged approximately15 days later. These nymphs were fed daily with live *Drosophila* spp. (Diptera: Drosophilidae) adults (1-3 flies per individual) until the 4th instar. Fourth instar *Z. longipes* were fed daily with adults of *Anastrepha suspensa* (Loew) (Diptera: Tephritidae) (1-3 flies per individual), which were supplied by the Division of Plant Industry, Biocontrol Rearing Facility, Florida Department of Agriculture and Consumer Services, Gainesville, Florida. *Drosophila* spp. was reared using ripe banana fruits kept in

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use

1-L plastic containers and flies were transferred to the *Z. longipes* cages using an aspirator. In this rearing system, *Z. longipes* adults were obtained 45 to 60 days after the emergence of the 1st instars. All predators were deprived of food for 24 h prior to initiating the experiments.

Tamarixia radiata were collected on the *M. exotica* hedge and then placed with *M. exotica* flushes infested with *D. citri* 4th and 5th instars. Psyllid infested flushes were formed into large bouquets inserted in polystyrene containers (26 × 51 mm, Fisherbrand®) and then placed inside a plexiglas cage (30 × 30 × 30 cm). Then, 20 *T. radiata* adults were introduced to the cages for 4 days. After the oviposition period, flushes with presumably parasitized *D. citri* nymphs were transferred to emergence cages where parasitoids began to emerge approximately 12-15 days later. Honey and water were provided in the same way as for *Z. longipes*. This procedure was repeated every 10 days.

Susceptibility of Different Psyllid Life Stages to Predation by *Zelus longipes*

Experimental arenas (glass mason jars with volume of 946 cm^3) were prepared with either 2 *M. exotica* flushes and 20 adults of *D. citri* (presumably mated, 1:1 ♂:♀) or 1 flush of *M. exotica* and 20 *D. citri* 5th instars. Sets of 1, 2, 4 or 8 1-d-old unfed *Z. longipes* adults (♂ and ♀ tested separately), or 1st instars of *Z. longipes* were introduced into the arenas. Experimental arenas with *D. citri* but no predators were used as a control. Twenty four h after introducing the predators, the flushes were inspected under a stereomicroscope and the number of *D. citri* eggs, dead *D. citri* and *Z. longipes* per flush were counted. Each predator-stage density was replicated 5 times.

Susceptibility of *Tamaraxia radiata* Adults to Predation by *Zelus longipes*

Experimental arenas were prepared with 2 *M. exotica* flushes and 20 1-d-old *T. radiata* adults (1:1 ♂:♀). Sets of 1, 2, 4 or 8 1-d-old unfed *Z. longipes* adults (♂ or ♀), or 1, 2, 4, 8, or 12 1st instars of *Z. longipes* were introduced into the arenas. Twenty four h later, the number of live and dead adults of both predator and prey was counted. The untreated control was set up in the same way but contained no *Z. longipes*. The response variables were the number of dead *T. radiata* adults and number of surviving *Z. longipes*. Each predator density was replicated 5 times.

Statistical Analysis

The response variables were analyzed using analysis of variance performed with PROC GLM (SAS 2001). Tukey's test was used to determine significant differences between means ($P < 0.05$). The number of D. *citri* eggs was not normally distributed (PROC GPLOT, SAS 2001) so a √(x+1) transformation was used to normalize the data.

Functional Response of *Zelus longipes* to *Diaphorina citri* Adults

Six densities of *D. citri* adults (presumably mated, 1:1 ♂:♀) (4, 8, 12, 16, 20, and 24 individuals per arena) were offered to a single 1-d-old *Z. longipes,* presumably mated female adult. Both the prey and the predator were placed in the glass jar experimental arena with 1 flush of *M. exotica*. Twenty four h later, the numbers of live and dead adults of *D. citri* were counted. Each prey density was replicated 6 times. The untreated control for each density consisted of the prey without the predator. The type of functional response was determined using the polynomial logistic regression model (Juliano 2001) analyzed in SAS (SAS Institute 2001).

$$\frac{N_e}{N_0} = \frac{exp(P_0 + P_1 N_0 _ P_2 N^2_0 + P_3 N^3_0)}{1 + exp(P_0 + P_1 N_0 _ P_2 N^2_0 + P_3 N^3_0)}$$

Where *Ne* is the number of prey eaten, *No* is the initial number of prey, and *P0*, *P1*, *P2*, and *P3* are parameters estimated in the model.

