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Comparative Prey Predation Ability of Big-Eyed Bug *Geocoris Ochropterus* (Fieber) (Hemiptera: Geocoridae)

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Abstract

We investigated the predation ability of big-eyed bugs *Geocoris ochropterus* on different single prey species of thrips, whiteflies, and aphids. Results indicated that *G. ochropterus* adults consumed the highest number of aphids per day (33.6 ± 3.35). First instar nymphs of *G. ochropterus* showed low ability to consume prey, while from second to fifth instar nymphs showed high ability to consume prey with significant differences. The number of eggs deposited per female fed on whiteflies was significantly different larger than other prey types. In addition, development time of *Geocoris ochropterus* nymphs first to fourth instar was longest when fed on aphids and significantly different among prey types. Results suggest that *G. ochropterus* consumed the highest numbers of aphids, with the order of preference aphids > whiteflies > thrips.

Keywords**:** *aphids; big-eyed bugs; Geocoris ochropterus; thrips; whiteflies; predation ability; prey*

1. Introduction

Big-eyed bugs, *Geocoris ochropterus* (Fieber) (Hemiptera: Geocoridae) are important predators of thrips, aphids, whiteflies, red spiders, mites, flea beetles and immature stages of lepidopteran pests (López Jr et al., 1976; Crocker & Whitcomb, 1980; Suresh Kumar & Ananthakrihnan, 1985; Capinera, 2001; Chau, 2019; Kóbor, 2018; Chau et al., 2021). Polyphagous predators provide more effective biological control because their dynamics are not solely dependent on a target pest species but can be positively enhanced by alternate prey (Murdock et al., 1985). Using predators can resolve problems relating to insecticide resistance and provide sustainable agro-ecosystems (Alves et al., 2005). Many studies on *Geocoris* sp. showed high variability in development rates, survival and reproduction when fed on a variety of prey species (Dunbar & Bacon, 1972; Torres et al., 2004). Japan uses native *G. varius* (Uhler) for biological control of thrips (Oida & Kadono, 2011; Igarashi & Nomura, 2013). Study on the predation ability of big-eyed bugs on different prey species provides valuable insights into ecological systems.

The predatory-prey relationship between *G. ochropterus* and larvae or eggs has been well studied (Lawrence & Watson, 1979; Suresh Kumar & Ananthakrihnan, 1985). Chiravathanapong & Pitre (1980) found that nymphs and adults of *G. punctipes* successfully attacked and sucked dry

Heliothis virescens larvae of various sizes. Feeding behavior and life cycle of the lygaeid *G. ochropterus* on different species of thrips such as *Caliothrips indicus*, *Scirtothrips dorsalis*, *Ayyaria chaetophora*, *Retithrips syriacus*, *Rhipiphorothrips cuentatus*, and *Zaniothrips ricini* indicated preference for different thrips species (Suresh Kumar & Ananthakrihnan, 1985). In this study, the predatory efficiency of *G. ochropterus* on thrips, whiteflies, and aphids was investigated to assess the potential of this predator for biological pest control.

2. Objectives

The main study objective was to determine the prey consumption preference of *Geocoris ochropterus* (Fieber).

3. Materials and methods

3.1 Insects

Geocoris specimens were collected from vegetable fields of hot peppers (*Capsicum annuum*) and melon (*Benincasa hispida*) in Cu Chi area, Ho Chi Minh City, Vietnam. The nymphs and adults were maintained on pupae of *Oecophylla smaragdina* (Hymenoptera: Formicidae) in the laboratory until eggs were laid. The specimens were morphologically identified as *Geocoris ochropterus* (Head brownish yellow, pronotum and scutellum black, translucent membranous wings (Animesh & Miswas, 2013) and their sequence (Accession number LC536156) was deposoted in the NCBI (Chau et al., 2021). *Geocoris ochropterus* was maintain the population in the laboratory of Animal Science, Faculty of Biotechnology, Ho Chi Minh City until the experiment.

3.2 Prey

Thrips *Thrips palmi* (Karny) and aphids *Aphis gossypii* (Glover) second instar larvae were used as prey and maintained on cucumber leaves. Whiteflies *Bemisia tabaci* (Gennadius) larvae were maintained on eggplant in a net cage (50x50x50 cm).

