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Feeding responses of *Euthyrhynchus floridanus* (Hemiptera: Pentatomidae) to brown marmorated stinkbug (Hemiptera: Pentatomidae) adults and nymphs

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Euthyrhynchus floridanus (L.) (Hemiptera: Pentatomidae), is a native predator that is common throughout the yr in many agro-ecosystems. It preys on a diversity of crop pests, including immature beetles, lepidopterous pests, and true bugs including plant-damaging pentatomoids (Mead 1976; Logan et al. 1987; Medal et al. 2018). The distribution range includes the central and southeastern USA, Mexico, Central, and South America into southern Brazil (Ables 1975; Mead & Richman 2013). Adults and nymphs tend to be aggregated and have a low level of cannibalism (Medal personal observation). Both nymphs and adults capture prey of different sizes, and feed individually or in aggregations. Since the discovery of the brown marmorated stink bug in Pennsylvania in 1996 (Hoebeke & Carter 2003), attempts have been made to use parasitoids and predators (Dieckhoff & Hoelmer 2014; Lara et al. 2016) as a sustainable management option of this new invasive polyphagous Asian immigrant (Hamilton et al. 2008; Haye et al. 2015; Leskey & Nielsen 2018) that has been reported in 44 states, including a limited reproductive localized infestation in Lake County, Florida (Northeastern IPM Center 2017; Penca & Hodges 2018). In this laboratory study, we determined the feeding response of *E. floridanus* to brown marmorated stinkbug *Halyomorpha halys* (Stål) (Hemiptera: Pentatomidae) nymphs and adults in controlled environmental conditions.

Euthyrhynchus floridanus used in this study was obtained from a laboratory colony established from nymphs and adults collected in a kudzu (*Pueraria montana* Lour (err.) variety *lobata* (Willd.); Fabaceae) patch in Gainesville, Alachua County, Florida, USA (29.639686°N, 82.399092°W) during the summer-fall of 2014. The second to fifth instars and adult brown marmorated stinkbug used in the experiments were obtained from a colony obtained from the USDA-ARS laboratory colony located in Newark, New Jersey, USA, and held in the laboratory in clear plastic containers (23 cm width × 32 cm length × 10 cm height) with moistened paper, and bean pods and carrots. Growing conditions were set at 25 ± 3 °C, 16:8 h (L:D) photoperiod, and 50 to 60% RH.

Euthyrhynchus floridanus nymphs, and male and female adults were starved for 24 h before the experiment. Predators were placed individually in Petri dishes (14.6 cm × 2.5 cm) with a bean pod, *Phaseolus vulgaris* L. (Fabaceae), and moistened paper as food and moisture sources. Crumpled Kimwipes® (Kimberly-Clark, Roswell, Georgia, USA) were inserted in each dish to provide refugia for predators. One brown

marmorated stinkbug nymphal instar or an adult was provided to 1 *E. floridanus* third nymphal instar, or a male or female adult predator. Control consisted of the same experimental set-up with only prey. The predator-prey studies incorporated a completely randomized design with 20 replications for predator prey interaction. After 24 h, the number of dead prey was recorded. Percent prey mortality data for each predator stage was analyzed using Fisher's Exact Test for Count Data (Fisher 1970). Mean prey mortality resulting from predation on developmental stage was analyzed as a 2-way factorial and compared using Tukey's multiple comparison test of means (Montgomery 2013). Means were considered statistically different at $P < 0.05$. Brown marmorated stinkbug mortality data were not adjusted because of low (< 5%) mortality in controls. These studies were conducted during 2015 and 2016. Predation rate of *E. floridanus* to brown marmorated stinkbug has not been reported previously in the literature.