The handling time and attack constant were estimated using the NLIN procedure (Juliano 2001) with the Hassell equation as a model (Hassell 1978):

$$N_e = N_0\{1 - exp[-aT N_0/(1 + bN_0 + aT_h N^2_0]\}$$

In this equation, a is the attack constant, b is a constant, T_h is handling time and T is total time available for *Z. longipes* to search for and attack the *D. citri* adults.

Prey Preference of *Zelus longipes*

Prey preferences of 1st instar nymphs, adult females or males of *Z. longipes,* were determined by choice tests. The prey species offered were *T. radiata, D. citri*, and *A. suspensa* adults. In the first choice test, one flush of *M. exotica* containing 15 adults of *D. citri* and 15 adults of *T. radiata* was introduced into the experimental arena followed by the introduction of a 1st instar, an adult male, or an adult female *Z. longipes*. The arena was sealed thereafter. Twenty four h later, the numbers of live and dead adults of *D. citri* and *T. radiata* were counted. Each experimental unit was replicated 15 times. The β index proposed by Manly et al. (1972) was used to quantify prey preference.

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use

$$\alpha = \frac{\ln(\frac{Ne}{N})}{\ln(\frac{N'e}{N'})}$$

$$\beta = \frac{1}{(1 + a)}$$

Where *N* and *N*' are the numbers of each provided prey type and *Ne* and *Ne*' are the numbers of each prey type killed. The preference β index assigns values from 0 to 1, where 0.5 represents no preference. Mean β values were considered significant when 95% confidence intervals based on the *t*-distribution did not overlap with β = 0.5.

The same methodology was used for a separate experiment in which adult *Z. longipes* (male and female) had to choose between 15 adults of *A. suspensa* and 15 adults of *D. citri*.

Results

Susceptibility of Different Psyllid Stages to Predation by *Zelus longipes*

All tested stages of *Z. longipes* consumed significantly more *D. citri* adults than nymphs (F = 77.05; df = 1, 149; $P < 0.001$). In addition, adult female and male *Z. longipes* showed significantly higher predation rates on *D. citri* than did 1st instar *Z. longipes* (F = 11.68; df = 2, 147; $P < 0.001$).

Zelus longipes adults at densities of 2 to 8 predators per arena caused significantly higher mortality (females: F = 117.58; df = 4, 20; $P < 0.001$; males: F = 28.77; df = 4, 20; $P < 0.001$) of *D. citri* adults than did a single male or female (Table 1). However, the average number of prey consumed per adult predator decreased significantly when the number of predators in the arenas increased (females: F = 83.62; df = 4, 20; $P < 0.001$; males: F = 8.65; df = 4, 20; $P < 0.001$) (Table 1).

Zelus longipes nymphs were only effective as predators of *D. citri* adults at a predator density of 8 per arena (F = 14.04; df = 4, 20; P<0.001). The number of prey consumed per *Z. longipes* nymph was higher when a single predator was released in the arena compared with 2, 4 and 8 predators per arena, which caused low mortality similar to that observed in the predator-free control (Table 1).

The mortality levels of *D. citri* nymphs caused by *Z. longipes* adult females were density dependent. Mortality was significantly higher at a predator density of 8 females/arena, followed by 4 or 2 females/arena, and 1 female/arena; the latter showed mortality rates similar to the control treatment (F =30.44; df = 4, 20; $P < 0.001$) (Table 1). The average number of *D. citri* nymphs consumed per Z. *longipes* female did not vary among the tested predator densities (Table 1).