The experiments were conducted at 28-30ºC and 70-75% relative humidity (RH), with photoperiod of light/dark (L:D) 16:8 at the Laboratory of Plant Protection, Faculty of Agronomy, Nong Lam University, Vietnam.

Fifty second instar larvae of each prey *T. palmi*, *B. tabaci*, and *A. gossypii* were used as treatment. There were three treatments with 15 replications for each treatment. Fifty larvae of each prey were placed on a cucumber leaf on a Petri dish (9 cm diameter) (Figure 1). The Petri dish was then put into a plastic box (13x11.5x10 cm) with cotton wool soaked with water. The prey larvae were checked every day for 7 days and supplied to maintain 50 larvae. One male adult and one female adult *Geocoris ochropterus* were released together into the box for each treatment. The significant differences between treatments were determined by Dunnett's test and the number of prey consumed per day, number of eggs, time to lay eggs, time and ratio of egg hatch and times of development were recorded.

3.3 Statistical analysis

Data of development time, body size and log-transformed number of eggs at log (x+1) were analyzed using an ANOVA model implemented in SPSS 22.0. Treatment means were compared using Dunnett's two-sided t-tests.

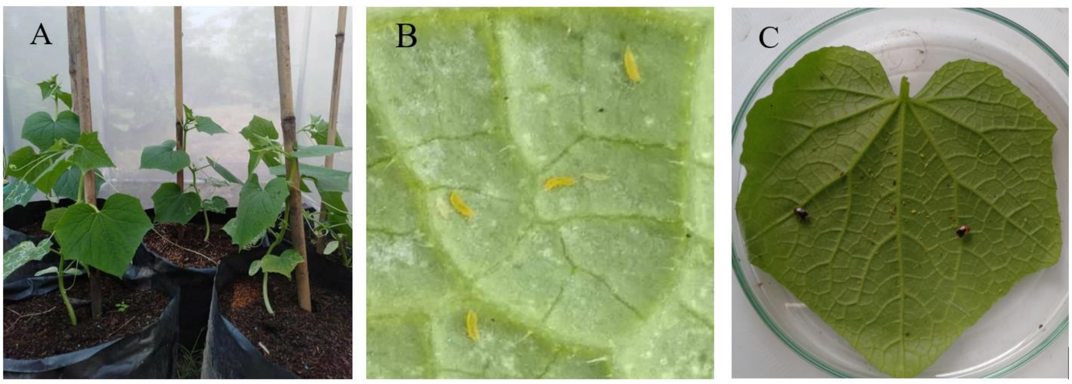

Figure 1 *Thrips palmi* were reared on cucumber (A, B) and adults of *G. ochropterus* on cucumber leaf infected aphids.

4. Results and discussion

4.1 Results

Results in Table 1 indicate that G. ochropterus adults consumed the highest number of aphids per day (33.6 ± 3.35). This consumption rate showed a statistically significant difference compared to when thrips and whiteflies were used as prey (p<0.01). Additionally, the longevity of G. ochropterus adults was greatest when fed with aphids and varied significantly among different prey types (ANOVA, F = 111.91, df = 2, p<0.01). The number of eggs deposited was significantly different among prey types (ANOVA, F=14.55, df = 2, p<0.01). Fecundity when fed on aphid was not much different from when fed whiteflies even though there was huge difference in the number of prey consumed. Duration time for laying eggs was shortest when bugs were fed on thrips and significantly different compared to the other prey types (ANOVA, F-32.78, df= 2, p<0.01). The percentage of eggs hatched was highest and significantly different when the bugs were fed on aphids compared with thrips and whiteflies (ANOVA, F = 4.76, df = 2, p<0.05).