These studies indicated that the feeding responses of *E. floridanus* male, female, and third nymphal instar to brown marmorated stinkbug generally were affected by the prey developmental stage (Tables 1 & 2). The percent mortality of brown marmorated stinkbug adults or nymphs due to *E. floridanus* male, female, or intermediate nymph differed significantly ($X^2 = 25$; $df = 7$; $P = 0.036584738$). Females had a preference to feed on brown marmorated stinkbug second to fourth nymphal instar, whereas males did not show any difference in the feeding response to the brown marmorated stinkbug nymphal instar (Table 1). The *E. floridanus* female was more effective than males, showing higher prey mortality of brown marmorated stinkbug male or female ($df = 3$; $P = 0.021$). The feeding responses (30–40%) by *E. floridanus* third nymphal instar to brown marmorated stinkbug second to fourth nymphal instars were significantly different ($df = 3$; $P < 0.05$) than those obtained on the fifth nymphal instar (Table 2). Mortality of brown marmorated stinkbug nymphs ranged from 30 to 100% for *E. floridanus* females, and from 50 to 70% for *E. floridanus* males. *Euthyrhynchus floridanus* males were not able to feed on brown marmorated stinkbug females, probably due to the larger size of the female prey than the male predator. This was contrary to the female predators, which fed an average of 80% on female prey (Table 1). A possible explanation for the lower feeding response, in addition to the difference in size, may be related to the defense mechanism of larger prey sizes when attacked by

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Table 1. Mortality (% \pm SD) of brown marmorated stinkbug, *Halyomorpha halys* caused by *Euthyrhynchus floridanus* male and female.

Predator gender	Prey growth stage	Prey mortality % (\pm SD)
Female	Nymph second instar	80 \pm 10 b
Female	Nymph third instar	80 \pm 8 b
Female	Nymph fourth instar	100 \pm 0 a
Female	Nymph fifth instar	30 \pm 10 d
Male	Nymph second instar	60 \pm 8 c
Male	Nymph third instar	60 \pm 6 c
Male	Nymph fourth instar	50 \pm 10 c
Male	Nymph fifth instar	70 \pm 10 bc
Male	Female prey	0 e
Female	Female prey	80 \pm 6 b
Male	Male prey	70 \pm 4 c
Female	Male prey	90 \pm 10 ab

Means % followed by the same letter in the column for each treatment did not differ significantly ($P \geq 0.05$); 20 replications.

a predator. Results indicated that *E. floridanus*, as an effective predator of the brown marmorated stinkbug, may complement other control strategies to reduce its population in infested regions.

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Summary

The Florida predatory stink bug, *Euthyrhynchus floridanus* L. (Hemiptera: Pentatomidae), is a generalist predator native to North America that feeds on a broad range of lepidopterous and heteropterous key pests in a great diversity of crops and non-crop situations. Feeding tests conducted in the laboratory to determine the most susceptible stage of the brown marmorated stink bug, *Halyomorpha halys* (Stål) (Hemiptera: Pentatomidae), to third nymphal instar, and male and female *E. floridanus*, indicated that this predator has great potential for biological control of *H. halys* nymphs and adult stages.

Key Words: Heteroptera; biological control; predator; agriculture pest

Table 2. Mortality (% \pm SD) of brown marmorated stinkbug, *Halyomorpha halys* nymphs caused by *Euthyrhynchus floridanus* third instar.

Treatment	Prey mortality % (\pm SD)
Predator nymph vs. prey nymph second instar	40 \pm 10 ab
Predator nymph vs. prey nymph third instar	30 \pm 5 b
Predator nymph vs. prey nymph fourth instar	40 \pm 8 ab
Predator nymph vs. prey nymph fifth instar	20 \pm 4 c

Means % followed by the same letter in the column for each treatment did not differ significantly ($P \geq 0.05$); 20 replications.

Sumario

La chinche hedionda depredadora de Florida, *Euthyrhynchus floridanus* L. (Hemiptera: Pentatomidae), es una generalista nativa de Norte América que se alimenta de un amplio rango de plagas importantes lepidópteros y heterópteros en una gran diversidad de cultivos y áreas naturales. Pruebas de alimentación en laboratorio para determinar el estado más susceptible de la chinche hedionda marrón marmoleada, *Halyomorpha halys* (Stål) (Hemiptera: Pentatomidae) al tercer estadio ninfal, y macho y hembra *E. floridanus* indicaron que este depredador tiene un gran potencial para control biológico de ninfas y adultos de *H. halys*.

Palabras Claves: Heteroptera; control biológico; depredador; plaga agrícola

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