Four to 8 *Z. longipes* males per arena caused the highest number of dead *D. citri* nymphs compared with the results obtained at lower predator densities or in the untreated control (F =13.17; df

Table 1. Mean numbers (± SEM) of *Diaphorina citri* adults and nymphs found dead in treatments with different densities of *Zelus longipes* adult females, adult males or 1st instars.

			D. citri adults		*D. citri* nymphs	
Zelus Stage	Predator density	No. *D. citri* prey	No. *D. citri* dead	No. *D. citri* killed/ predator	No. *D. citri* dead	No. *D. citri* killed/ predator
Adult female	0	20	0.2 ± 0.2 c	0.0 ± 0.0 d	0.2 ± 0.2 d	0 ± 0.0 b
	1	20	14.8 ± 1.4 b	14.8 ± 1.4 a	1.2 ± 0.2 cd	1.2 ± 0.2 a
	2	20	18.6 ± 0.7 a	9.3 ± 0.3 b	2.0 ± 0.3 bc	1.0 ± 0.2 a
	4	20	18.0 ± 0.5 a	4.5 ± 0.1 c	3.2 ± 0.7 b	0.8 ± 0.2 a
	8	20	19.8 ± 0.2 a	2.5 ± 0.02 cd	6.0 ± 0.3 a	0.8 ± 0.04 a
Adult male	0	20	0.2 ± 0.2 c	0 ± 0.0 b	0.4 ± 0.2 c	0 ± 0.0 b
	1	20	8.4 ± 2.7 b	8.4 ± 2.7 a	1.0 ± 0.5 bc	1.0 ± 0.5 ab
	2	20	16.2 ± 1.5 a	8.1 ± 0.7 a	3.0 ± 0.3 ab	1.5 ± 0.2 a
	4	20	18.8 ± 0.8 a	4.7 ± 0.2 ab	4.2 ± 0.9 a	1.0 ± 0.2 ab
	8	20	18.6 ± 1.7 a	2.3 ± 0.1 b	5.0 ± 0.4 a	0.6 ± 0.1 ab
1st Instar nymph	0	20	0.4 ± 0.2 b	0 ± 0.0 b	0.0 ± 0.0 b	0 ± 0.0 c
	1	20	2.4 ± 0.7 b	2.4 ± 0.7 a	1.8 ± 0.2 ab	1.8 ± 0.2 a
	2	20	2.0 ± 0.8 b	1.0 ± 0.4 ab	1.4 ± 0.4 ab	0.7 ± 0.2 b
	4	20	3.0 ± 1.1 b	0.8 ± 0.3 ab	2.2 ± 0.5 ab	0.6 ± 0.1 cb
	8	20	8.6 ± 1.0 a	1.0 ± 0.1 ab	3.4 ± 1.2 a	0.4 ± 0.2 cb

Means followed by different letters within columns separated by lines differ significantly (Tukey's test, P < 0.005).

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use

= 4, 20; $P < 0.001$). The average number of *D. citri* nymphs consumed per *Z. longipes* male was significantly higher than the control when 2 predators were released per arena ($F = 4.13$; df = 4, 20; $P < 0.01$) (Table 1).

Compared to the control, only the treatment with 8 *Z. longipes* nymphs could reduce significantly the number of *D. citri* nymphs ($F = 3.82$; df = 4, 20; $P < 0.01$). The number of prey consumed per *Z. longipes* nymph was density dependent. The average number of *D. citri* nymphs consumed per *Z. longipes* nymph was significantly higher when 1 predator was released per arena and it decreased as the number of predators increased ($F = 18.83$; df = 4, 20; $P < 0.01$) (Table 1).