Table 1 Predation ability of adult male and female *Geocoris ochropterus*

Prey	Mean prey consumed (prey/day)	Longevity (days)	Total number of prey consumed
Thrips	10.7 ± 1.32 c	13.2 ± 1.09 c	141.1 ± 15.98 c
Whiteflies	17.5 ± 1.19 b	15.4 ± 1.43 b	269.3 ± 29.24 b
Aphids	33.6 ± 3.35 a	21.7 ± 2.12 a	721.8 ± 26.93 a
F value	430.27**	111.91**	2281.50**
CV	10.65	9.60	6.56

Temperature: 29 ± 2ºC, Humidity: 75 ± 5%. Values represent mean ± standard deviation.
*Asterisks and different letters indicate significant differences, *p<0.05, ** p<0.01.*
F value of an ANOVA; CV: Coefficient of variation.

Table 2 Number of eggs deposited after feeding on different prey types

Prey	No. of eggs deposited	Duration time for laying eggs (days)	Time for eggs to hatch (days)	Eggs hatched (%)
Thrips	17.7 ± 1.59 b	8.2 ± 0.67 b	7.3 ± 0.73	78.1 ± 6.60 ab
Whiteflies	20.1 ± 1.16 a	10.3 ± 0.93 a	7.2 ± 0.71	74.4 ± 6.89 b
Aphids	19.7 ± 1.16 a	10.5 ± 0.90 a	7.8 ± 0.74	81.5 ± 5.22 a
F value	14.55**	32.78**	2.49ns	4.76*
CV	6.89	8.69	10.95	8.04

Values represent mean ± standard deviation.
*Asterisks and different letters indicate significant differences, *p<0.05, ** p<0.01.*
F value of an ANOVA; CV: Coefficient of variation; ns: non-significant differences.

Table 3 Predation ability of big-eyed bug nymphs

Prey	Prey numbers consumed by different instars of big-eyed bugs per day				
	First instar	Second instar	Third instar	Fourth instar	Fifth instar
Thrips	5.8 ± 0.51 b	6.3 ± 0.46 c	12.3 ± 0.68 c	14.5 ± 1.14 c	24.5 ± 2.83 c
Whiteflies	13.2 ± 0.59 a	12.4 ± 0.81 b	24.5 ± 1.02 b	30.6 ± 2.06 b	43.4 ± 3.23 b
Aphids	12.9 ± 0.61 a	13.3 ± 0.82 a	26,8 ± 1,06 a	34,6 ± 1,71 a	83,5 ± 5,51 a
F value	800.82**	412.55**	1047.88**	599.04**	723.39**
CV (%)	5.39	6.76	4.41	6.33	8.58

Values represent mean ± standard deviation.
*Asterisks and different letters indicate significant differences, *p<0.05, ** p<0.01.*
F: value of an ANOVA; CV: Coefficient of variation

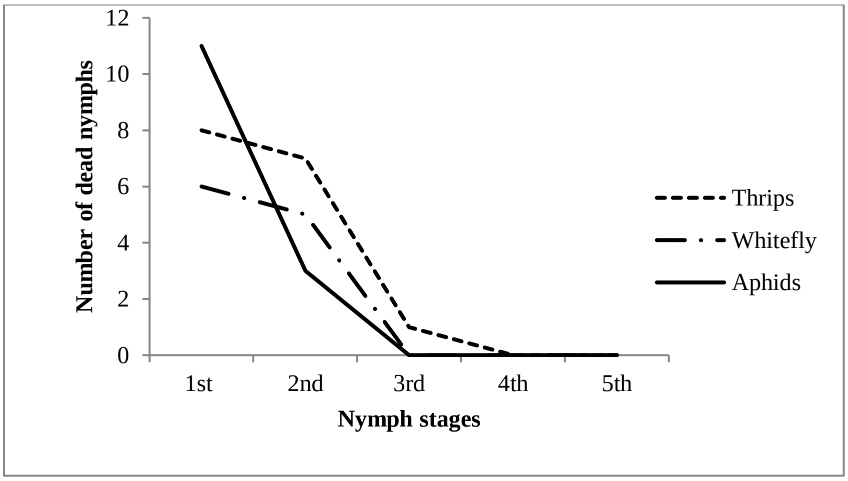

Figure 2 Mortality rate of *G. ochropterus* nymphs when consuming different prey types