Susceptibility of *Tamarixia radiata* Adults to Predation by *Zelus longipes*

All densities of male ($F = 93.98$; df = 4, 20; $P < 0.001$) and female ($F = 318.71$; df = 4, 20; $P < 0.001$) *Z. longipes* adults resulted in approximately 90% mortality of the parasitoids offered compared to the untreated control (< 1%). Mortality of the adult parasitoids increased with increasing densities of *Z. longipes* nymphs. Densities as low as 2 nymphs per arena significantly increased *T. radiata* mortality relative to natural mortality (control) ($F = 28.77$; df = 4, 20; $P = <0.001$) (Fig. 1).

Functional Response of *Zelus longipes* to *Diaphorina citri* Adults

The regression analysis resulted in the following coefficient estimates: intercept (a) = -1.1742 ± 1.57 (SE), $\chi^2 = 0.56$, $P = 0.4545$; linear (b) = 0.8682 ± 0.4106 (SE), $\chi^2 = 4.47$, $P = 0.003$; quadratic (c) = -0.0621 ± 0.0304 (SE), $\chi^2 = 4.17$, $P = 0.041$ and cubic (d) = 0.00125 ± 0.00067 (SE), $\chi^2 = 3.45$, $P = 0.0631$. The linear coefficient (b) was > 0 indicating that adult female *Z. longipes* showed a Type III functional response (Juliano 2001). The model produced the following values for the parameters of the Hassel equation: The handling time (Th) was 1.15 ± 0.08 h and the attack rate constant (a) was 0.017 ± 0.004 (Fig. 2).

Prey Preference of *Z. longipes*

First instar *Z. longipes* nymphs expressed a significant preference for *T. radiata* adults (95% confidence intervals did not include $\beta = 0.5$) over *D. citri* adults. Neither male nor female adults of *Z. longipes* showed a preference for one prey type over the other (Fig. 4). In the second experiment *Z. longipes* females showed a significant preference for *A. suspensa* adults (95% confidence intervals did not include $\beta = 0.5$) over *D. citri* adults, but males did not show any preference (Fig. 3).

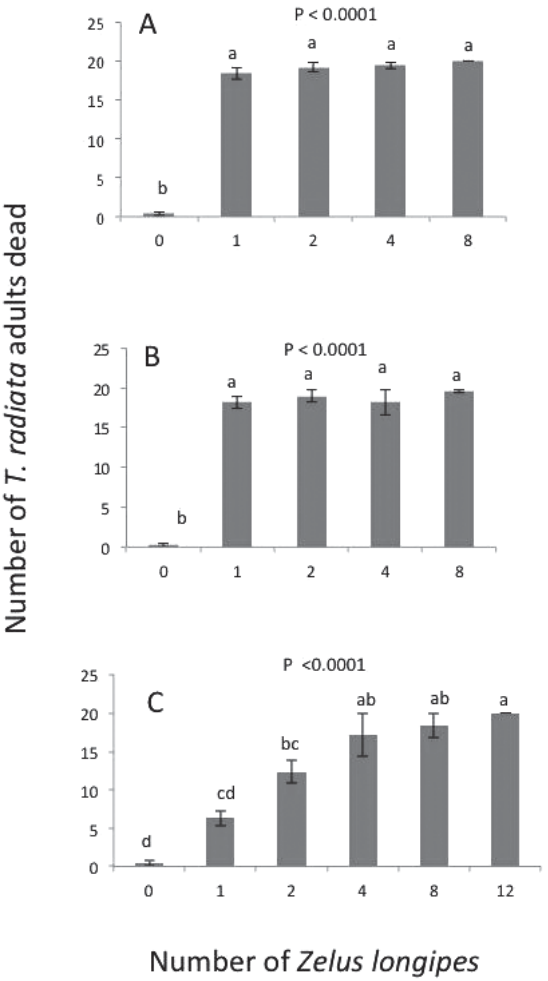


Fig. 1. Number of *Tamaraxia radiata* adults found dead in treatments with different densities of *Zelus longipes* adult females (A), adult males (B), and 1st instar nymphs (C). Treatments with different letters are significantly different (Tukey's test, $P < 0.05$). Error bars represent one standard error of the mean.