Table 4 Development time of nymphs when fed on different prey types

Prey	Development time of nymphs (days)				
	First instar	**Second instar**	**Third instar**	**Fourth instar**	**Fifth instar**
Thrips	5.5 ± 0.44 b	3.4 ± 0.27 b	3.7 ± 0.45 b	3.6 ± 0.26 b	5.5 ± 0.27
Whiteflies	5.7 ± 0.50 b	3.6 ± 0.28 b	3.6 ± 0.41 b	3.4 ± 0.27 b	5.7 ± 0.25
Aphids	6.2 ± 0.46 a	4.5 ± 0.35 a	4.2 ± 0.62 a	4.7 ± 0.30 a	5.9 ± 0.81
F value	11.08**	54.79**	4.96*	97.91**	1.82 ns
CV (%)	8.05	7.90	13.07	7.06	9.02

Values represent mean ± standard deviation.
*Asterisks and different letters indicate significant differences, *p<0.05, ** p<0.01.*
F value of an ANOVA; CV: Coefficient of variation.

Geocoris ochropterus nymphs had high mortality rate when first and second instar nymphs consuming preys (Figure 2). Results in Table 3 show that first instar nymphs of *G. ochropterus* consumed the highest number of whiteflies (13.2 ± 0.59) and aphid (12.9 ±0.61) compared to thrips as prey (5.8 ± 0.51) and significant differences among treatments. First instar nymphs of *G. ochropterus* showed low ability to consume prey, while from second to fifth instar nymphs showed high ability to consume prey and significant differences ($p<0.05$), with highest ability to consume aphids. The number of prey eaten increased as the age of the larvae increased.

Development time of *Geocoris ochropterus* nymphs first to fourth instar was longest when fed on aphids and significantly different among prey types ($F= 4.96$, $df=2$, $p<0.05$ for third instar nymphs; $p<0.01$ for other nymph instars) (Table 4).

4.2 Discussion

Functional responses of predators are affected by prey defence and predator age (Morris, 1963). Adult thrips have a highly sclerotized body that is difficult to pierce. The low predation rate on thrips was due to inadequate nutrients available from the prey to support the metabolic demands of *G. ochropterus* instars. Fourth instar of *Geocoris* had high mortality when reared on thrips and caterpillars may be due to their inability to gain higher body weight needed by the fifth instar for entering adulthood. Bugs fed on aphids developed longer body length than other prey (Sannigrahi & Mukhopadhyay, 1992). Eubanks & Denno (2000) reported pea aphids as poor quality prey for *G. punctipes.* This result concurred with Kapadia & Puri (1991) who measured *G. ochropterus* average egg period as 14.28 days, with total nymphal stages lasting for 26-33 days when consuming *B. tabaci*, while Funderbuck (2003) found that *G. ochropterus* laid eggs that took 6-10 days to hatch. Crocker et al. (1975) reported that larger consumption by adult females than adult males contributed to greater size of females to satisfy their metabolic demands during egg production, while Awmack & Leather (2002) suggested that food quality also affected various components of insect reproductive strategy such as egg size, resource allocation to eggs and sex ratios. Oida & Kadono (2011) found that at 26ºC and density of aphids *A. gossypii* 20, 30 and 40, third instar nymphs of *G. ochropterus* consumed aphids at 7-10 individuals per day. *Geocoris punctipes* more preyed on *A. pisum* (Homoptera: Aphididae) in choice tests, indicating that big-eyed bugs are visually oriented predators that react to moving prey more readily than to sessile prey (Eubanks & Denno, 2000). Besides, the gross nutritional profit (GNP) in adult female whiteflies was demonstrated an optimal diet for *G. punctipes* (Cohen & Debolt, 1983), especially protein contents of whiteflies was similar to that of pea aphids, but the carbohydrate percentage was lower than that of pea aphids (Cohen & Byrne, 1992). The results of this study highlight the potential of control aphid by *G. ochropterus.* However, the mechanisms that determine the direct and indirect interactions that occur among predators and their prey require further examination.

5. Conclusions

Results indicated that *G. ochropterus* consumed the highest numbers of aphids compared to thrips and whiteflies, with order of preference aphids>whiteflies>thrips. Our study results confirmed that quality of prey was more important than quantity for *G. ochropterus.*

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