Discussion

Our research suggests that *Z. longipes* can reduce the population of *D. citri* in *M. exotica*. Females were slightly more efficient predators of *D. citri* adults than are males, which may be explained by the fact that *Z. longipes* females are larger and perhaps need more prey than the males (Kalsi 2011). Due to their small size, 1st instar nymphs of *Z. longipes* were not able to reduce psyllid numbers to the same extent as the adults; Groups of 2 or 3 *Z. longipes* nymphs often attacked a single prey, and thus an individual nymph consumed fewer psyllids than did an individual adult *Z. longipes*. Similar results were noted with *Zelus exsanguis* Stål attacking *Ephestia*

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use

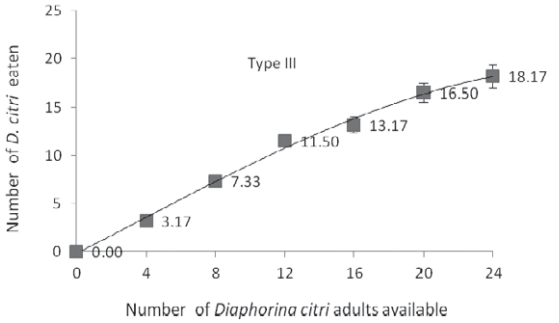


Fig. 2. Functional response of single adult females of *Z. longipes* that were provided with increasing densities of *D. citri* adults. Data fit a Type III functional response.

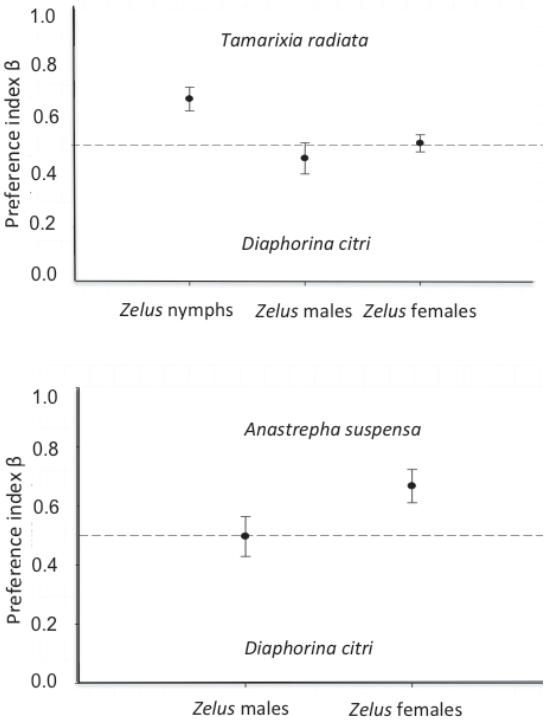


Fig. 3. Preferences of *Zelus longipes* 1st instar nymphs, adult males and females of *Z. longipes* between *Diaphorina citri* and *Tamarixia radiata* adults (upper panel) and *Diaphorina citri* and *Anastrepha suspensa* adults (lower panel). The preference index β assigns preference values from 0 to 1, where 0.5 represents no preference. The position of β in the bottom ($0 < \beta < 0.5$) or top ($0.5 < \beta < 1$) of the graph shows preference for a particular prey. Mean β-values were considered significant when 95% confidence intervals (error bars) based on the t-distribution did not overlap with $\beta = 0.5$.

kuehniella Zeller and *Drosophila* spp. (Edwards 1966).

Immatures and adults of *Z. longipes* consumed relatively fewer 5th instars of *D. citri* than adult *D. citri*. Apparently *Z. longipes* prefers to eat mobile prey instead of sessile prey. Visual stimuli seem to be the most important cue needed for reduviids to trigger an attack, as shown in work with *Z. renardii* and *Rhynocoris marginatus* Fab. (Haridass et al. 1988; Cisneros & Rosenheim 1998). In contrast, other Harpactorinae like *Scipinia repax* Stål and *Nagusta* sp., which are specialist predators of spiders, seem to rely on other sensory cues for orienting to prey (Jackson et al. 2010). *Tamarixia radiata* adults were suitable prey for adults and nymphs of *Z. longipes,* suggesting the possibility that intra-guild predation may be disruptive to biological control of the psyllid. This may also explain low levels of parasitism at certain sites (Peña et al. 2008). Kalsi & Seal (2011) mentioned that *Z. longipes* can be a predator of other natural enemies like *Orius* spp. *Zelus renardii* has been reported as an important predator of parasitoids of the genus *Aphytis*, thus interfering with biological control of the California red scale *Aonidiella aurantii* (Maskell) (Heimpel et al. 1997). No cannibalistic behavior was observed among *Z. longipes* individuals during any experiment, likely as a result of the short duration (24 h) of trials. According to personal observations by BN of the *Z. longipes* colony, cannibalism will begin after 3 d of starvation. Similar behavior was observed by Evans (1976) with the pirate bug *Anthocoris confusus* (Reuter).

Zelus longipes female adults had a type III functional response to *D. citri* adults (Juliano 2001). Type III functional response is typical for generalist predators that can switch from one prey to another (Hassell 1978; Akre & Johnson 1979; van Baalen et al. 2001). Kalsi (2011) found that both genders of *Z. longipes* adults had a type II functional response when feeding upon flies of the genus *Euxesta*. The different types of functional responses for the same predator species may be explained by the use of different prey with different behaviors and size.

As generalist predators, reduviids are thought not to express strong prey preferences (Louis 1974). Our work confirms that *Z. longipes* adults do not exhibit a preference for *D. citri* versus *T. radiata* as prey items. However, *Z. longipes* 1st instar nymphs prefer *T. radiata* adults over *D. citri* adults, which may be due to the comparatively smaller size of the parasitoid. For instance, Cogni et al. (2002) inferred from choice experiments that *Z. longipes* adults prefer smaller prey. In this study, adult females of *Z. longipes* showed a prey preference for *A. suspensa* adults over *D. citri* adults; in this case the females chose a bigger prey, which may be explained by greater nutritional needs of the females or by their bigger size in comparison with males.

Our research indicated that *Z. longipes* adults could potentially prey upon adults of *D. citri* un-

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use

der field conditions. Considering the high populations of this reduviid seen in south Florida, this predator may contribute to *D. citri* mortality. However, it was also demonstrated in this research that the parasitoid *T. radiata* is a suitable prey for *Z. longipes*. The prey preference studies showed that 1st instar nymphs had a preference for the smaller parasitoid over the larger *D. citri*. Hence, the real effect of this predator on parasitoids and other natural enemies should be tested under field conditions, particularly in *M. exotica* systems where *Z. longipes* appears to be more frequent than on *Citrus* spp.

Acknowledgments

We thank K. Santos and A. Vargas for their help. We thank Drs. K. Wyckhuys (CIAT, Vietnam), J. Jacas (Universitat Jaume I, Spain) for their suggestions to improve this manuscript. This research was supported by INIAP (Ecuador) and INIFAP (Mexico).

References Cited

Akre, B. G., and Johnson, D. M. 1979. Switching and sigmoid functional response curves by damselfly naiads with alternative prey available. J. Anim. Ecol. 48: 703-720.

Cisneros, J. J., and Rosenheim, J. A. 1998. Changes in the foraging behavior, within-plant vertical distribution, and microhabitat selection of a generalist insect predator: an age analysis. Environ. Entomol. 27: 949-957.

Cogni, R., Freitas, A. V. L., and Amaral Filho, B. F. 2002. Influence of prey size on predation success by *Zelus longipes* L. (Het., Reduviidae). J. Appl. Entomol. 126: 74-78.

Edwards, J. S. 1966. Observations on the life history and predatory behaviour of *Zelus exsanguis* (Stål) (Heteroptera: Reduviidae). Proc. R. Entomol. Soc. London (A): 21-24.41.

Evans, H. F. 1976. Mutual interference between predatory anthocorids. Ecol. Entomol. 1: 283-286.

Hall, D. G., Hentz, M. G., and Adair Jr., R. C. 2008. Population ecology and phenology of *Diaphorina citri* (Hemiptera: Psyllidae) in two Florida citrus groves. Environ. Entomol. 37: 914-924.

Haridass, E., Noble Morrison, M., and Balu, A. 1988. Predatory behaviour of *Rhinocoris marginatus* Fabricius (Harpactorinae-Reduviidae-Heteroptera-Insecta). Proc. Indian Acad. Sci. Sect. B 97: 41-48.

Hassell, M. P. 1978. The dynamics of arthropod predator-prey systems. Princeton University Press, New Jersey.

Heimpel, G. E., Rosenheim, J. A., and Mangel, M. 1997. Predation on adult *Aphytis* parasitoids in the field. Oecologia 110: 346-352.

Jackson, R. R., Salm, K., and Nelson, X. J. 2010. Specialized prey selection behavior of two East African assassin bugs, *Scipinnia repax* and *Nagusta* sp. that prey on social jumping spiders. J. Insect Sci. 10: 1-19.

Juliano, S. A. 2001. Non-linear curve fitting: predation and functional response curves, pp. 178-196 *In* S. M. Schener and J. Gurevitch [eds.], Design and analysis of ecological experiments. Oxford Univ. Press, New York, NY.

Kalsi, M. 2011. Potential predators of corn-infesting picture-winged flies (Diptera: Ulidiidae) in Homestead, Florida: seasonal abundance, distribution and functional response. M.S. Thesis, Univ. Florida, Gainesville.

Kalsi, M., and Seal, D. R. 2011. Milkweed assassin bug (suggested common name) *Zelus longipes* L. (Insecta: Hemiptera: Reduviidae). (http://entnemdept.ifas.ufl.edu/creatures/beneficial/bugs/zelus_longipes.htm)

Louis, D. 1974. Biology of Reduviidae of cocoa farms in Ghana. American Midl. Nat. 91: 68-89.

Lucas, E. 2005. Intraguild predation among aphidophagous predators. European. J. Entomol. 102: 351-354.

Manly, B., Miller, P., and Cook, L. 1972. Analysis of a selective predation experiment. American Nat. 106: 719-736.

Michaud, J. 2002. Biological control of Asian citrus psyllid, *Diaphorina citri* (Hemiptera: Psyllidae) in Florida: a preliminary report. Entomol. News 113: 216-216.

Michaud, J. 2004. Natural mortality of Asian citrus psyllid (Homoptera: Psyllidae) in central Florida. Biol. Control: 29: 260-269.

Peña, J. E., Duncan, R., and Jacas, J. 2008. Dynamics of mortality factors of the citrus psyllid in South Florida. Proc. Florida State Hort. Soc. 121: 113-117.

Rosenheim, J. A., Wilhoit, L. R., and Armer, C. A. 1993. Influence of intraguild predation among generalist insect predators on the suppression of an herbivore population. Oecologia 96: 439-449.

SAS Institute. 2001. PROC user's manual, version 6th ed. SAS Institute, Cary, NC.

Van Baalen, M., Krivan, V., Van Rijn, P. C. J., and Sabelis, M. W. 2001. Alternative food, switching predators, and the persistence of predator-prey systems. American Nat. 157: 512-524.

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use